Bor Tiger Reserve

Status of Tigers, CoPredators & Prey

2021

Report Title:
Status of Tigers, Co-Predators and Prey in Bor Tiger Reserve

Project Title:
Long-term monitoring of tigers, co-predators and prey in tiger bearing areas of Vidarbha Maharashtra

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Contents

Executive Summary

The Phase IV monitoring exercise as a part of the project "Long Term Monitoring of Tigers-predators and prey in tiger reserves and other bearing areas of Vidarbha, Maharashtra, for Bor Tiger Reserve was conducted from December 2020-May 2021. This exercise, having three main objectives, the status of prey, estimation of minimum tiger and leopard numbers, and capacity building among staff flagged off with a capacity-building workshop in December 2020.

Line transects surveys aimed to estimate the density of prey species were carried out in two blocks with an effort of 7 days for each transect line. In the core area among all the prey species, the highest density was recorded for Chitals 7.14 (±4.44)/km^2 followed by Sambar 6.45 (±2.26)/km. sq. and Nilgai 2.53(±0.67)/km^2.In the buffer area, the highest density was recorded for wild pigs 5.75 (±1.26)/km^2 among all the ungulate species. The density of other species includes Chital 0.81 (±0.22), Sambar 0.40 (±0.15), Nilgai 4.72 (±0.58), Peafowl 2.56 (±0.54), Langur 19.09 (±2.49).

Camera trapping based on the spatial capture-recapture framework was conducted on the same locations of the same grids (2 km^2) similar to the previous cycle (2020) which were selected based on a rigorous sign survey that provided sign encounters of tiger, leopard, and other co-predators. This year both core and buffer areas were covered in two blocks with 211 active camera trap stations during February 2021-May 2021. The effort resulted in 7572 trap nights. The number of individual tigers captured was 9 along with 46 leopards. Tiger density based on the Spatially Explicit Capture-Recapture framework was 1.10(±0.37)/100km^2 and the density of leopard was 6.68 (±0.80)/100km^2.

To study space use and activity patterns we have used camera-trapping data from both core and buffer areas of Pench Tiger Reserve. Higher activity overlap was recorded between tigers and leopards (Dhat1=0.88) among predators. Camera trap locations with the number of captures of each species were modeled in a GIS domain using IDW (Inverse distance weighted) interpolation technique to generate spatially explicit capture surfaces. The times recorded on camera trap photos provide information on the period during the day that a species is most active. Species active at the same periods may interact as predator and prey, or as competitors. Sensors that record active animals (e.g. camera traps) build up a record of the distribution of activity over the day. Records are more frequent when animals are more active and less frequent or absent when animals are inactive. The area under the distribution of records thus contains information on the overall level of activity in a sampled population.

1. Introduction

The tiger is one of the biggest symbols of conservation in India. However, the success of tiger conservation is not all about tigers, but it is about the landscapes, biodiversity, rivers, diverse ecosystems that are being given legal protection in a protected area by iconizing tiger as an umbrella species. But protected areas, being only confined to 5.02% area of land are a challenge for conservation and need to be managed well. The Eastern Vidarbha landscape in Maharashtra holds some of the prime tiger habitats along with their dispersal corridors that maintain connectivity among the source and sink. As escalating development has forced the tiger and people to share habitats, it has also triggered the chances of conflicts. The future of such areas is very much dependent on the success of management efforts for the wellbeing of both people and wildlife.

Bor Tiger Reserve (BTR) is located in the Wardha district of the Maharashtra state between N20°59'34.74" and E78°40'24.47". It is spread over an area of 152.94 sq. km. (core) and a buffer of 659.84 sq. km. The drainage basin and Bor dam falls within the reserve area. The core tiger reserve is divided into three ranges Bor Dharan, Extended New Bor, and New Bor.

BTR lies in the middle of other tiger reserves and is an important tiger source population (Figure 1). Towards the northeast lies the Pench Tiger Reserve, towards the east is Nagzira Navegaon Tiger Reserve, to the South-east is Karhandla Wildlife Sanctuary. The Tadoba Andhari Tiger Reserve is located to the South-east, Melghat Tiger Reserve stands to the west while Satpura Tiger Reserve lies to the North-west of the Sanctuary.

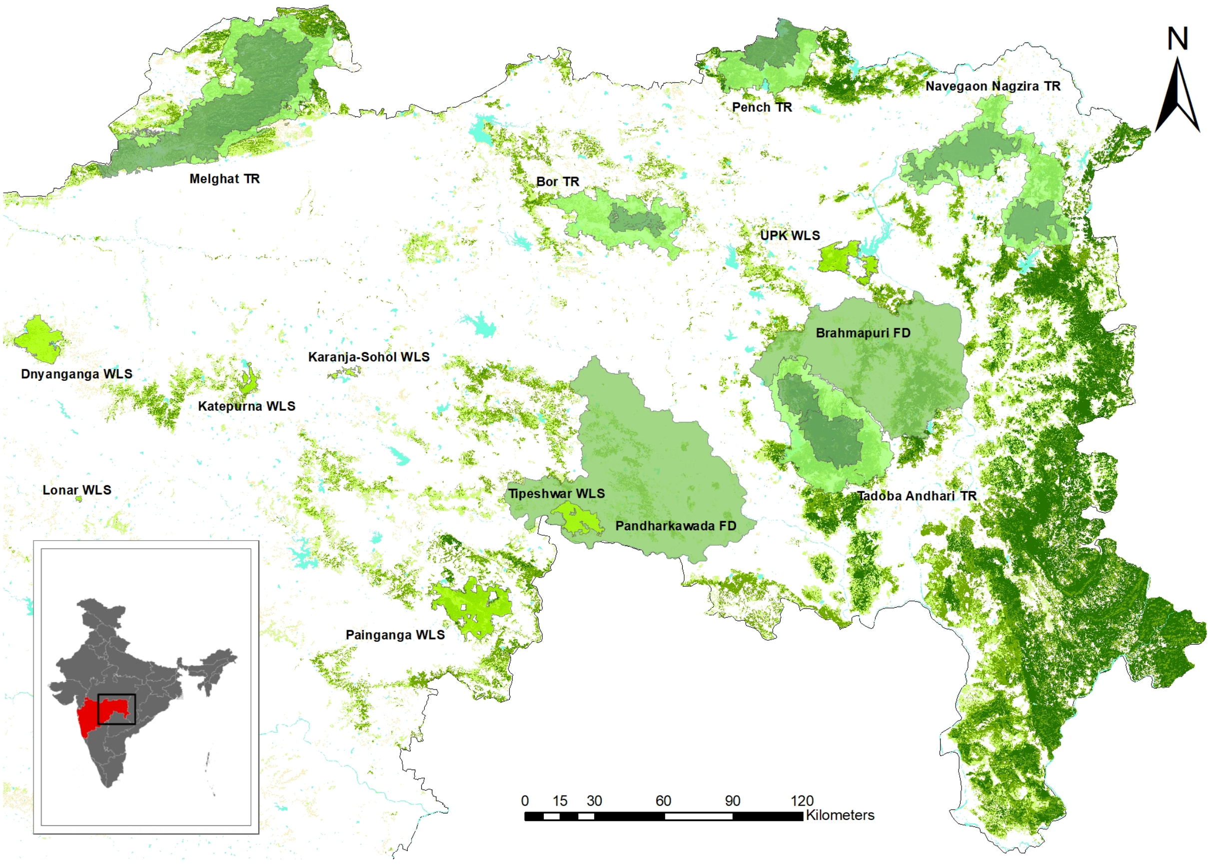


Figure 1: Map showing study sites in Vidarbha Landscape, Maharashtra, India

Flora and Fauna

The forest mainly exhibits very dry teak forest and southern dry deciduous forest. Teak (*Tectona grandis)* is common there along with Tendu (*Diospyros melanoxylon)*, Arjuna (*Terminalia arjuna),* etc. The other associated tree species include Bhera (*Chloroxylon swietenia),* Dhawada (*Anogeissus latifolia),* Arjuna (*Terminalia arjuna),* Ain (*Terminalia elliptica*), Mahuwa *(Madhuca longifolia),* Salai (*Boswellia serrata*), Palash (*Butea monosperma*) etc.

Bor tiger reserve (Figure 2) is home to large carnivores such as tiger and leopard and has around 160 species of birds. The Tiger (*Panthera tigris*) holds its place as the top predator followed by other co-predators, leopard (Panthera pardus), dhole (*Cuon alpinus*), Wolf (*Canis lupus)*, Jackal (*Canis aureus*), etc. Jungle cat (*Felis chaus*) rusty-spotted cat *(Prionalurus rubiginosus*) represents small cats and sloth bear (*Melursus ursinus*) is also present here. The Ungulate community, supported by diverse habitats is represented by Chital (*Axis axis*), Sambar (*Rusa unicolor*) Chausingha (*Tetracerus quadricornis),* Wild Pig (*Sus scrofa),* etc.

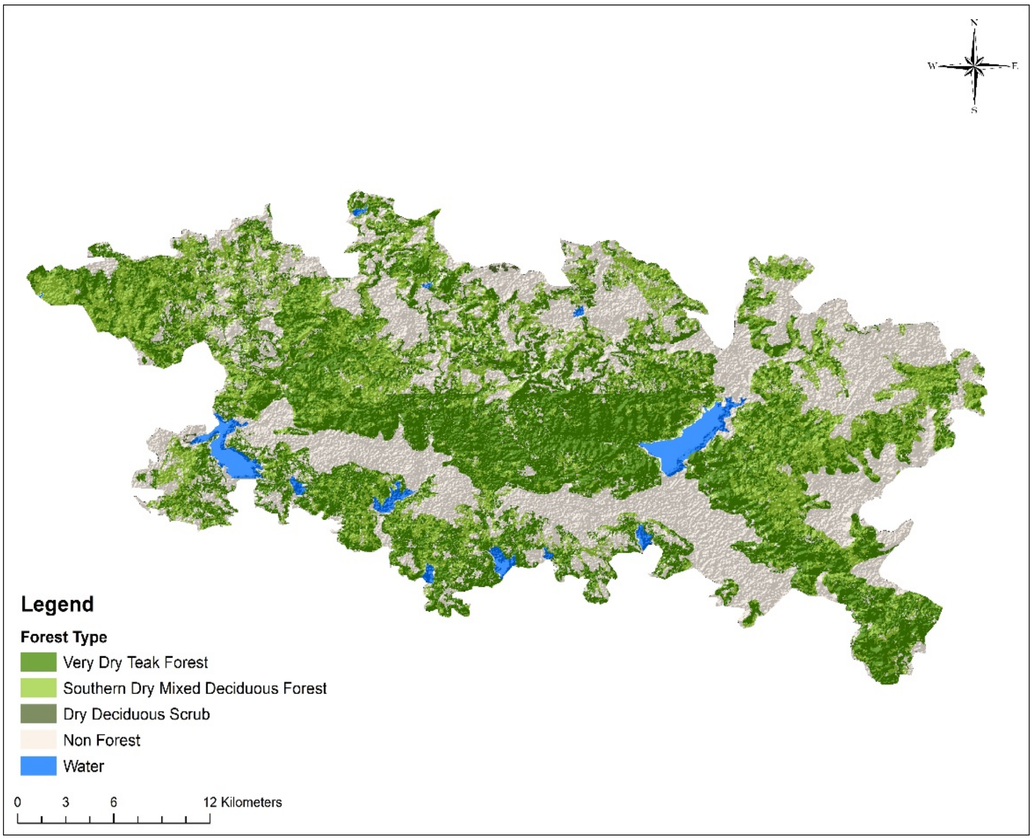


Figure 2: Map depicting Forest type of Bor Tiger Reserve

As a part of the research project titled "Long-term monitoring of Tigers, Co-predators and prey in Tiger reserves and other Tiger bearing areas of Vidarbha, Maharashtra, the Wildlife Institute of India has initiated this study in 2019 having the objectives that are as follows:

Objective 1: Status of tigers, co-predators and their prey in the landscape

a) Field surveys will be conducted to detect the presence of tigers, co-predators and prey species using animal signs (tracks, scats, direct sightings, calls etc) in an occupancy-based framework.

The data will be analysed in occupancy framework to estimate occupancy of the target species. Single season or multiple season occupancy models will be used depending on data collection approaches. These occupancy field surveys will be carried in all the tiger areas. The data collection will be followed by modelling and estimation approaches described in detail by Mackenzie et al., (2002, 2006).

b) Density, abundance and demography of tigers and co-predators will be carried by using camera traps in all the tiger areas followed by analysing the data in capture –recapture frame work. Rigorous field methods will be followed to achieve small CV and high precision. These filed surveys will be conducted in all the tiger areas.

c) Estimation of abundance and density of the key ungulate species will be conducted using distance sampling employing line transect survey protocols. The survey protocols and analyses of this data set will be based on modelling and estimation approached developed by Buckland et al. (2001, 2004).

d) Estimation of recruitment, survival, transience, temporary emigration, permanent emigration and dispersal rates of tigers and leopards. Will be based on data collected from radio-telemetry. The information will be supplemented by data generated by camera trap surveys.

e) Scat analysis is indirect, non-invasive and unbiased technique for recording frequency of occurrence of prey in the diet of large carnivores and hence it is most widely used (Johnson et al., 1983; Leopold and Krausman, 1986; Jhala, 1993; Mukherjee et al., 1994a, b; Spaulding et al., 1997; Jethva, 2002; Biswas and Sankar, 2002). Scats will be collected at regular time intervals, generally every week. The scats will be collected in polythene bags, labelled and sun-dried in the field. Information on habitat, substratum where scat will be found and its GPS location will also be recorded.

Objective 2: Development of database on tigers across the landscape

a) The photo database generated by the methodology delineated in 1b above will be collated at every tiger area level. Identification of unique individuals will be done from these collated photographs and a database of identified tiger individuals will be generated. New photographs from every camera trapping session will be compared with the existing database, whereby recaptured individuals will be noted and any new individuals found will be added to the database.

Objective 3: Identification of tiger dispersal in the landscape

a) On an event when a previously captured individual goes missing in pictures from the current camera trapping exercise, or when a new individual is discovered, it will be cross-checked against tiger databases of adjoining areas. This will enable us to find out if a missing individual has dispersed to a new area.

Objective 4: Development of feedback for management intervention at reserve and landscape level

a) The outputs of the project will help in developing management feedback for the State of Maharashtra to effectively manage tiger populations.

2. Status of Prey in Bor

Introduction

To maintain a viable population, large carnivores require sufficient prey species. On the other side, the diversity of prey is dependent on the soil property and vegetation characteristics of an area. The presence of different body size ungulates is very much required to facilitate the existence of multi carnivores in an ecosystem. Prey depletion is a major threat to the decline of large carnivores. Therefore, it is imperative to know the status of prey species in an area for planning conservation efforts in the right direction.

Distance Sampling

Distance sampling is one of the robust methods in conservation biology to estimate prey species. Line transects, among such applications, are practiced widely to estimate the abundance and density of prey species. In this survey an observes walks through a line of predetermined length and records animal sightings on both sides along with its number, bearing angle, and GPS.

Line transect surveys were carried out after a brief theoretical & practical training about the same. Each transect was walked for 7 consecutive days in the early morning hours shown in Figure 3. A wide range of prey species of different body sizes was recorded during these surveys like Chital (*Axis axis*), Sambar (*Rusa unicolor*), Wild Pig (*Sus scrofa*), Nilgai (*Boselaphus tragocamelus*), Barking Deer (*Muntiacus muntjak*), Langur (*Semnopithecus entellus*), Peafowl (*Pavo cristatus*), Grey Jungle Fowl (G*allus sonneratii*). In addition to the number of animals, their group composition, sex, habitat type, terrain type, etc. were also recorded. For density estimation data has been analyzed on Distance 7.0 software and the best fit model was chosen as per AIC Value. The results are provided in Tables 1 – 4 and Figures 4 and 5.

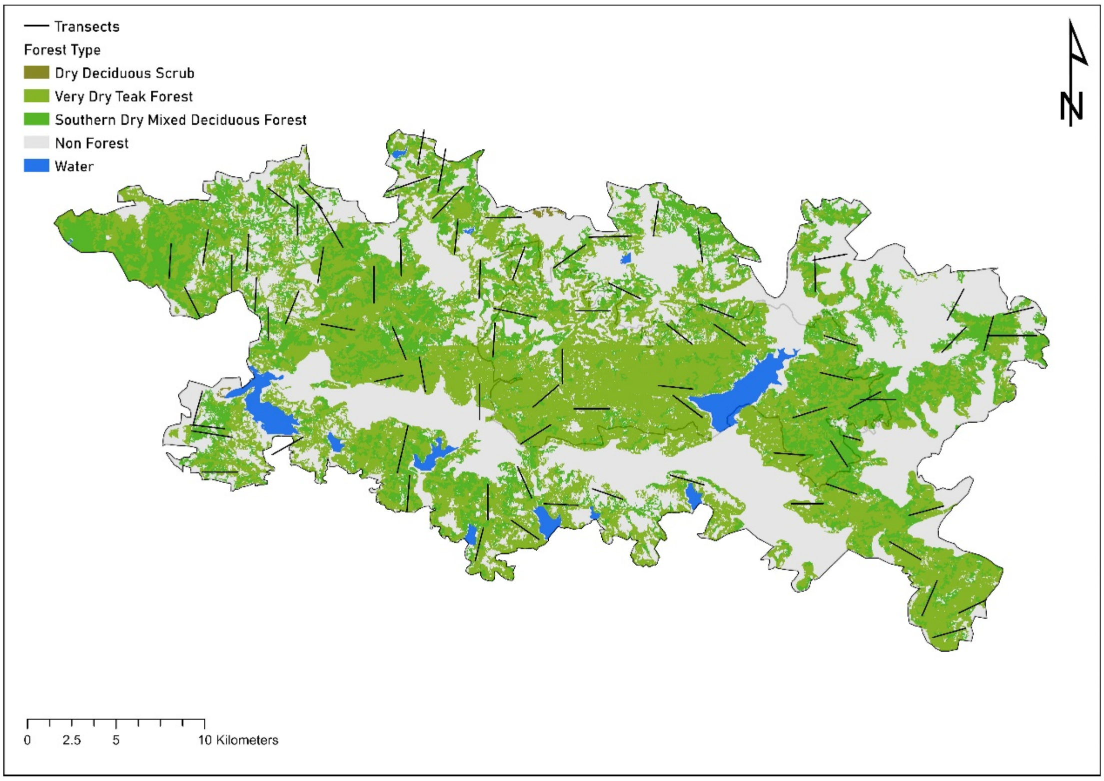


Figure 3: Map showing transect lines surveyed during Phase IV monitoring 2021 of Bor Tiger Reserve

Table 1: Line Transect monitoring effort and species reported from Core and Buffer Area in Bor Tiger Reserve during Phase IV monitoring 2021

Transect Details	**Core**	**Buffer**
Number of transects	19	73
Length of each transect	2 km	2 km
Number of replicates	7	7
Number of species recorded	9	10
Survey Effort	266 km	1022

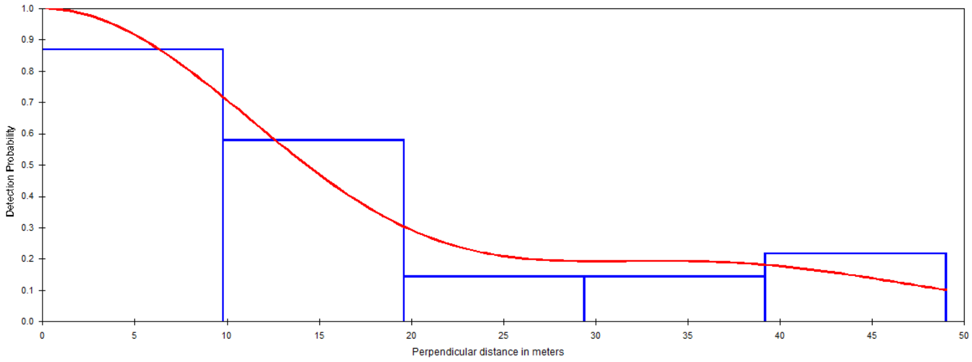
Table 2: Summary of species recorded during line transect surveys as a part of Phase IV monitoring 2021 in Bor Tiger Reserve

	Core		**Buffer**	
Species	**Number of Observations**	**Individuals recorded**	**Number of Observations**	**Individuals recorded**
Chital	27	145	32	103
Sambar	70	183	20	69
Nilgai	38	84	142	608
Wild pig	11	60	59	448
Barking deer	-	-	32	103
Langur	11	125	77	893
Hare	2	2	28	34
Peafowl	4	29	53	190
Chousingha	2	3	-	-

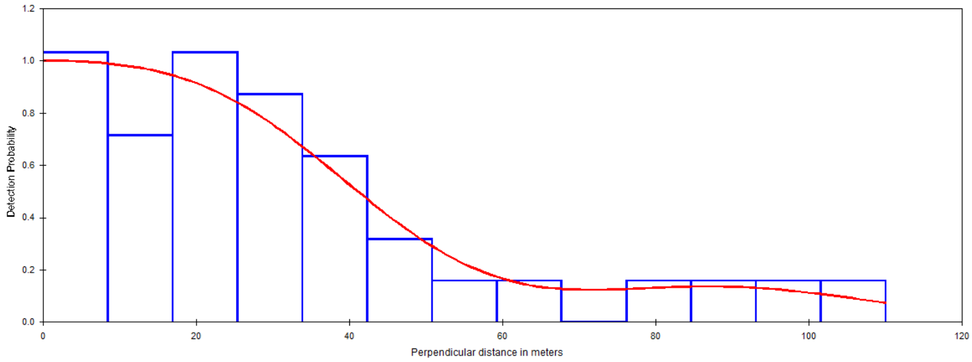
*Species with less than 15 observations were not used in the analysis.

Table 3: Individual Density, Group Density, Effective Strip Width, Average Group Size of Prey Species Reported during Line transect survey 2021 in the Core Area of Bor Tiger Reserve

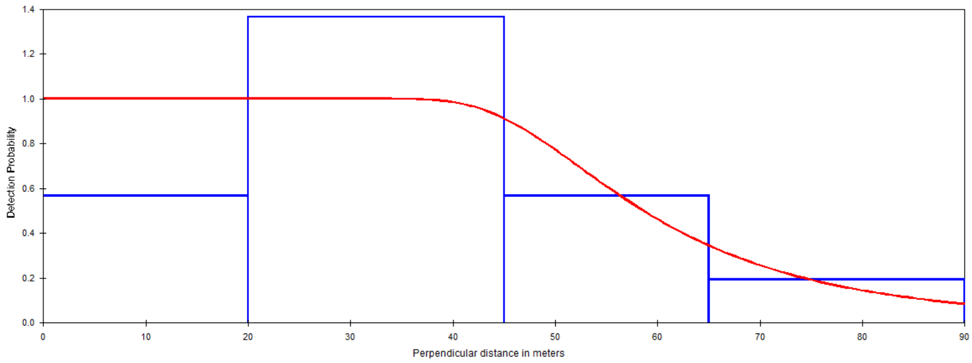
Parameters	**Chital**	**Sambar**	**Nilgai**
Density(individual/sq.km)	7.14	6.45	2.53
Standard error	4.44	2.26	0.67
Percent CV	62.28	35.08	26.58
95%CI	2.20-23.11	3.22-12.89	1.49-4.30
Group density (no. of groups/sq.km)	2.79	2.95	1.22
Standard error	1.64	1.00	0.28
Percent CV	58.89	33.96	23.71
95%CI	0.90-8.67	1.50-5.80	0.75-1.97
Effective strip width (ESW)	19.15	46.94	61.74
Standard error	4.01	8.16	7.26
Percent CV	20.97	17.40	11.77
95%CI	12.49-29.35	33.25-66.26	48.67-78.33
Average group size	2.55	2.61	2.08
Standard error	0.51	0.19	0.24
Percent CV	20.28	13.33	12.01
95%CI	1.68-3.86	2.00-3.40	1.63-2.65
Probability of a greater chi square value, P	0.53	0.89	0.03



Chital



Sambar

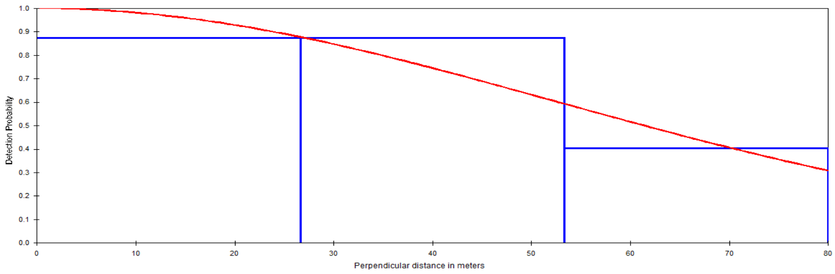


Nilgai

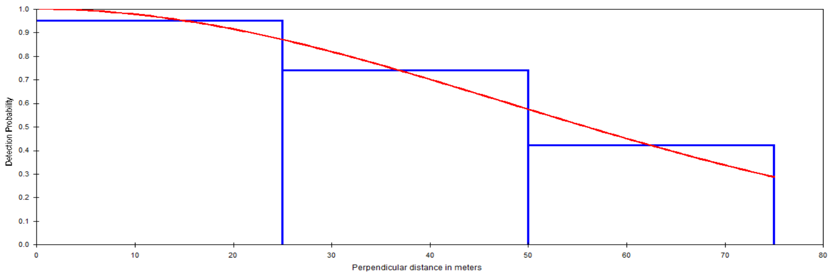
Figure 4: Detection functions of the best-selected model for prey species during the line transect estimation survey 2021 in Core Area of Bor Tiger Reserve

Table 4: Individual Density, Group Density, Effective Strip Width, Average Group Size of Prey Species Reported during Line transect survey 2021 in Buffer Area of Bor Tiger Reserve, Maharashtra

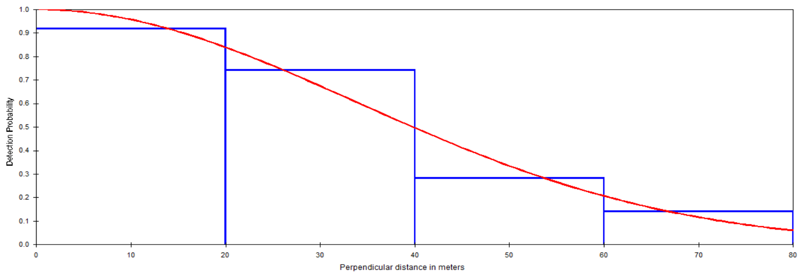
Parameters	**Chital**	**Sambar**	**Nilgai**	**Wild Pig**	**Peafowl**	**Langur**
Density(individual/sq.km)	0.81	0.40	4.72	5.75	2.56	19.09
Standard error	0.22	0.15	0.58	1.26	0.54	2.49
Percent CV	28.24	37.40	12.43	21.94	21.30	13.06
95%CI	0.46-1.40	0.19-0.83	3.70-6.03	3.74-8.82	1.68-3.88	14.76-24.68
Group density (no of groups/sq.km)	0.30	0.20	1.11	0.76	0.73	1.64
Standard error	0.07	0.07	0.12	0.13	0.14	0.19
Percent CV	24.85	34.76	11.22	17.91	19.25	11.79
95%CI	0.18-0.49	0.10-0.40	0.89-1.39	0.53-1.08	0.50-1.07	1.30-2.07
Effective strip width (ESW)	57.22	52.76	68.87	41.63	39.02	40.34
Standard error	10.18	11.76	4.30	4.53	4.06	3.66
Percent CV	17.79	22.31	6.26	10.88	10.41	9.08
95%CI	39.92-82.02	33.26-83.68	60.86-77.93	33.50-51.73	31.68-48.07	33.68-48.32
Average group size	2.68	1.99	4.23	7.50	3.49	11.59
Standard error	0.36	0.27	0.22	0.95	0.31	0.65
Percent CV	13.41	13.81	5.36	12.68	9.12	5.62
95%CI	2.04-3.52	1.49-2.66	3.81-4.71	5.83-9.66	2.90-4.18	10.37-12.97
Probability of a greater chi square value, P	0.47	0.96	0.00009	0.74	0.13	0.48



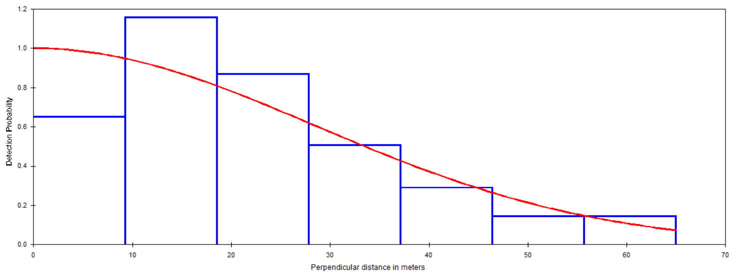
Chital



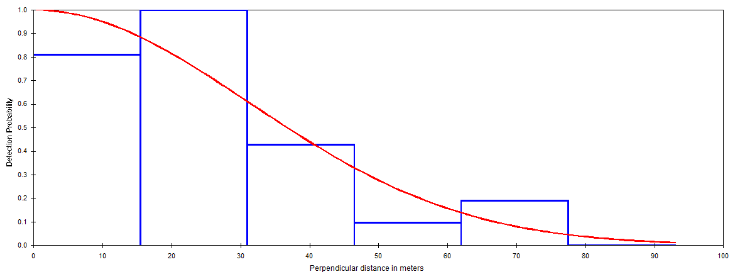
Sambar



Wild Pig



Langur



Peafowl

Figure 5: Detection functions of the best-selected model for prey species during prey estimation survey in Core of Bor Tiger Reserve 2021.

3. Status of Predators in Bor Tiger Reserve

Introduction:

Monitoring of large carnivore populations is important to guarantee their survival, to adapt management practices to changing situations, and to fulfill obligations for the conservation of habitat. It is also a very demanding exercise because of the large scales over which it must be conducted, often stretching across huge areas. The combination of biological characteristics of tigers - extensive distributional range, low densities, elusiveness, wide-ranging behaviors, low chances of detection of tiger signs in most situations – poses major challenges to the task of monitoring tiger populations. Typically, over large regions, even results of the mere presence or absence surveys tend to be equivocal or indeterminate. In particular, it is difficult to infer the absence of tigers based on the absence of a tiger sign. The collection of quantitative data on the abundance of tigers or tiger signs is usually handicapped by small sample sizes, low detection probabilities, and numerous logistical and physical constraints. These species occur under a diversity of situations across BTR and their monitoring hence represents a variety of challenges. The long-term monitoring projects are effective in understanding population trends in great detail. The need for long term scientific monitoring of large carnivore populations arises from three considerations:

a) To objectively audit or evaluate the success or failure of earlier management measures and conservation interventions to react adaptively and solve problems (Walters, 1986; Nichols et al., 1995).

b) To establish benchmark data that can serve as a basis for specific objectives for management and conservation efforts and

c) To improve our basic understanding of tiger, co-predator, and prey ecology through rigorous field studies, to develop a body of theoretical knowledge that can generate the predictive capacity to deal with new situations and contributes to the general advancement of scientific knowledge.

Population Estimation of Predators:

For estimating the density and population we used "SECR" instead of the conventional capture-recapture model. Spatially explicit capture-recapture (SECR) is a set of methods for modelling animal capture-recapture data collected with an array of 'detectors. The methods are used primarily to estimate population density and have advantages over non-spatial methods when the goal is to estimate population size (Efford and Fewster 2013). SECR methods overcome edge effects that are problematic in the conventional capture-recapture estimation of animal populations (Otis et al. 1978). Here detectors are camera traps that take photographs of tigers and leopards and they are recognized by their natural marks and stripes. Camera-traps are proximity detectors because they can detect multiple animals within an occasion, and they do not detain detected animals, which remain free to be detected by other camera traps within each occasion. Like other statistical methods for estimating animal abundance, SECR also combines a state model and an observation model. The state model describes the distribution of animal home ranges in the landscape, and the observation model (a spatial detection model) relates the probability of detecting an individual at a particular detector to the distance of the detector from a central point in each animal's home range. Unlike the maximum-likelihood and Bayesian estimation methods, it is not based on an explicit likelihood function and does not have the same inference foundation as these methods. In SECR the basic parameter for a population is density instead of number. The detectors in this case are the camera traps. The photographs are then manually scanned for identification of individuals based on their stripe or rosette pattern. SECR combines both the state model and the observation model. The state model describes the distribution of animal home ranges in the landscape, and the observation model (a spatial detection model) relates the probability of detecting an individual at a particular detector to the distance of the detector from a central point in each animal's home range. The distances are not observed directly (usually we don't know the range centers), so conventional distance sampling that we would normally apply to study prey species do not apply (Efford, 2017).

For the Phase IV exercise, the number of active trap stations was 211 in Bor Tiger reserve in a grid of $2km^2$ (Figure 6). A pair of camera traps were deployed in each location and were kept for 25-40 days in the field that resulted in 7572 trap nights. For this year's study three different types of camera models Cudde Back C1, Cudde Back Pro, and Ambush were used. All the traps were assigned an ID number same as the Grid and the locations of each station were recoded for spatial analysis. Individual tigers and leopards were identified based on their flanks. Both flanks were used for tigers and leopards right flanks were used for estimation because of maximum captures of that flank. The data of the present exercise have been analyzed on the Camtrap R package in R and density was estimated by using the SECR package in R software. The results are provided in Tables 5 – 9 and Figures 7(a -f) shows the MCP of tigers and leopards in Bor Tiger Reserve.

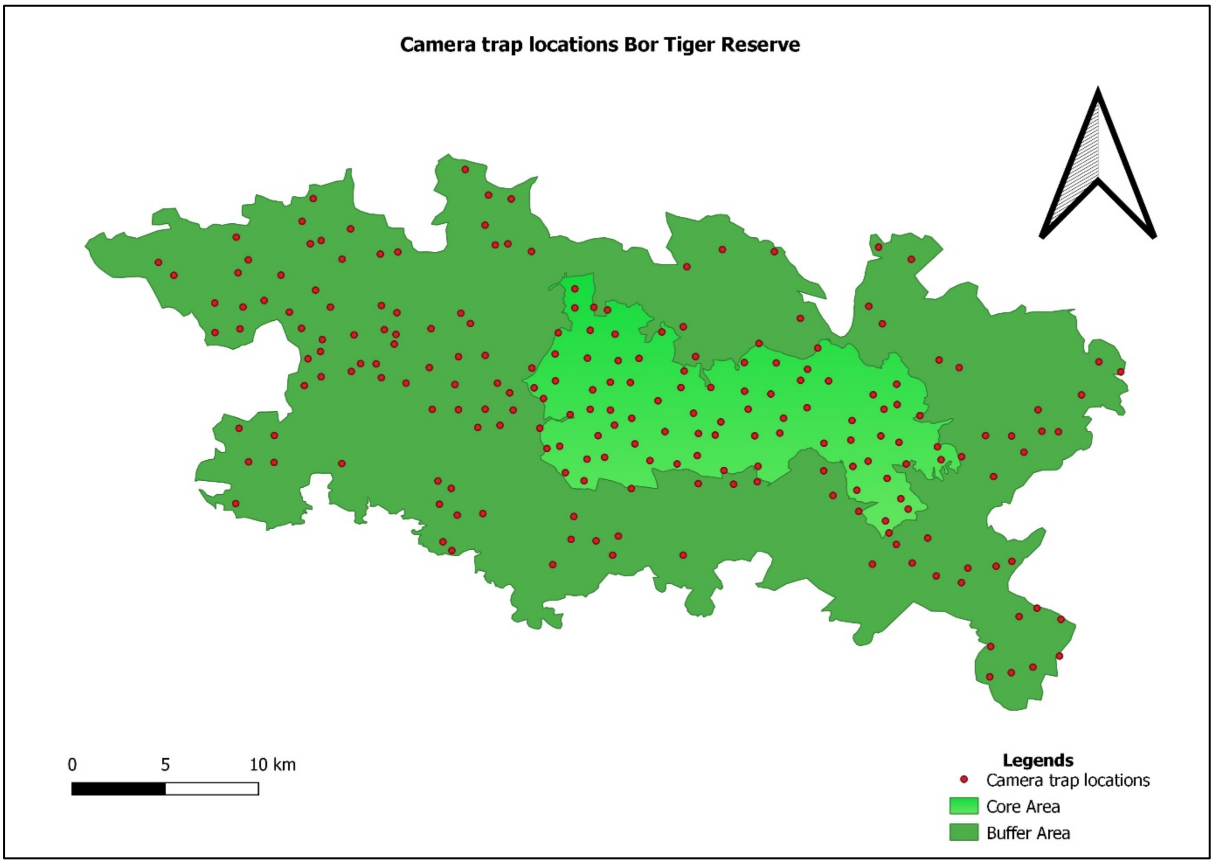


Figure 6: Map Showing Camera trap locations of Bor Tiger Reserve during Phase IV monitoring 2021

Table 5: Estimates of Leopards using Spatially Explicit Capture-Recapture Models Bor Tiger Reserve, Maharashtra, India for the year 2020-2021

Year	Area Coverage	Species	No. of individuals captured	Estimate	Density per 100 km2
2020	Core Only	Leopard	24	30(±3.66)	7.37 (±1.60)
2021	Core and Buffer	Leopard	46	56 (±4.25)	5.68 (±0.80)

Table 6: Density estimates of Tigers using Spatially Explicit Capture-Recapture Models Bor Tiger Reserve, Maharashtra for the year 2020 & 2021.

Parameters	2020	2021
Model	Heterogeneity	Heterogeneity
Detection function	Half Normal	Half Normal
Density Estimate	1.19	1.10
Density SE	0.50	0.37
Density CI	0.5-2.66	0.57-2.11
g0 Estimate	0.0324	0.024
g0 SE	0.00456	0.0027
g0 CI	0.0246-0.0426	0.019-0.030
Sigma Estimate	4.25	5.77
Sigma SE	2.80	0.18
Sigma CI	3.73-4.83	5.09-6.54

Table 7: Core and Buffer area use by Tigers During Phase IV monitoring 2021

Details	2021
Tigers (Exclusively Core)	2
Tigers (Exclusively Buffer)	2
Tigers (Core and Buffer)	5

Table 8: Estimates of Tigers using Spatially Explicit Capture-Recapture Models Bor Tiger Reserve, Maharashtra for the year 2020-2021

Year	Area Coverage	Species	No of individuals captured	Estimate	Density per 100 km2
2020	Core Only	Tiger	6	6.0(±0.72)	1.19 (±0.5)
2021	Core and Buffer	Tiger	9	9 (±1.01)	1.10(±0.37)

Table 9: Density estimates of Tigers using Spatially Explicit Capture-Recapture Models Bor Tiger Reserve, Maharashtra for the year 2020- 2021.

Parameters	2020	2021
Model	Heterogeneity	Heterogeneity
Detection function	Half Normal	Half Normal
Density Estimate	7.37	6.68
Density SE	1.60	0.80
Density CI	4.84-11.2	4.21-7.66
g0 Estimate	0.115	0.018
g0 SE	0.00249	0.005
g0 CI	0.00757-0.0176	0.01-0.03
Sigma Estimate	2.09	3.33
Sigma SE	2.43	0.2
Sigma CI	1.66-2.62	1.08-4.83

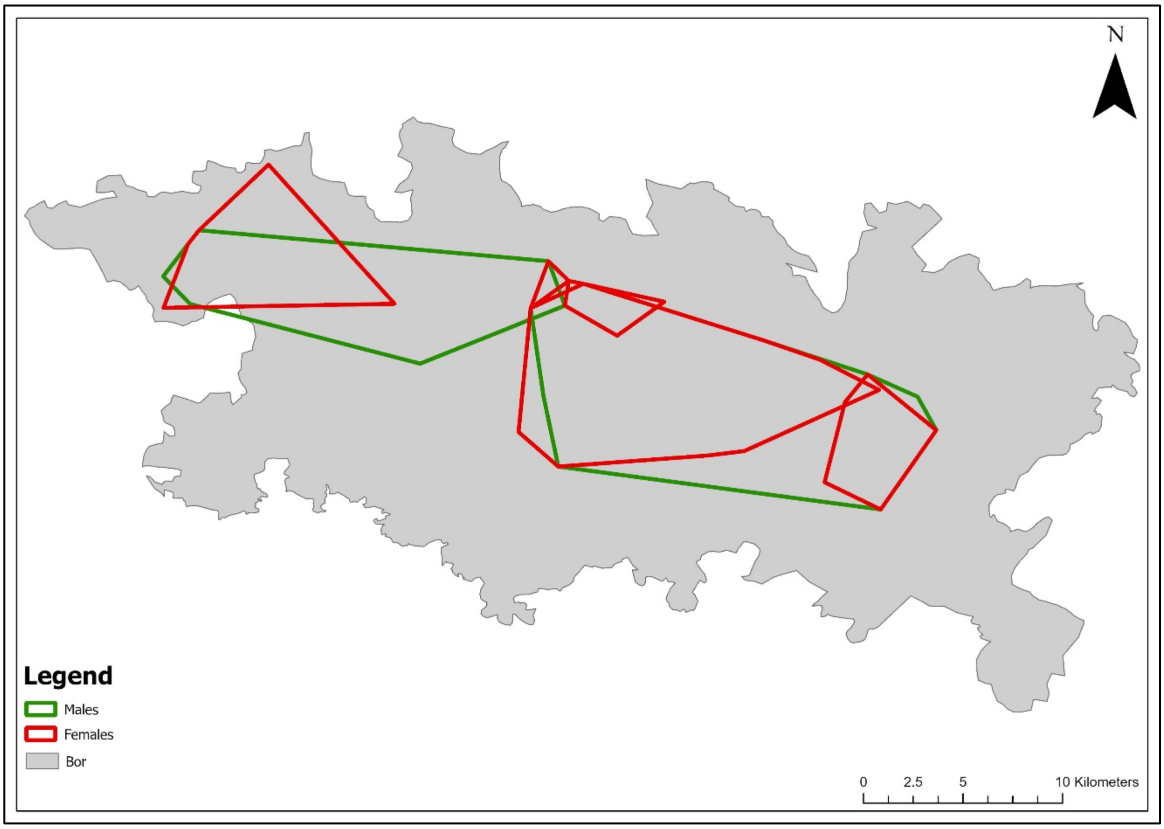


Figure 7(a): Minimum Convex Polygon of Tigers in Bor Tiger Reserve during Phase IV monitoring 2021

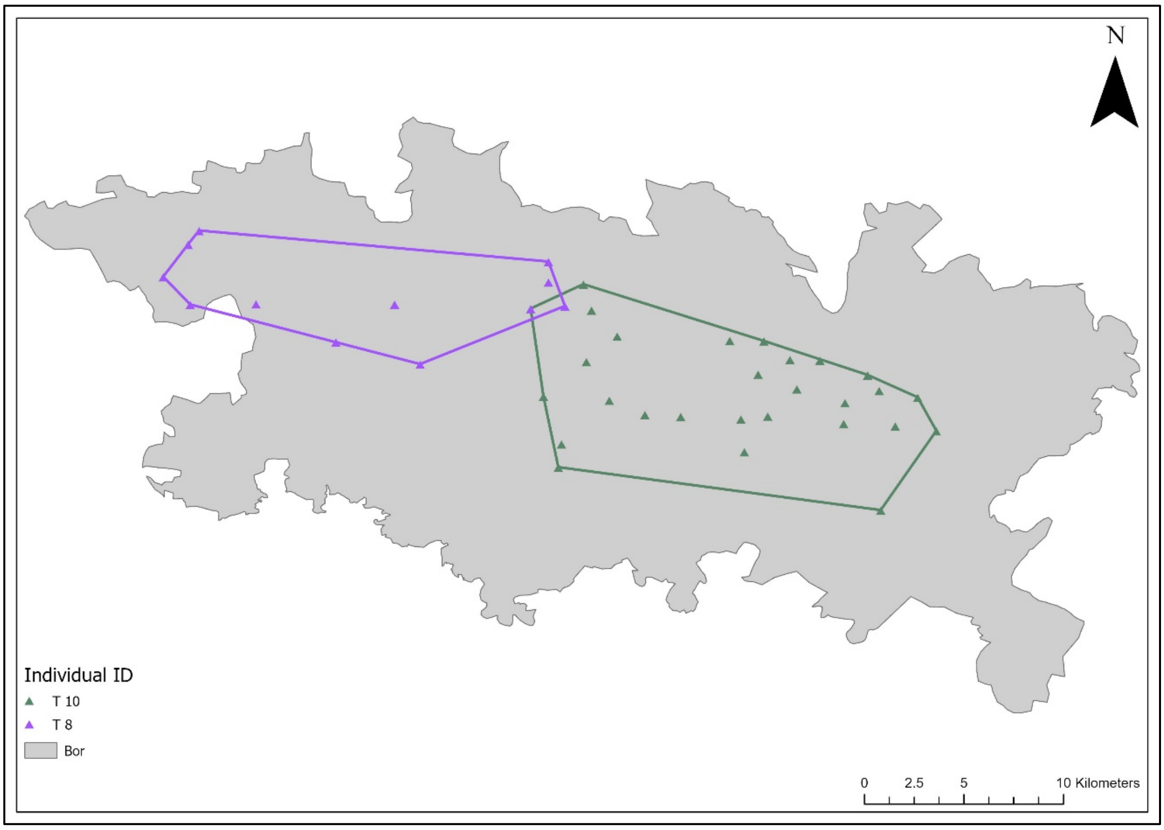


Figure 7(b): Minimum Convex Polygon of Tigers (Males) in Bor Tiger Reserve Phase IV monitoring 2021

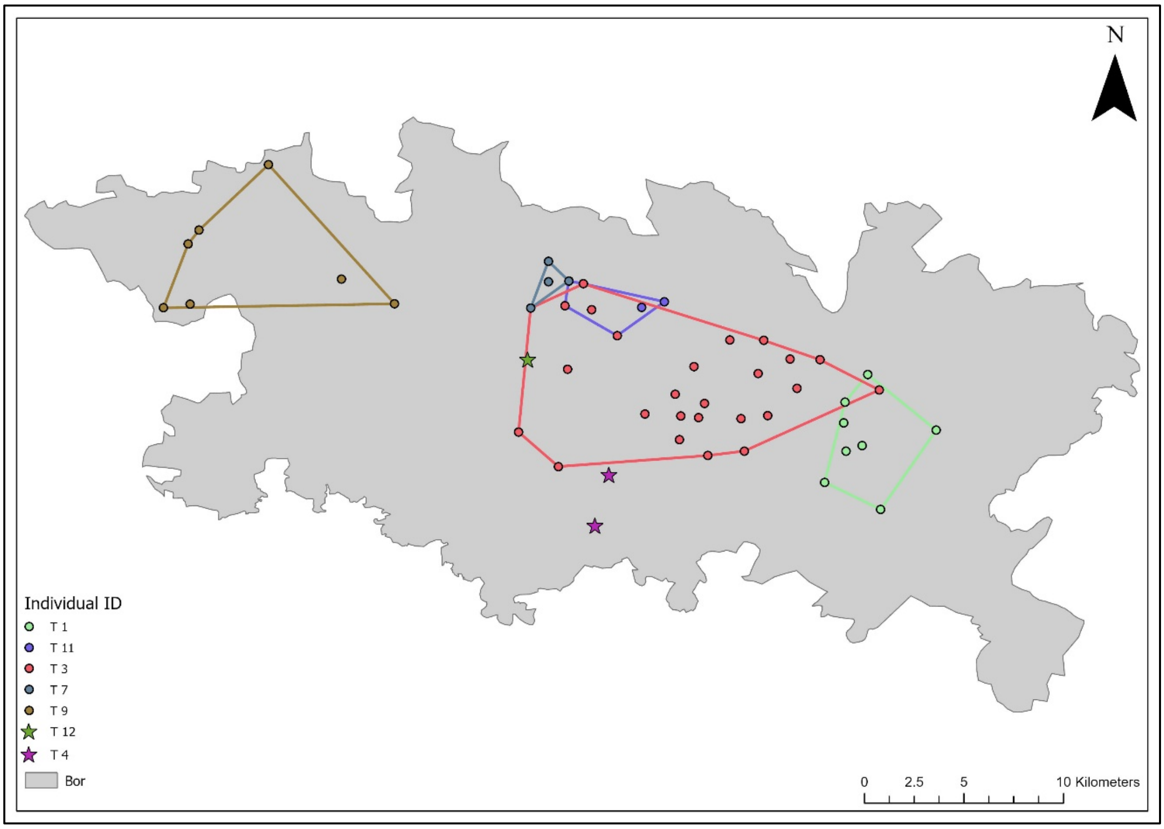


Figure 7(c): Minimum Convex Polygon of Tigers (Females) in Bor Tiger Reserve Phase IV monitoring 2021

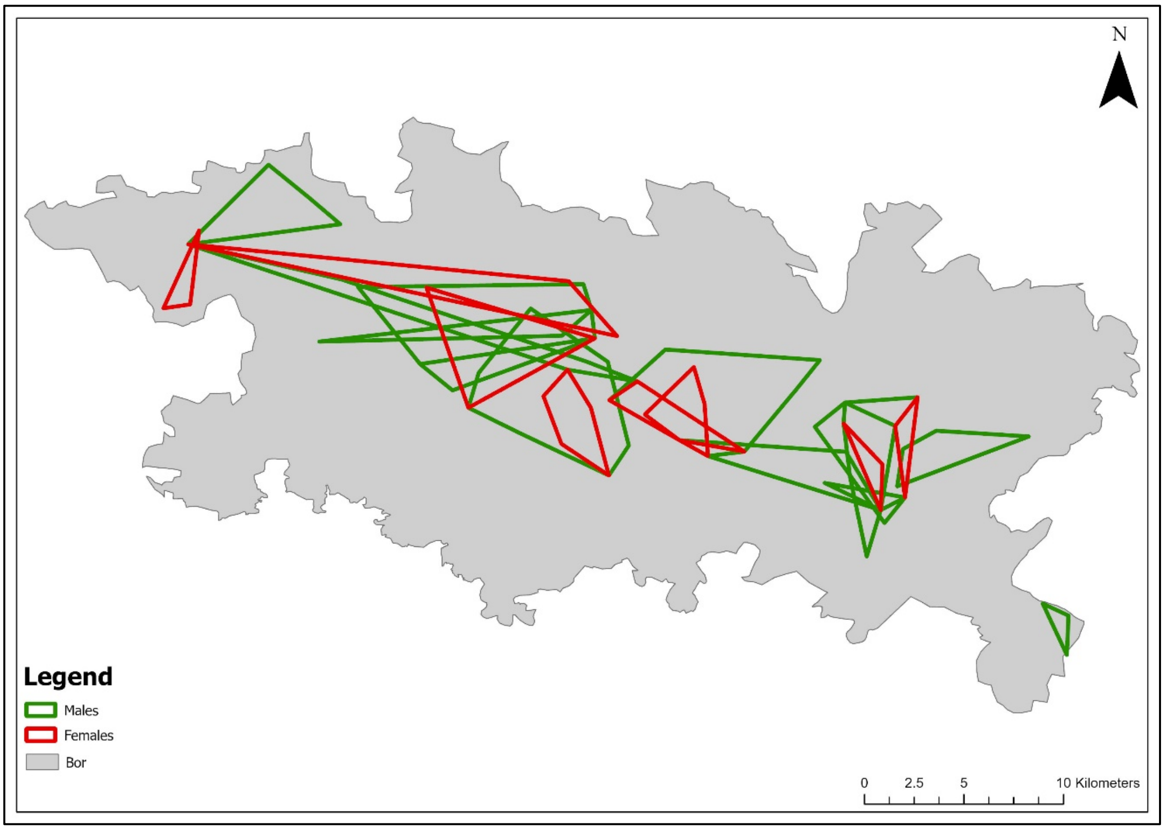


Figure 7(d): Minimum Convex Polygon of Leopards in Bor Tiger Reserve during Phase IV monitoring 2021

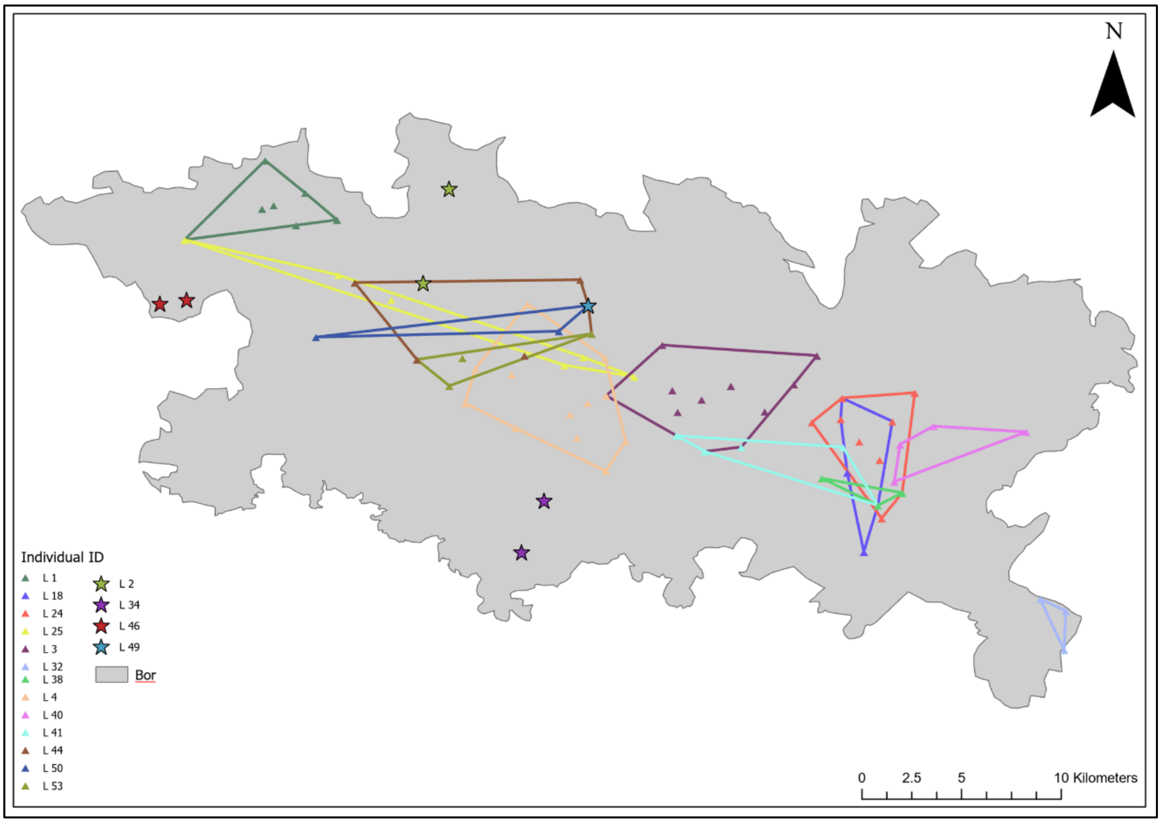


Figure 7(e): Minimum Convex Polygon of Leopards (Males) in Bor Tiger Reserve during Phase IV monitoring 2021

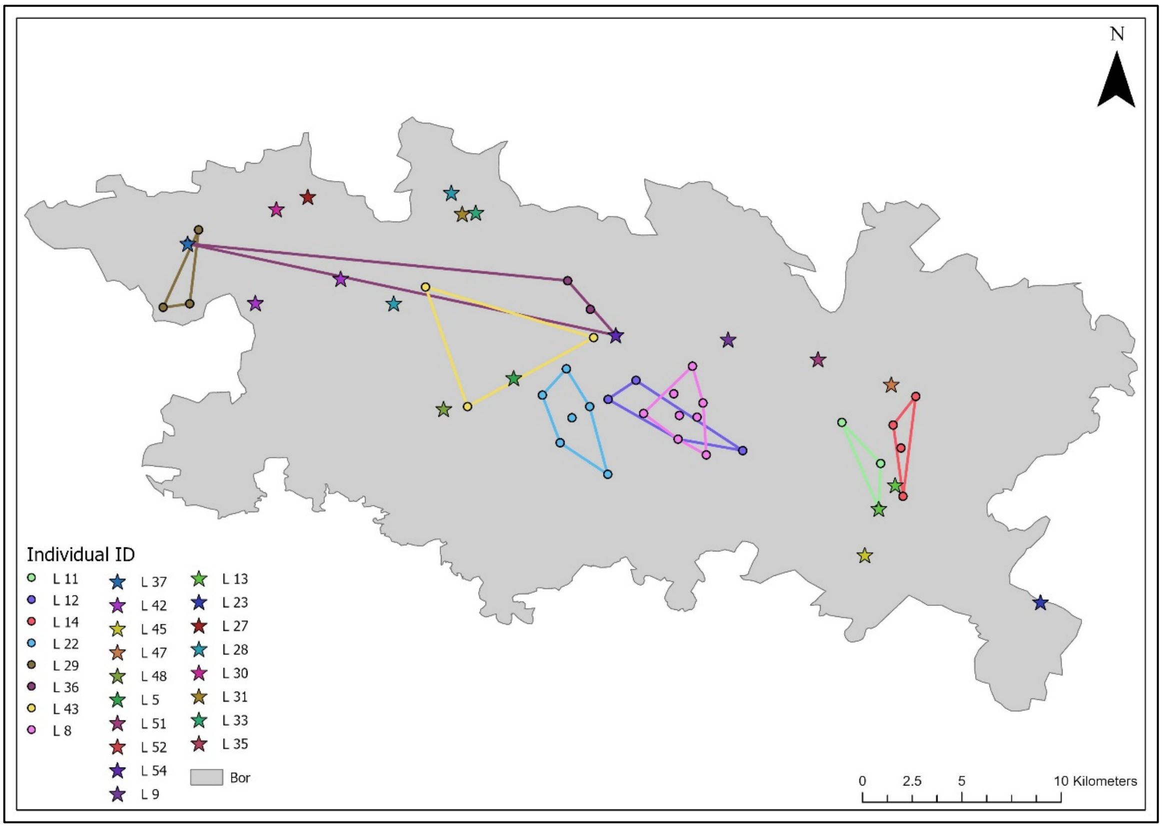


Figure 7(f): Minimum Convex Polygon of Leopards (Females) in Bor Tiger Reserve during Phase IV monitoring 2021

4. Temporal Activities of Predator and Prey Species in Bor Tiger Reserve

Introduction:

To know how prey species interact with each other over time and space, it is imperative to study their activity patterns as well as their overlap. Camera trap being an excellent tool provides capture timings that have been used to determine the peak activity period among sympatric predators and prey of the study area.

Methods and Results

The temporal pattern of the predators and their prey was analyzed using R Studio in R statistical software (version 3.6.2). The approach established by Linkie and Ridout (2009) was used to study temporal activity patterns and the package "overlap" which estimates the coefficient of temporal overlap non-parametrically using kernel density estimates was used. In the package 'overlap', data are regarded as a random sample from the underlying distribution that describes the probability of a photograph being taken within any particular interval of the day. The probability density function of this distribution is then referred to as the activity pattern, which assumes that the animal is equally likely to be photographed at all times when it is active (Ridout & Linkie 2009). It is a two-step process. In the first step, each activity pattern is estimated nonparametrically, using kernel density estimation. The kernel density estimates used a bandwidth parameter, which is selected following the procedure developed by Taylor (2008). For the second step, a measure of overlap between the two estimated distributions was calculated. Ridout and Linkie (2009) reviewed several alternative measures of overlap between two probability distributions, favouring the coefficient of overlapping, Δ (Weitzman 1970), which ranges from 0 (no overlap, e.g. one species entirely diurnal, the other entirely nocturnal) to 1 (complete overlap). This is defined as the area under the curve that is formed by taking the minimum of the two density functions at each time point. A useful interpretation of the coefficient of overlapping is that for any time period during the day the proportion of activity that occurs during that period differs between the two distributions by <1–Δ. 1000 bootstrap samples are used to derive the confidence intervals.

These estimators use kernel density estimates fitted to the data to approximate the true density functions f(t) and g(t). Schmid & Schmidt (2006) propose five estimators of overlap:

$$\hat{\Delta}_1 = \frac{2\pi}{T} \sum_{i=1}^{T} \min\{\hat{f}(t_i) - \hat{g}(t_i)\}$$

Dhat1 is calculated from vectors of densities estimated at T equally spaced times, t, between 0 and 2π:

For circular distributions, Dhat2 is equivalent to Dhat1, and Dhat3 is inapplicable. Dhat4 and Dhat5 use vectors of densities estimated at the times of the observations of the species, x, and y:

$$\hat{\Delta}_4 = \frac{1}{2}\left(\frac{1}{n}\sum_{i=1}^{n} \min\left\{1, \frac{\hat{g}(x_i)}{\hat{f}(x_i)}\right\} + \frac{1}{m}\sum_{j=1}^{m} \min\left\{1, \frac{\hat{f}(x_j)}{\hat{g}(x_j)}\right\}\right)$$

$$\hat{\Delta}_5 = \frac{1}{n}\sum_{i=1}^{n} \mathrm{I}\{\hat{f}(t_i) < \hat{g}(t_i)\} + \frac{1}{m}\sum_{j=1}^{m} \mathrm{I}\{\hat{f}(y_j) \geq \hat{g}(y_j)\}$$

Where n, m are the sample sizes and I is the indicator function (1 if the condition is true, 0 otherwise).

The Kernel density estimates of daily temporal activity patterns of different predator and prey species are shown in Figures 8 - 11. From the kernel density estimators, the tiger and leopard were observed to have a high degree (0.81) of overlap as indicated by the estimated overlap coefficients in Table 10.

Table 10: Activity of Overlap among Prey and Predator Species in Bor Tiger Reserve

Species	Tiger	Leopard	Dhole
Sambar	0.84	0.91	0.63
Chital	0.54	0.64	0.85
Wild Pig	0.73	0.81	0.83
Hare	0.78	0.69	0.46
Chinkara	0.39	0.47	0.77
Chousingha	0.41	0.46	0.69
Nilgai	0.43	0.51	0.81
Langur	0.41	0.46	0.72
Tiger	-	0.88	0.57
Leopard	0.88	-	0.66
Dhole	0.57	0.66	-

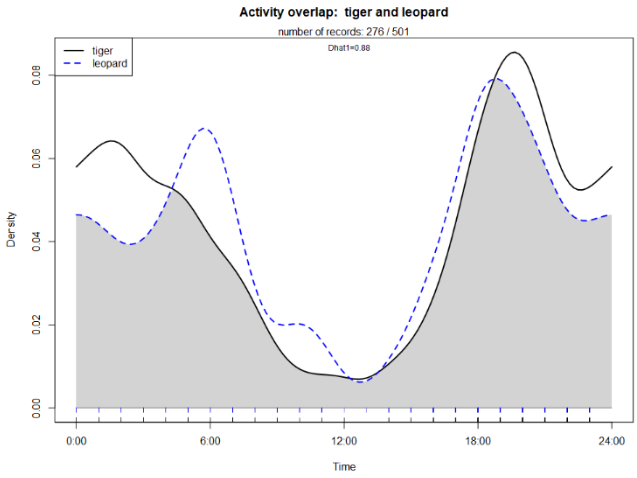


Figure 8(a): Tiger - Leopard

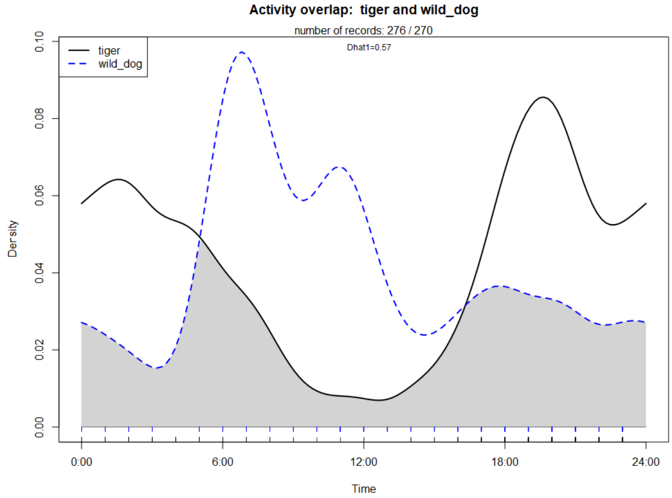


Figure 8(b): Tiger - Wild Dog

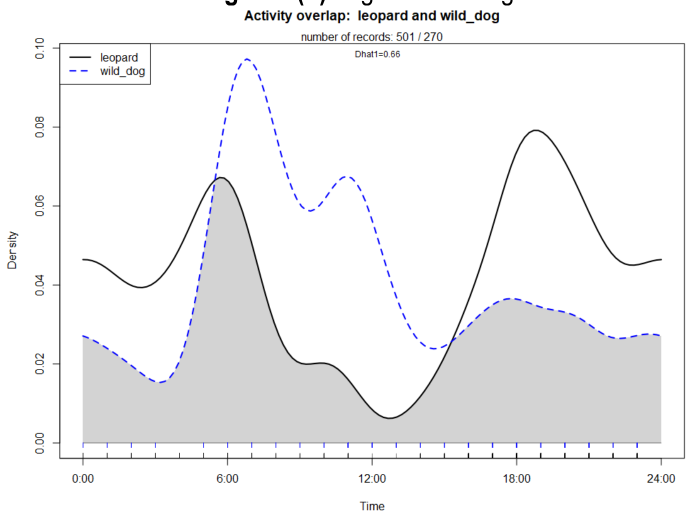


Figure 8(c): Leopard - Wild Dog

Figures 8 (a-c): Daily temporal activity pattern overlap between co-predators. a) tiger vs. leopard; b) tiger vs. dhole; c) leopard vs. dhole in Bor Tiger Reserve. The lines represent the kernel density estimates based on individual photograph times. The overlap is shown by the shaded area in each plot.

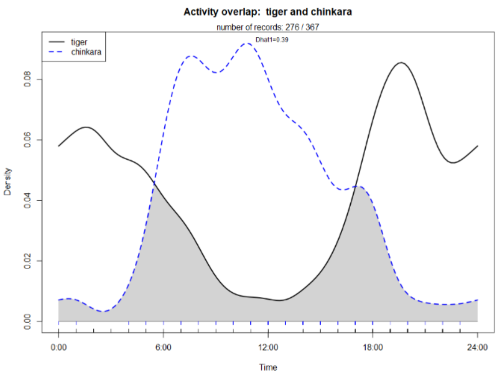


Figure 9(a): Tiger-Chinkara

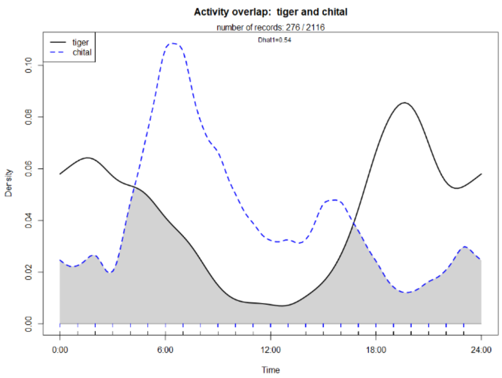


Figure 9(b): Tiger-Chital

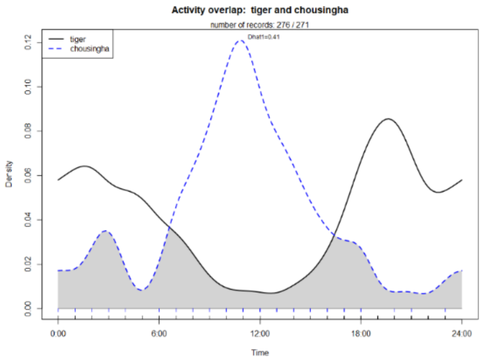


Figure 9(c): Tiger-Chousingha

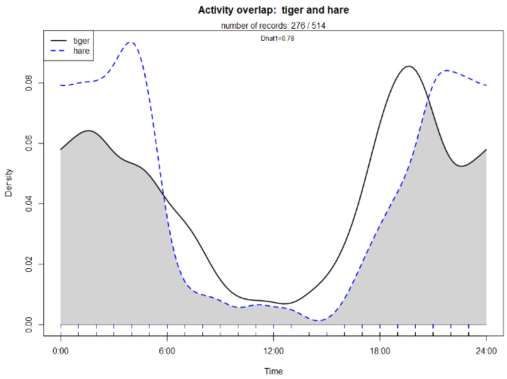


Figure 9(d): Tiger-Hare

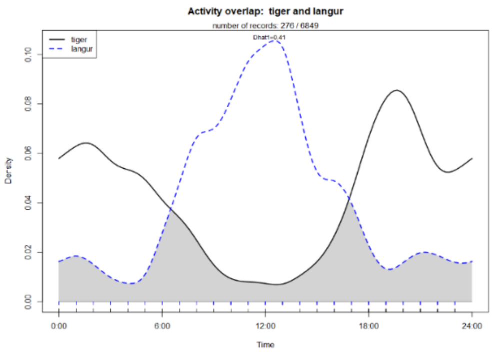


Figure 9(e): Tiger-Langur

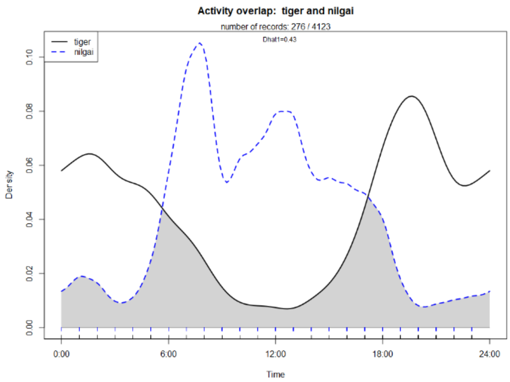


Figure 6(f): Tiger-Nilgai

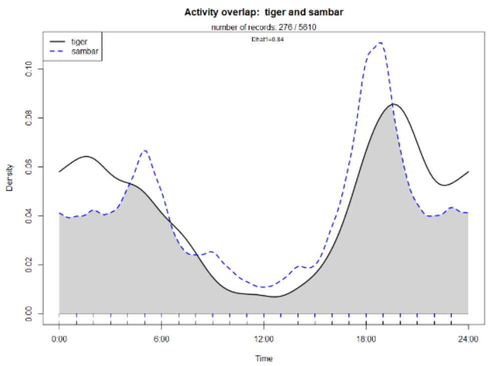


Figure 9(g): Tiger-Sambar

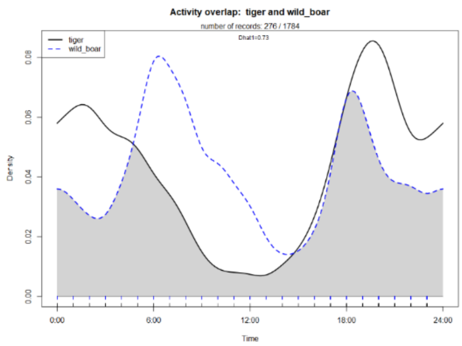


Figure 9(h): Tiger-Wild Pig

Figure 9 (a-h): Daily temporal activity pattern of Tiger vs. prey species in Bor Tiger Reserve. The lines represent the kernel density estimates based on individual photograph times. The overlap is shown by the shaded area in each plot

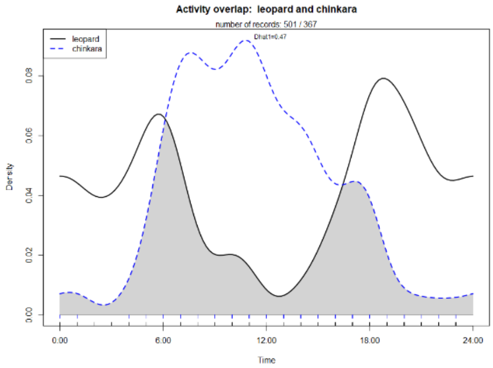


Figure 10(a): Leopard-Chinkara

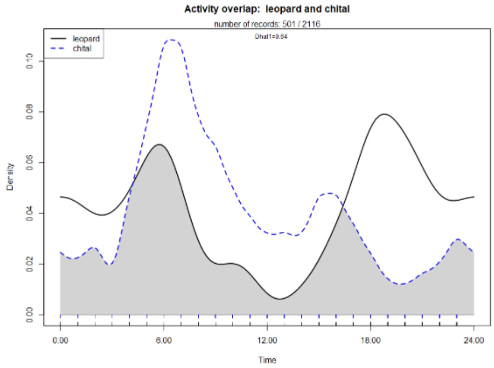


Figure 7b: Leopard-Chital

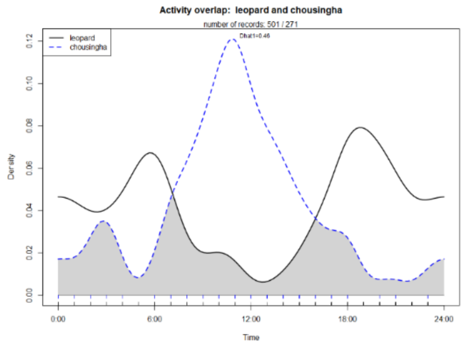


Figure 10(c): Leopard-Chousingha

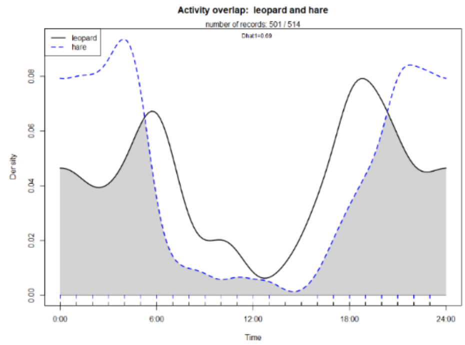


Figure 10(d): Leopard-Hare

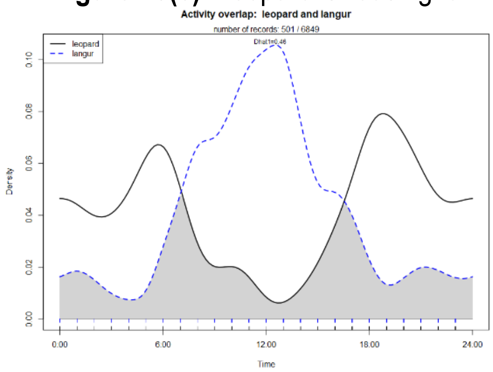


Figure 10(e): Leopard-Langur

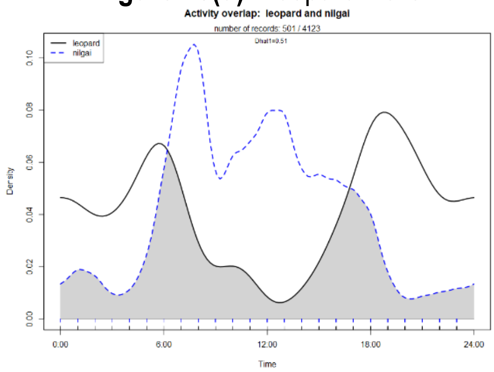


Figure 10(f): Leopard-Nilgai

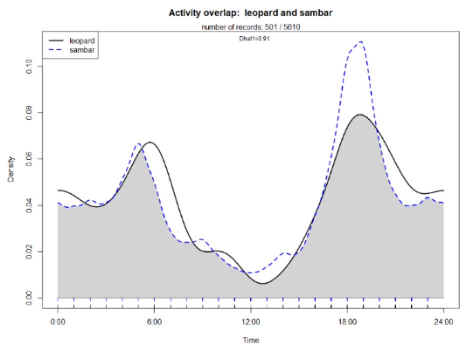


Figure 10(g): Leopard-Sambar

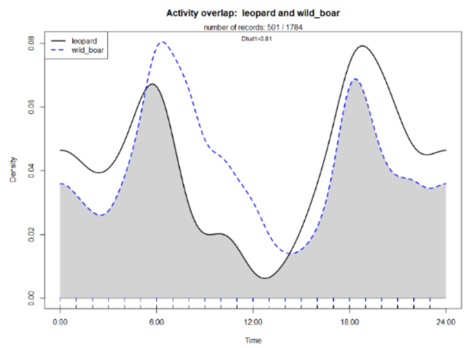


Figure 10(h): Leopard-Wild Pig

Figure 10 (a-h): Daily temporal activity patterns of the Leopard vs. prey species in Bor Tiger Reserve. The lines represent the kernel density estimates based on individual photograph times. The overlap is shown by the shaded area in each plot

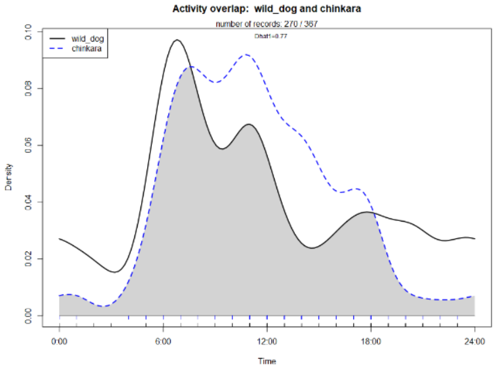


Figure 11(a): Wild Dog-Chinkara

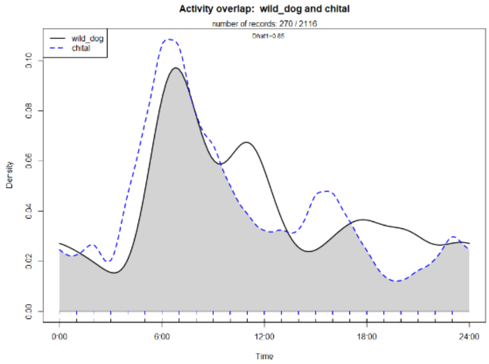


Figure 11(b): Wild Dog-Chital

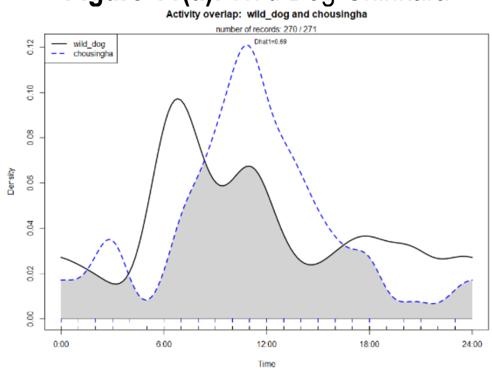


Figure 11(c): Wild Dog-Chousingha

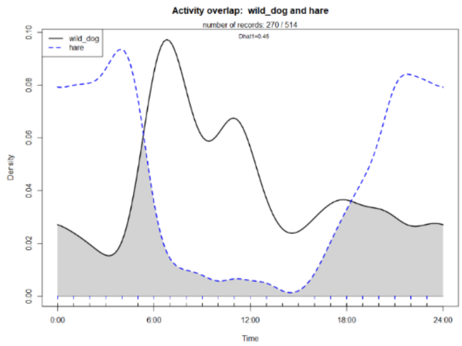


Figure 11(d): Wild Dog-hare

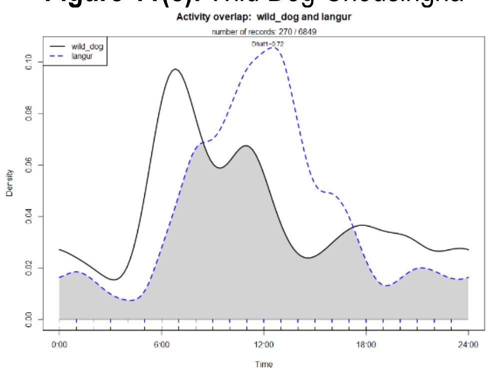


Figure 11(e): Wild Dog-Langur

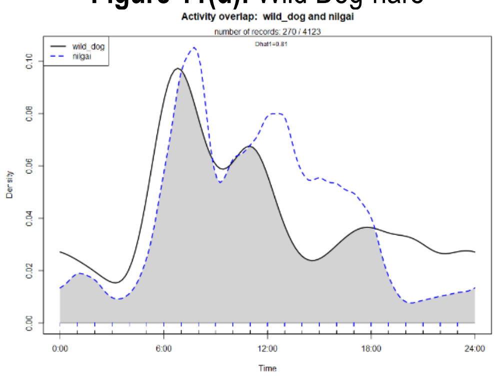


Figure 11(f): Wild Dog-Nilgai

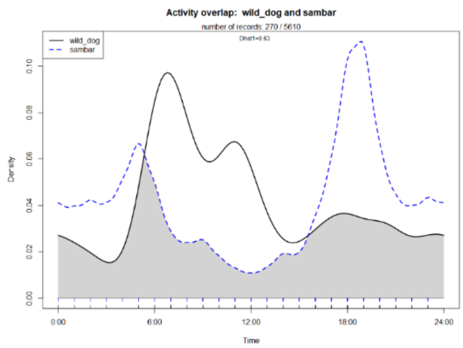


Figure 11(g): Wild Dog-Sambar

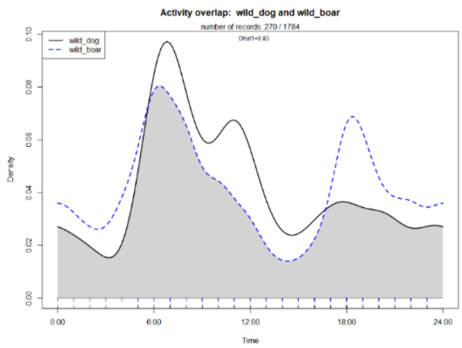


Figure 11(g): Wild Dog- Wild boar

Figure 11 (a-g): Overlap Wild Dog and Prey: Daily temporal activity pattern of the Dhole vs. prey species in Bor Tiger Reserve. The lines represent the kernel density estimates based on individual photograph times. The overlap is shown by the shaded area in each plot.

5. Modelling Spatially Explicit Intensive Use Areas: Predator & Prey Species

Introduction

Camera trap locations with the number of captures of each species were modeled in a GIS domain using IDW (Inverse distance weighted) interpolation technique to generate spatially explicit capture surfaces. Inverse Distance Weighting (IDW) interpolation is mathematical (deterministic) assuming closer values are more related than further values with its function. IDW function is used when a set of points is dense enough to capture the extent of local surface variation required for the analysis. IDW assumes that each measured point has a local influence that diminishes with distance. It gives greater weights to points closest to the prediction location, and the weights diminish as a function of distance, hence the name inverse distance weighted. IDW is an exact interpolator, where the maximum and minimum values (see Figure 12 below) in the interpolated surface can only occur at sample points. The output surface is sensitive to clustering and the presence of outliers. IDW assumes that the phenomenon being modelled is driven by local variation, which can be captured (modeled) by defining an adequate search neighbourhood.

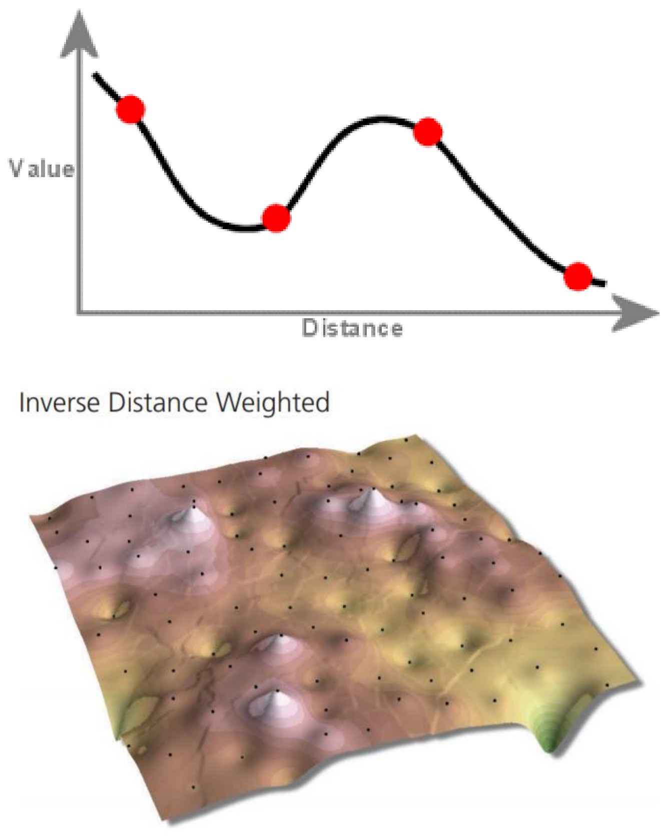


Figure 12: An example of IDW surface from points.

Using IDW technique spatially explicit intensive use area maps (Based on camera trap location and number of photographs at each location) has been developed for predator and prey species, Figures 13 (a-s) show intensive use areas by different species in Bor Tiger Reserve.

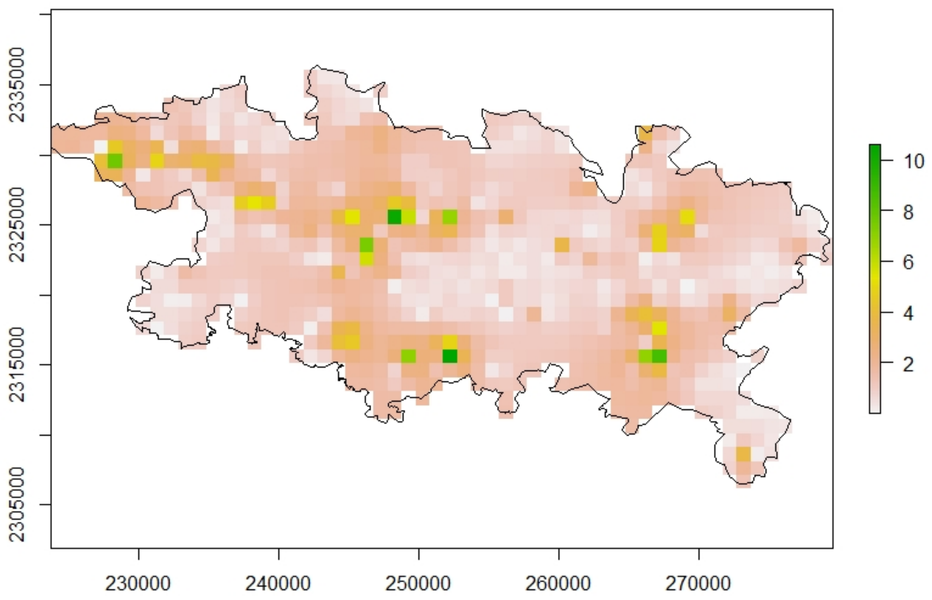


Figure 13(a): Intensive Area use by Tiger

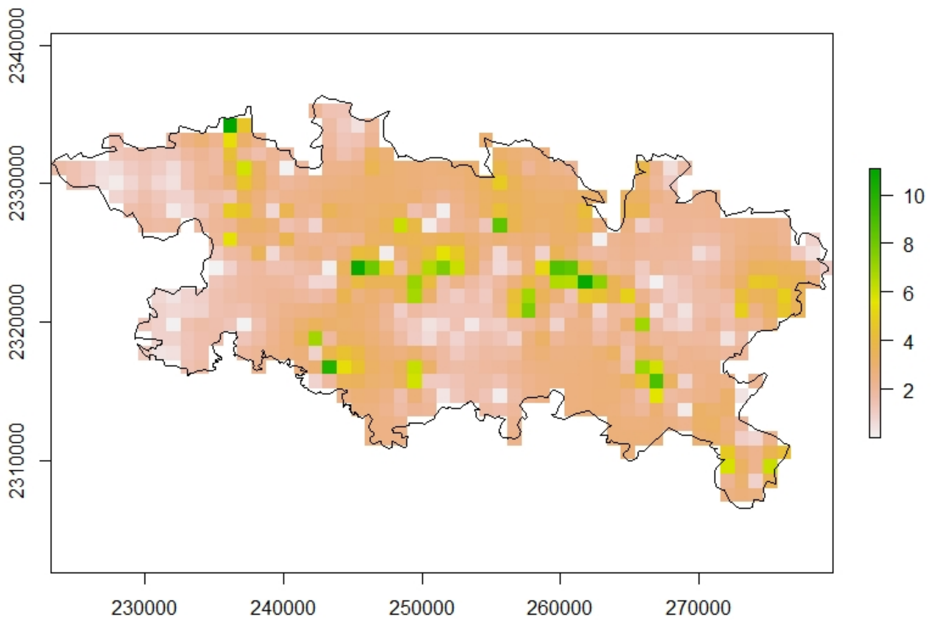


Figure 13(b): Intensive Area use by Leopard

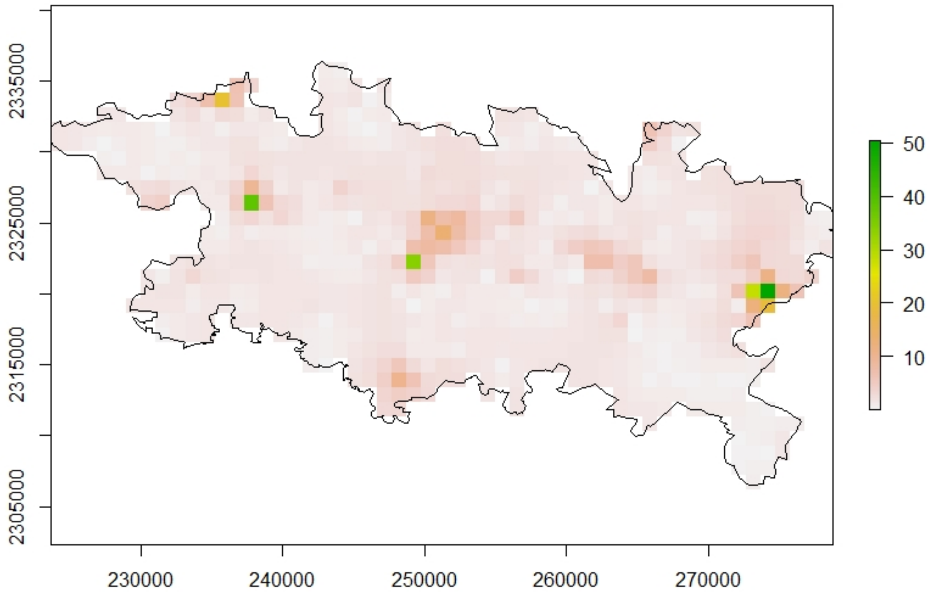


Figure 13(c): Intensive Area use by Wild Dog

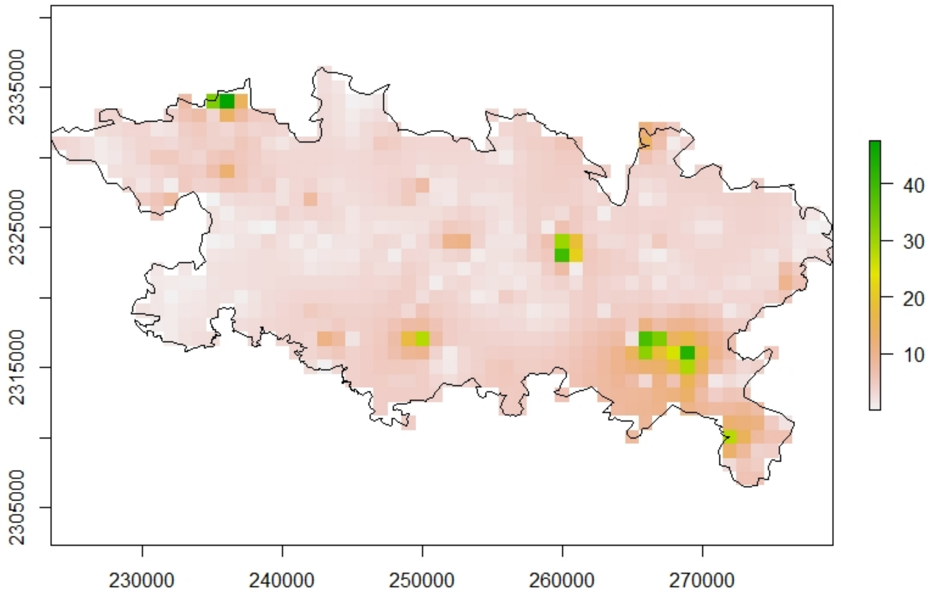


Figure 13(d): Intensive Area use by Sloth Bear

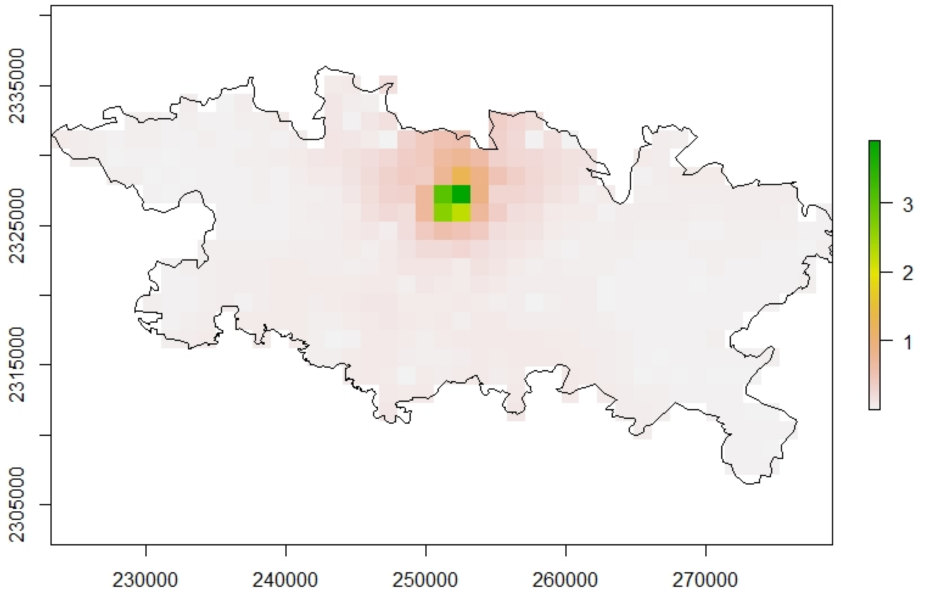


Figure 13(e): Intensive Area use by Black Buck

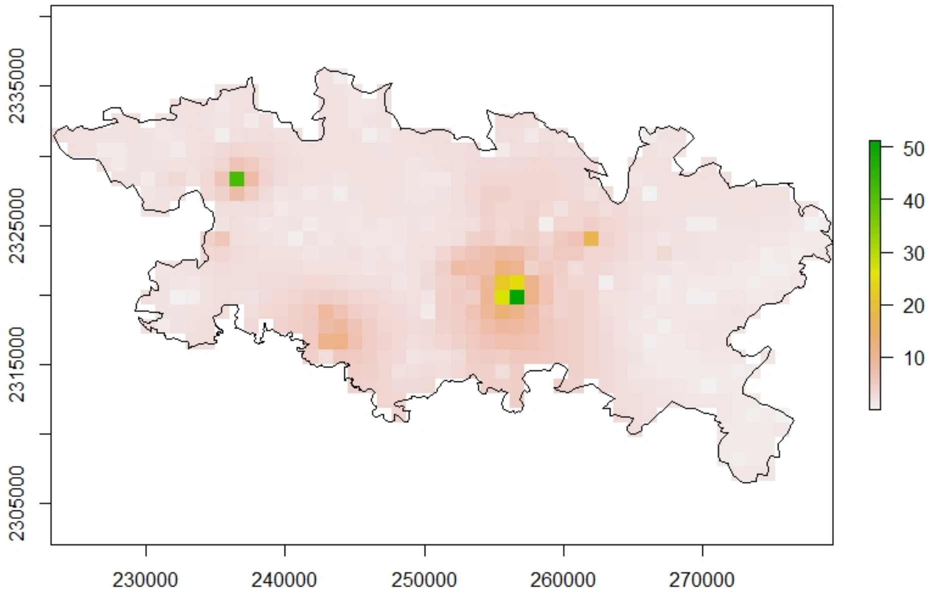


Figure 13(f): Intensive Area use by Chinkara

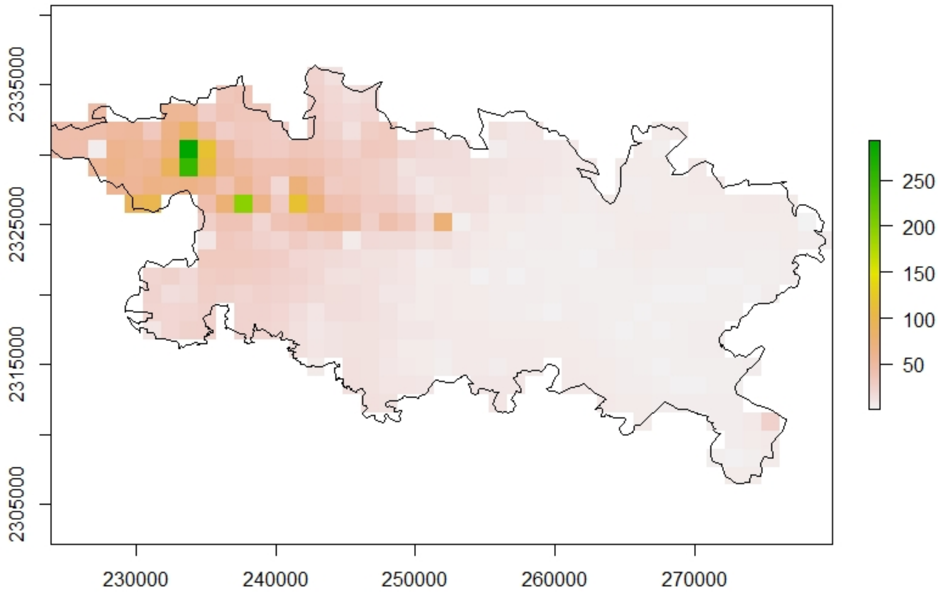


Figure 13(g): Intensive Area use by Chital

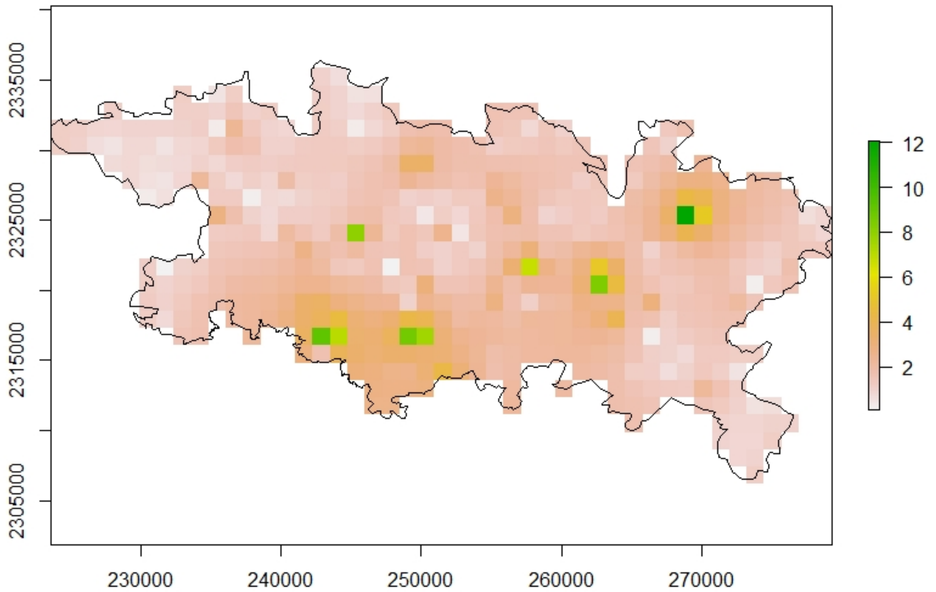


Figure 13(h): Intensive Area use by Chousingha

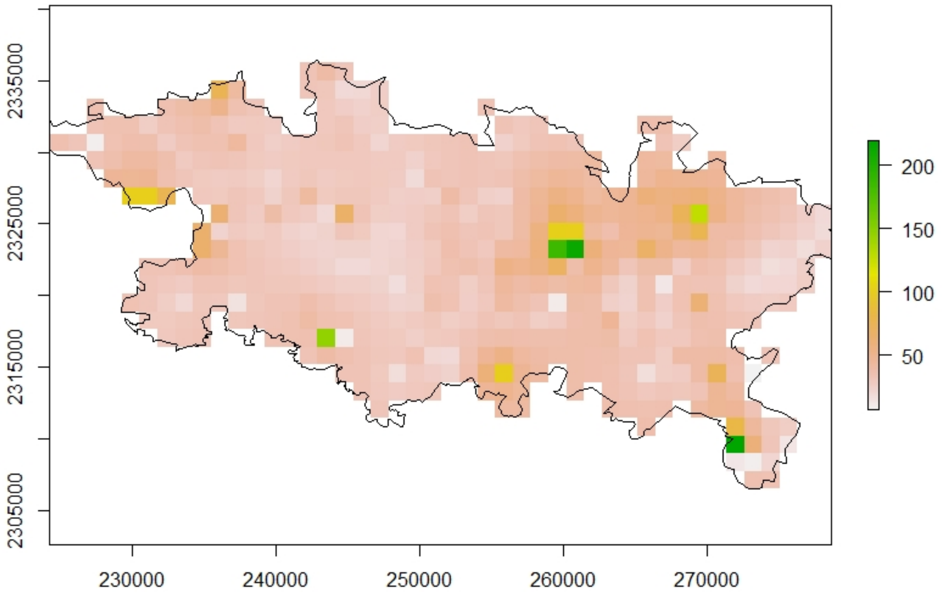


Figure 13(i): Intensive Area use by Nilgai

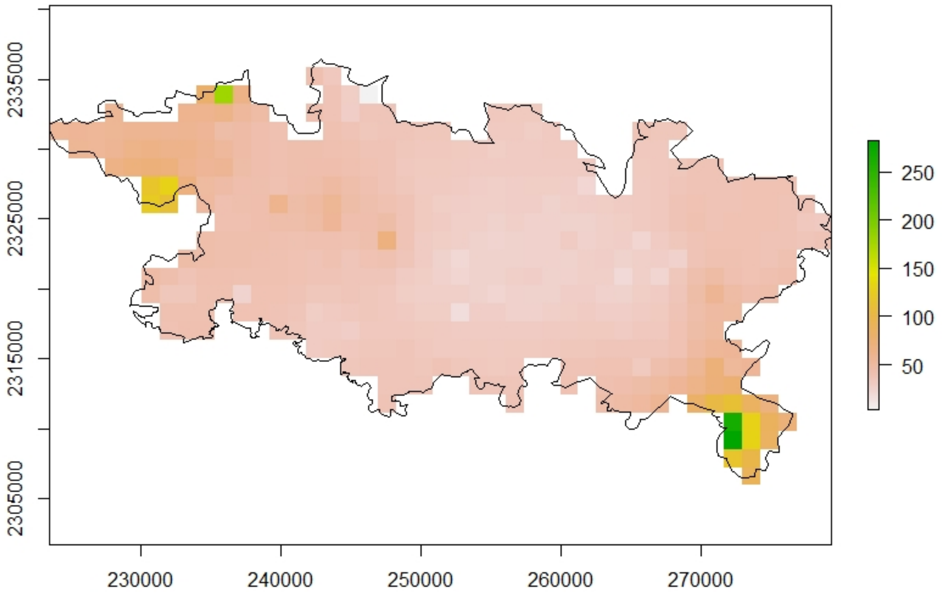


Figure 13(j): Intensive Area use by Sambar

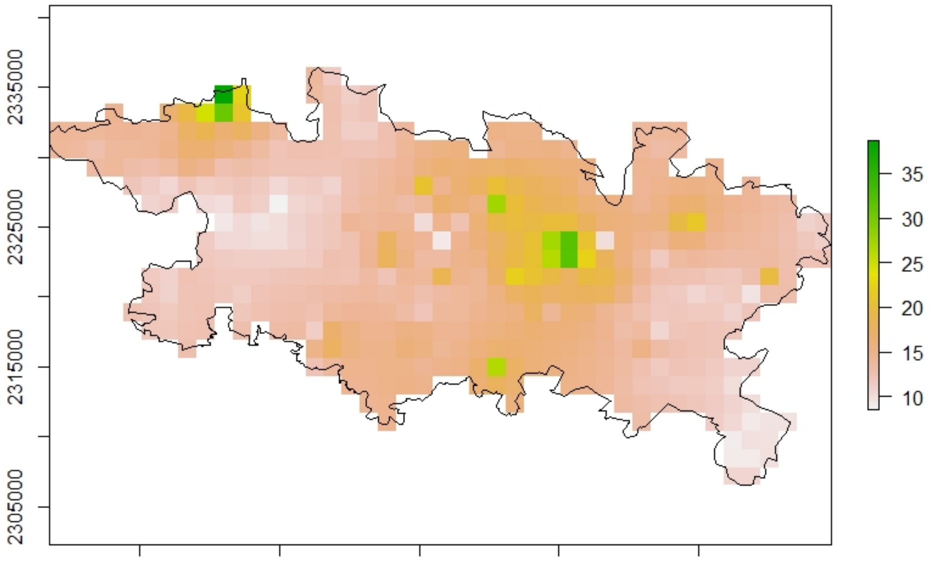


Figure 13(k): Intensive Area use by Wild Pig

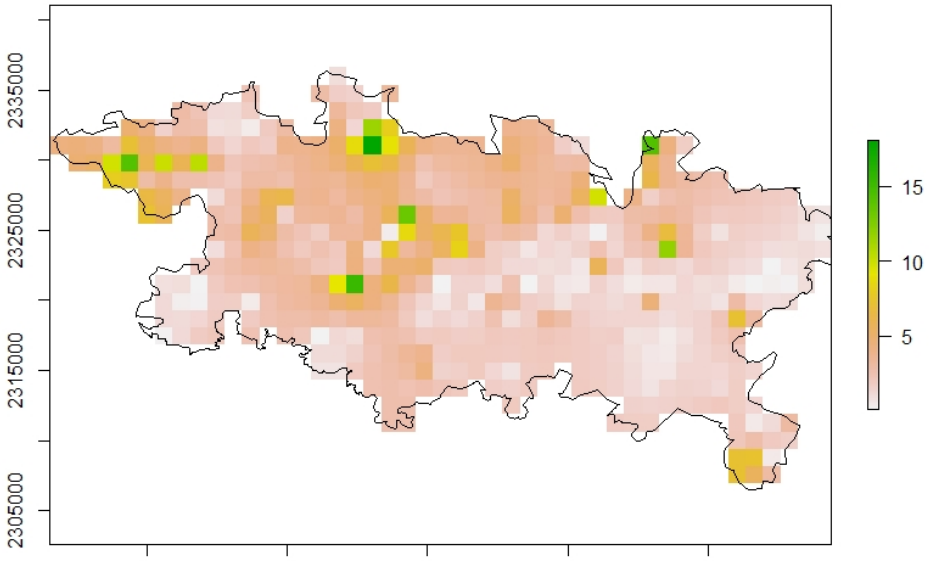


Figure 13(l): Intensive Area use by Jungle Cat

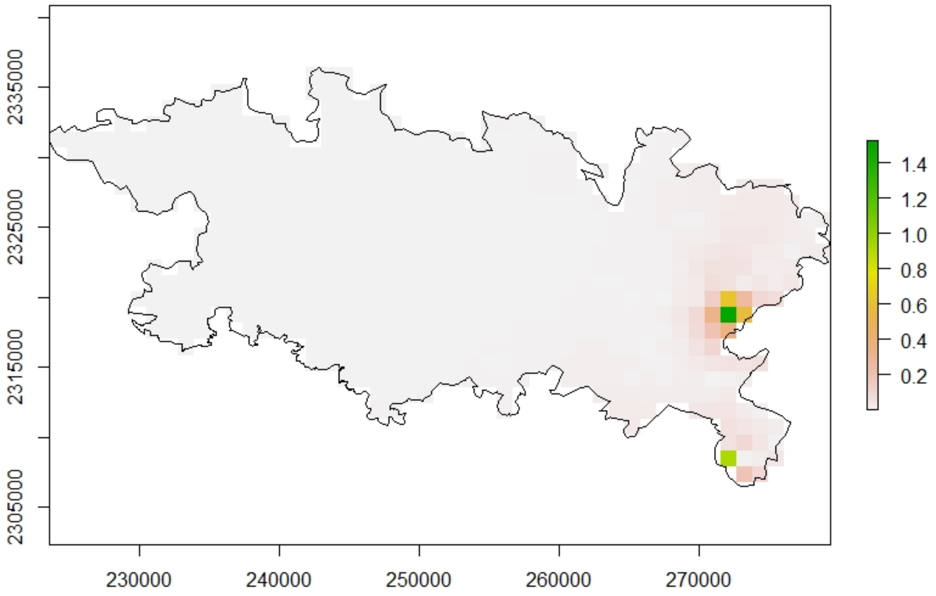


Figure 13-m: Intensive Area use by Rusty Spotted Cat

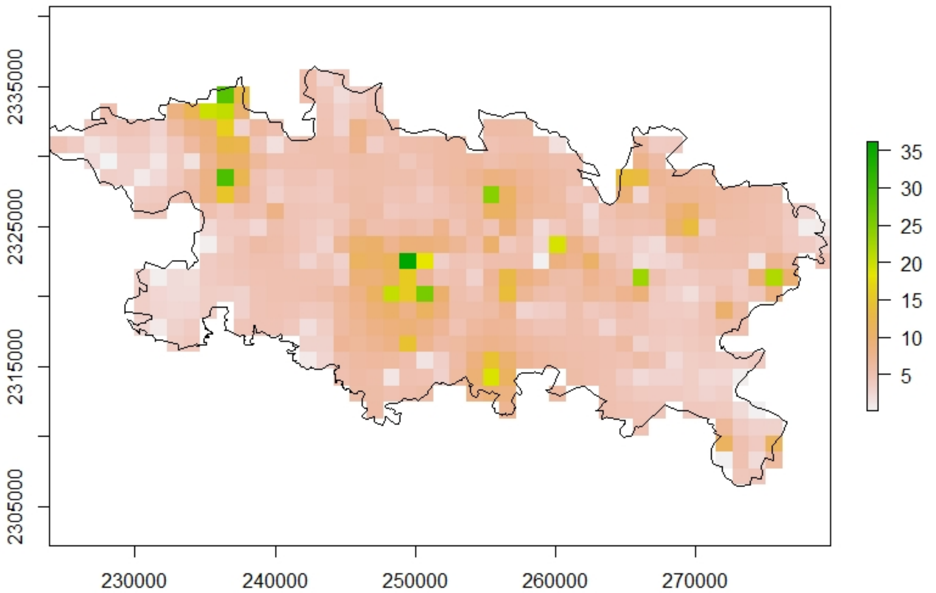


Figure 13(n): Intensive Area use by Porcupine

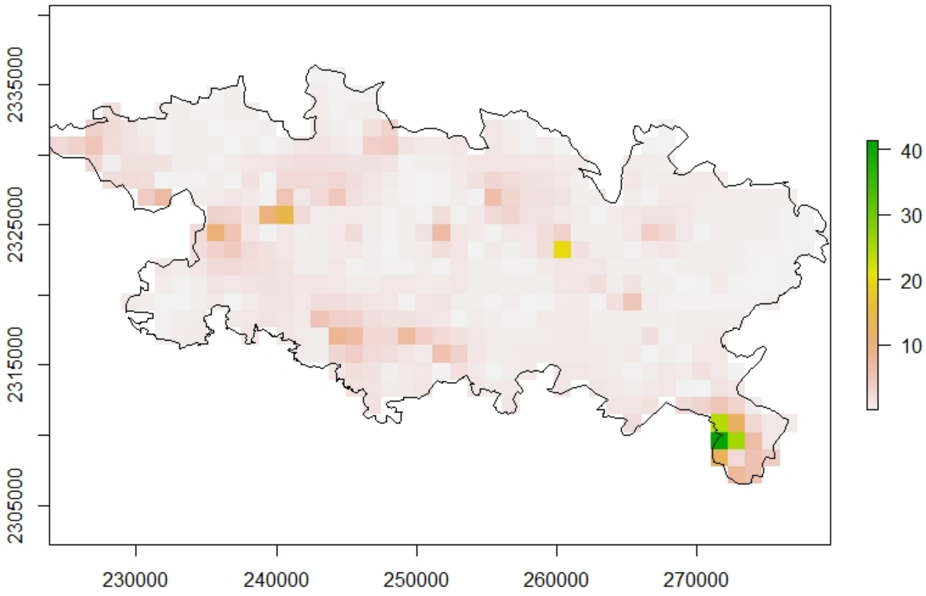


Figure 13(o): Intensive Area use by Palm Civet

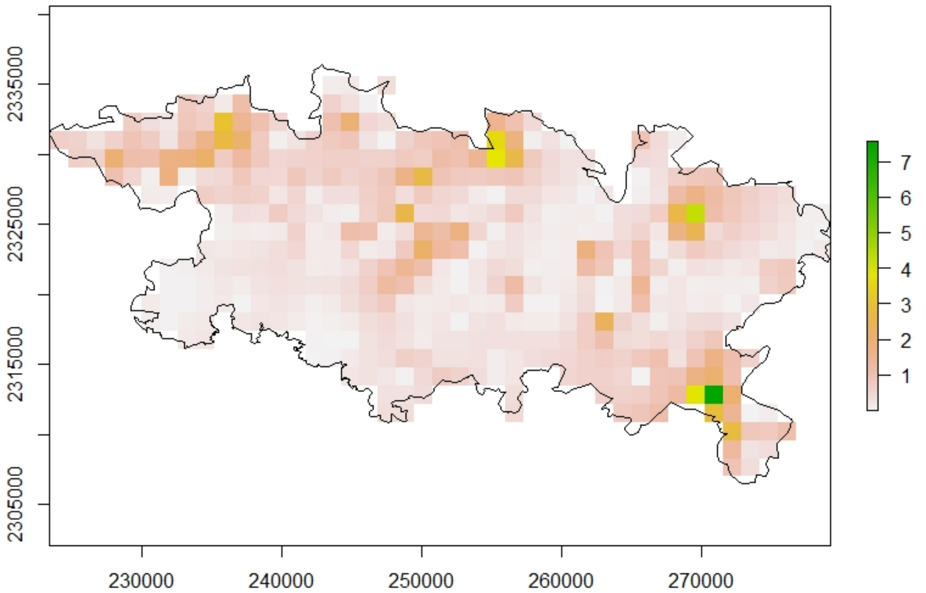


Figure 13-p: Intensive Area use by Small Indian Civet

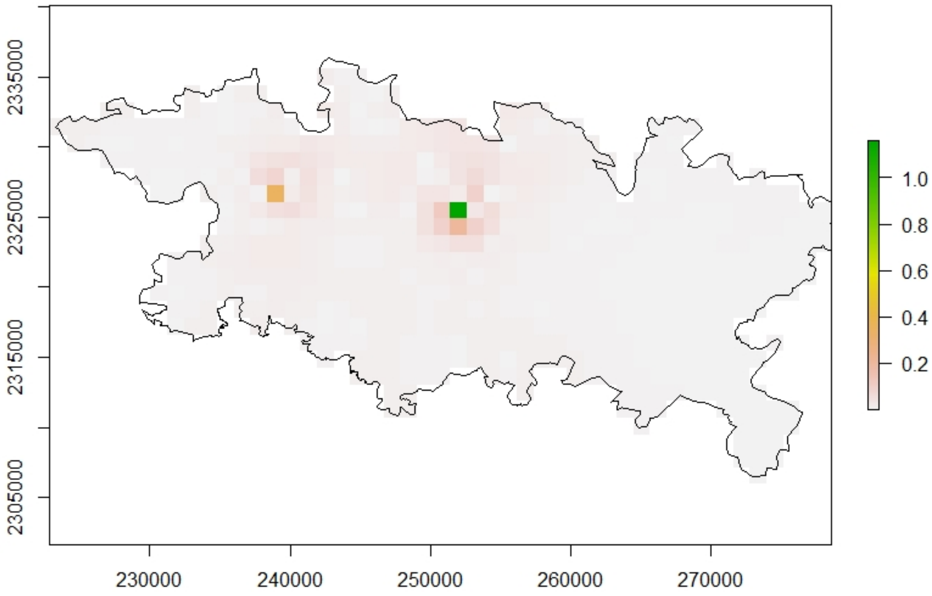


Figure 13(q): Intensive Area use by Ratel

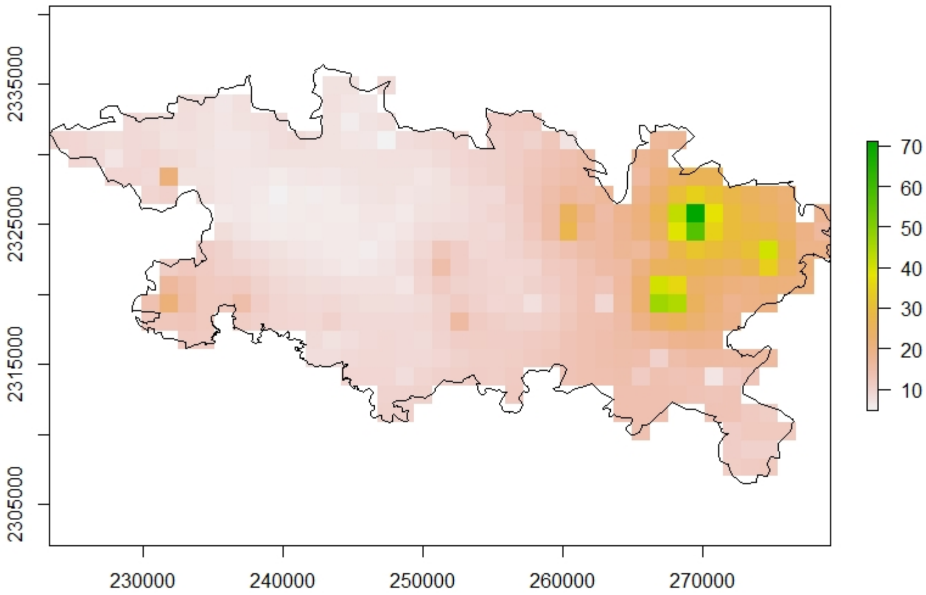


Figure 13(r): Intensive Area use by Livestock

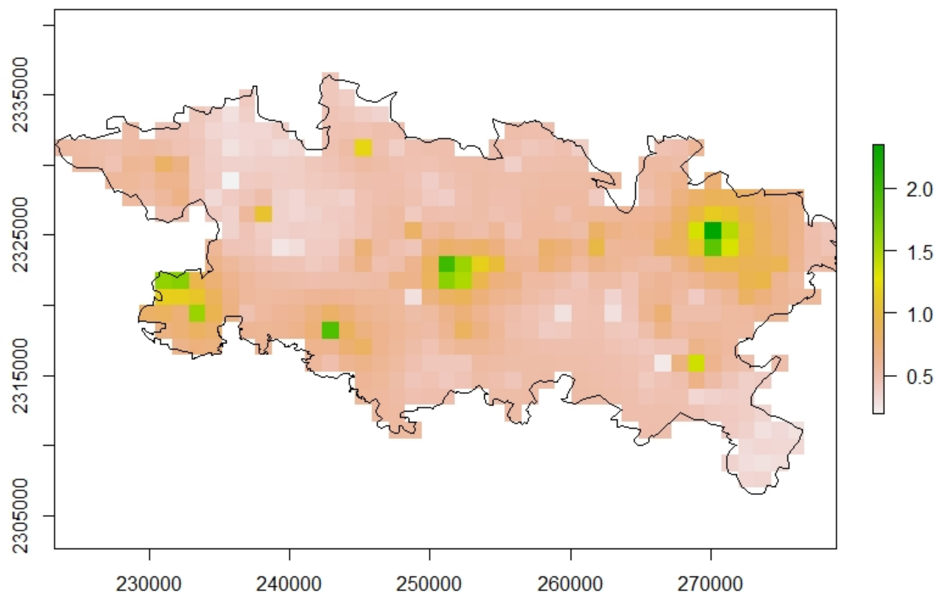


Figure 13-s: Intensive Area use by Stray Dog

Figures 13 (a – s): Intensive area use by various species from camera trap data at Pench Tiger Reserve, Maharashtra, during the Phase IV 2021 Monitoring.

5. Reference

Biswas, S. and Sankar, K., 2002. Prey abundance and food habit of tigers (Panthera tigris tigris) in Pench National Park, Madhya Pradesh, India. *Journal of Zoology*, *256*(3), pp.411-420.

Borchers, D., 2012. A non-technical overview of spatially explicit capture-recapture models. *Journal of Ornithology*, *152*(2), pp.435-444.

Buckland, S.T., Anderson, D.R., Burnham, K.P., Laake, J.L., Borchers, D.L. and Thomas, L., 2001. Introduction to distance sampling: estimating abundance of biological populations.

Burton, A.C., Neilson, E., Moreira, D., Ladle, A., Steenweg, R., Fisher, J.T., Bayne, E. and Boutin, S., 2015. Wildlife camera trapping: a review and recommendations for linking surveys to ecological processes. *Journal of Applied Ecology*, *52*(3), pp.675-685.

Efford, M., & Fewstaer, R. (2013). Estimating population size by spatially explicit capture-recapture. Oikos , 918-928.

Efford, M.G., 2015. Secr: Spatially explicit capture-recapture models. R package version 2.9. 4.

Habib, B., Nigam, P., Bhowmick, I., Govekar, R Gawai, R (2020): Status of Tigers, Co-Predator and Prey in Bor Tiger Reserve (PTR) 2020 – Pp 41. Maharashtra Forest Department and Wildlife Institute of India.

Jathanna, D., Karanth, K.U. and Johnsingh, A.J.T., 2003. Estimation of large herbivore densities in the tropical forests of southern India using distance sampling. *Journal of Zoology*, *261*(3), pp.285-290.

Jethva, B.D. and Jhala, Y.V., 2004. Foraging ecology, economics and conservation of Indian wolves in the Bhal region of Gujarat, Western India. *Biological Conservation*, *116*(3), pp.351-357.

Jhala, Y.V., 1993. Predation on blackbuck by wolves in Velavadar National Park, Gujarat, India. *Conservation Biology*, pp.874-881.

Karanth, K.U., and Nichols, J.D., 1998. Estimation of tiger densities in India using photographic captures and recaptures. *Ecology*, *79*(8), pp.2852-2862.

Leopold, B.D. and Krausman, P.R., 1986. Diets of 3 predators in Big Bend National Park, Texas. *The Journal of wildlife management*, pp.290-295.

Lima, S.L., 1988. Initiation and termination of daily feeding in dark-eyed juncos: influences of predation risk and energy reserves. *Oikos*, pp.3-11.

MacKenzie, D.I., Nichols, J.D., Lachman, G.B., Droege, S., Andrew Royle, J. and Langtimm, C.A., 2002. Estimating site occupancy rates when detection probabilities are less than one. *Ecology*, *83*(8), pp.2248-2255.

MacKenzie, D.I., Nichols, J.D., Royle, J.A., Pollock, K.H., Bailey, L.A. and Hines, J.E., 2006. Occupancy modeling and estimation.

Mukherjee, S., S. P. Goyal, and Ravi Chellam. "Standardisation of scat analysis techniques for leopard (Panthera pardus) in Gir National Park, Western India." *Mammalia* 58, no. 1 (1994): 139-144.

O'Brien, T.G., Kinnaird, M.F. and Wibisono, H.T., 2003. Crouching tigers, hidden prey: Sumatran tiger and prey populations in a tropical forest landscape. *Animal Conservation*, *6*(2), pp.131-139.

Otis, D.L., Burnham, K.P., White, G.C. and Anderson, D.R., 1978. Statistical inference from capture data on closed animal populations, volume 62. wildlife society.

Ridout, M.S., and Linkie, M., 2009. Estimating overlap of daily activity patterns from camera trap data. *Journal of Agricultural, Biological, and Environmental Statistics*, *14*(3), pp.322-337.

Schmid, F. and Schmidt, A., 2006. Nonparametric estimation of the coefficient of overlapping—theory and empirical application. *Computational statistics & data analysis*, *50*(6), pp.1583-1596.

Suselbeek, L., Emsens, W.J., Hirsch, B.T., Kays, R., Rowcliffe, J.M., Zamora-Gutierrez, V. and Jansen, P.A., 2014. Food acquisition and predator avoidance in a Neotropical rodent. *Animal Behaviour*, *88*, pp.41-48.

Talbot, L.M., 1978. The role of predators in ecosystem management. In *The Breakdown and Restoration of Ecosystems* (pp. 307-321). Springer, Boston, MA.

Taylor, C.C., 2008. Automatic bandwidth selection for circular density estimation. *Computational Statistics & Data Analysis*, *52*(7), pp.3493-3500.

Valeix, M., Fritz, H., Dubois, S., Kanengoni, K., Alleaume, S. and Said, S., 2007. Vegetation structure and ungulate abundance over a period of increasing elephant abundance in Hwange National Park, Zimbabwe. *Journal of Tropical Ecology*, pp.87-93.

Walters, C.J., 1986. *Adaptive management of renewable resources*. Macmillan Publishers Ltd.

Weitzman, M.S., 1970. *Measures of overlap of income distributions of white and Negro families in the United States* (Vol. 22). US Bureau of the Census.

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