STATUS OF TIGERS
COPREDATORS & PREY
IN INDIA, 2014

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मा वनं छिन्धि सव्याघ्रं मा
व्याघ्राः नीनशन् वनात्।
वनं हि रक्ष्यते व्याघ्रैः
व्याघ्रान् रक्षति काननम्।। (महाभारत)

Tigers are a conservation dependent species that represent the health of ecosystems they inhabit. *Mahabharat*

This is the third round of the country level assessment of Tigers, Co-predators and Prey, using the refined methodology. As a country having the maximum number of tigers and their source area, India also has the unique distinction of embarking on this refined methodology across all forested habitats and tiger States within the country. The state of the art technology has been put to use, involving remotely sensed data, geographical information system and camera traps, besides extensive ground survey. The latest computer application have been used for obtaining the results.

This science based monitoring and assessment would further strengthen our efforts to conserve our national animal.

I compliment the tiger States, National Tiger Conservation Authority, Wildlife Institute of India and collaborators outside the goverment system for this commendable effort.

Prakash Javadekar
Minister of State (Independent Charge)
Environment, Forests & Climate Change
Government of India

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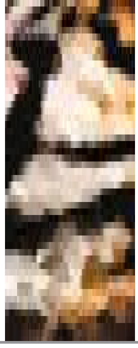


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Executive Summary

The tiger is an icon for conservation across forested systems of Asia. The Government of India has used the charismatic nature of the tiger to promote conservation of biodiversity, ecosystem functions, goods and services by launching Project Tiger in 1972 and subsequently using legislation to gazette tiger reserves and by allocating appropriate resources for their conservation. Since 2006 the status of tigers in India is being assessed every four years across all potential habitats in 18 Indian states within the distribution range of the tiger. This document reports the results of the third country wide assessment conducted in 2013-14.

The **methodology** used consists of:

a) Extensive and intensive surveys at high spatial resolution to determine i) occupancy and distribution of tigers and other predators, ii) distribution and relative abundance of prey species, iii) habitat condition and human impacts;

b) Remotely sensed information on i) landscape characteristics and habitat condition and ii) human footprint;

c) Abundance estimation of tigers and leopards through capture-mark-recapture using camera traps and of prey species through distance sampling on line transects. In extremely low tiger density areas or where camera trapping was not logistically feasible (due to militancy or other reasons), we used fecal DNA to determine tiger presence and minimum numbers.

Surveys (a) for occupancy and relative abundance estimation covered about 4,73,580 km^2 of wildlife habitat with an effort of 6,72,560 km walk on 87,679 spatial replicates for occupancy surveys and 90,750 transects. Habitat condition and human impacts were estimated from 1,63,292 plots sampled on line transects. We deployed remote cameras across 51 sites at 9,777 locations (c) to obtained 30,922 usable photo-captures of tigers and 17,143 photo-captures of leopards. Computer aided comparisons of stripe patterns and rosettes estimated 1686 individual tigers and 1647 individual leopards from these photographs. We used likelihood based spatially explicit capture-recapture (SECR) in a joint distribution framework with covariates of prey abundance, habitat characteristics, and human footprint in package secr (program R), to estimate tiger and leopard abundance within each landscape.

Tigers were **recorded to occupy** 89,164 km^2 in 2014 in India. Correction for imperfect detection of tigers resulted in a marginal increase in occupancy of 2.4 to 6% over the naïve estimate. Occupancy surveys had high detection probabilities ranging between 0.28 to 0.48. Tiger occupancy was best explained by remote *undisturbed forests with good prey populations.* ***Tiger population (excluding < 1 year cubs) was estimated to be 2226 (SE range 1945 to 2491) in India (Table 2.1)****. Amongst tiger reserves Corbett had the largest tiger population estimated at 215 (range 169-261) tigers, four tiger reserves (including Bandipur, Nagarhole and Kaziranga) had over 100 tigers. Tiger Reserves accounted for over 70% of all the tigers in India (Table 2.2).*

Leopard population in India was estimated to be 7910 (SE range 6566 to 9181) (Table 2.3). *The state of Madhya Pradesh had the highest number of leopards at 1817 followed by Karnataka at 1129 leopards. The leopard population was estimated only within forested habitats in tiger occupied states, therefore, it should be considered as a minimum number since leopards, unlike tigers, are also found outside forests. This is the first attempt to estimate leopard abundance at landscape scales. Distribution range and spatial extent of all major mammalian species are provided in the report.*

Tiger occupancy and abundance has substantially increased in the ***Shivalik Hills and Gangetic Plains landscape,*** *primarily due to improved status of tigers in the state of Uttrakhand. Rajaji-Corbett tiger population is now contiguous with Dudhwa-Pilibhit population since the intervening forests of Haldwani and Terai Divisions along with new protected areas like Nandhor Wildlife Sanctuary have tiger occupancy and reasonable tiger density. The landscape would benefit from supplementation of tigers in Western Rajaji that will assist in the occupancy of Shivalik forests in Uttar Pradesh and Kalesar Wildlife Sanctuary in Haryana. Maintaining and enhancing trans-boundary corridor connectivity between India and Nepal is an essential element of tiger, elephant and rhino conservation in this landscape. This connectivity is threatened by the new India-Nepal border road and special care is needed to ensure that proper mitigation measures are in place.*

Tiger status has improved within the ***Central Indian landscape*** *with an increase in tiger occupancy and numbers. This increase is contributed primarily by the states of Maharashtra and Madhya Pradesh. Indravati Tiger Reserve in Chhattisgarh was assessed for the first time. Sampling was limited to accessible areas of Palamau Tiger Reserve in Jharkhand. Conservation efforts need to focus on tiger populations in Orissa (Simlipal-Satkosia tiger reserves), Palamau landscape and in Northern Andhra Pradesh (Kawal Tiger Reserve). Sanjay-Guru Gasidas-Palamau landscape holds promise for future expansion of tiger population provided planned conservation investment continues. Tiger populations in Central Indian landscape are highly fragmented and some are quite small in numbers, therefore, their survival is dependent on corridor connectivity. Corridors in this landscape are threatened by developmental activities like mining and infrastructure. Appropriate safeguards and mitigation measures need to be implemented for development projects in this region so as to ensure that corridor connectivity between tiger populations is not compromised. Madhya Pradesh has also taken initiative to provide resources for corridor restoration by implementing corridor specific management plans.*

Western Ghat Landscape *has maintained its tiger status across all the three states of Karnataka, Kerala and Tamil Nadu. The world's largest tiger population (Nagarhole-Bandipur-Mudumalai-Wayanad-Satyamangalam-BRT) has further increased to about 585 tigers covering 10,925 km^2. New Protected Areas declared by Karnataka on the boarder of Goa has assisted in tiger dispersal into Goa and their movement further north into Radhanagri and Sahayadri Tiger Reserve. This region needs more conservation focus as it* *holds great potential for tiger and biodiversity conservation. It would be timely to consider declaring inter-state tiger reserve between Karnataka, Goa and Maharashtra. There is loss in tiger occupancy in the intervening habitat between Kudremukh-Bhadra and Anshi-Dandeli, threatening to disrupt connectivity between these tiger populations. Populations south of the Palghat gap (Parambikulum-Anamalai, Periyar, and Kalakad Munduntherai) have improved; attention is needed to conserve forest connectivity between these three major populations.*

Only select areas were sampled in the ***North Eastern Hills and Brahmaputra Flood Plains landscape****, therefore, tiger occupancy and numbers from this region are minimal estimates. The tiger population in Kaziranga-Karbi Anglong-Paake-Nameri-Orang is the largest source in this landscape (about 163 tigers) and should be managed as a single metapopulation with strategies to address movement corridors between these populations. Dibang and Namdapha were assessed through Scat DNA and opportunistic camera traps and show good promise for tiger and biodiversity conservation but need more conservation investment. Manas-Buxa along with areas of Bhutan landscape have potential for sustaining higher number of tigers and are currently below their carrying capacity. Enhanced protection in this region will help build prey and subsequently tiger population in the long-term. However, the management focus for these Protected Areas should be for forest biodiversity and not become tiger centric, since tiger density in many of these close canopy forests would be inherently low.*

The entire ***Sundarban tiger reserve*** *and parts of the Twenty Four Parganas were camera trapped in 2013-14. Tiger population of about 76 (62 to 92 tigers) has remained stable since 2010 and is likely to be near its carrying capacity. Sundarban tiger population is contiguous with that of Bangladesh and transboundary management including anti-poaching strategy and management of ship traffic in specific water channels needs to be implemented for long-term conservation of this unique tiger.*

Genetic analysis *based on a panel of 11 micro-satellites of 158 tiger individuals from across India has shown that at the country scale the tiger population of the North-East is genetically different. The most unique genetic unit of tigers are from Odisha and these need high conservation priority as their population is on a declining trend. The western-arid zone tigers of Ranthambore-Sariska showed a different genetic composition from those of terai and central Indian tigers with some genetic contribution from both these regions. At the local scale the tiger populations south of the Palghat gap differed from the Northern Western Ghat population. The tigers from Sahyadri (northern Western Ghats) shared their genetic makeup with tigers from central India. This preliminary country scale genetic analysis shall assist in planning reintroduction and supplementation strategies for tigers in the future and to prioritize conservation investments to target unique gene pools.*

Reduction in tiger and prey poaching and incentivised-voluntary relocation of human settlements from core areas of tiger reserves have been the primary drivers for the improved tiger status in India. These schemes and activities need continuous resource allocation for ecosystem maintenance and restoration. The implementation of MSTrIPES, landscape scale tiger management plans inclusive of buffer and corridors, and use of green infrastructure for mitigating impacts of development especially on corridors, need to become the norm across India. Tigers are conservation dependent species, political will driven by public opinion to ensure proper resource allocation is essential for their continued survival.

Introduction & Methods 01

By virtue of being the top predator, the tiger functions as an umbrella species for the conservation of biodiversity in forest systems of Asia. The "Project Tiger", a pioneering conservation initiative of the Government of India, aims to harness this role of the tiger along with the tiger's charisma to garner resources and public support for conserving representative ecosystems. Securing natural systems along with their functions would ensure that their inherent values, goods and services are available for future generations of Indians.

Survival of tigers is dependent on conservation and management efforts. Major threats to tigers are poaching driven by an illegal international demand for tiger parts and products, depletion of tiger prey caused by illegal wild meat consumption, and habitat loss due to the ever increasing demand for forested lands. To gauge the success of conservation efforts as well as to guide management inputs, it is important to estimate where tigers are and how many are there. National Tiger Conservation Authority in collaboration with the State Forest Departments, Conservation NGO's and coordinated by the Wildlife Institute of India conducts a National assessment for the "Status of Tigers, Co-predators, Prey and their Habitat" every four years. The methodology used for this assessment was approved by the Tiger Task Force in 2005. The data and inferences generated by this system not only serve as a monitoring tool but also as an information base for decision making. Many protected areas in India are too small to sustain tigers in the long-term. This dilemma can be addressed by managing these "small" tiger populations as meta-populations, i.e. several small populations and a few large populations all connected with each other, can ameliorate much of the ill effects of small fragmented populations. Many tiger reserves and some Protected Areas serve as source populations of tigers while intervening forested areas act as habitat sinks and corridors. By permitting dispersing tigers to move between different tiger populations long-term persistence of individual populations is enhanced. Thus, the "tiger bearing forests" need to be fostered with protection as well as restorative inputs to ensure their source, sink, and corridor values for long-term demographic and genetic viability of tiger populations.

With the implementation of annual monitoring (Phase 4) of tiger reserves by camera traps as mandated by NTCA, the magnitude of data available for the second, statistically robust abundance estimation part, of the double sampling approach has increased substantially compared to earlier cycles of tiger status assessment. In the current assessment over 70% of the estimated tiger population was actually photo-captured providing a rigorous population estimate for the country. As we demonstrate in this report, continuous monitoring of tiger populations across the country has yielded information on successful conservation management practices. More importantly, the report also highlights places where immediate intervention is required to recover tiger populations by re-evaluating current management strategies.

The countrywide assessment of tiger status uses a double sampling approach to estimate the distribution and abundance of tigers in India. The first component of the double sampling consists of ground surveys (Phase 1) of all potential tiger occupied forests in 18 States (Table 1.1, Fig. 1.1) wherein the ground survey data is collected by the State Forest Department personnel:

State & Landscape Complex	Sampled Beat	Tiger occupied Beat	No. of Sampled Trails	Sampled Trails with Tiger signs detected
Bihar	31	27	145	94
Uttar Pradesh	315	129	712	244
Uttarakhand	812	361	1810	658
Shivalik Hills & Gangetic Plains	**1158**	**517**	**2667**	**996**
Andhra Pradesh	2409	85	7036	172
Chattisgarh	3562	97	9595	150
Jharkhand	19	0	92	0
Maharashtra	5874	614	17640	1106
Madhya Pradesh	8580	717	25834	1493
Odisha	3299	81	10434	135
Rajasthan	179	84	642	180
Central Indian Landscape & eastern Ghats	**23922**	**1678**	**71273**	**3236**
Goa	105	7	315	10
Karnataka	2201	506	6819	1106
Kerala	672	208	2025	411
Tamil Nadu	1002	206	3214	506
Western Ghats	**3980**	**927**	**12373**	**2033**
Assam	547	95	851	190
Mizoram	13	3	45	3
Arunachal Pradesh				
North Bengal	45	23	152	52
North Eastern Hills & Brahmaputra Flood Plains	**605**	**121**	**1048**	**245**
Sundarbans	52	31	318	190
INDIA	**29717**	**3274**	**87679**	**6700**

* From scat DNA
\# From Camera trap and scat DNA

Table1.1: Country wide effort for ground surveys and camera trap sampling.

1) Trails surveys for occupancy of habitat patches by tigers and other predators
2) Line transects to estimate prey abundance
3) Sample plots on the line transects to assess
   a) Habitat characteristics,
   b) Human impacts and
   c) Prey dung density.

and from recent remotely sensed data (Phase 2) following variables

a) landscape characteristics,
b) human "foot-print", and
c) habitat attributes

were used to model tiger abundance and occupancy.

Total Length Trails (km)	No. of Transects Walked	Total Length Sampled (km)	No. Plots Sampled	No of Camera Trap Locations	Individual Tigers Photo - captured/DNA ID
830	118	360	854	235	21
3785	683	2107	828	551	92
9755	1592	3575	3503	806	292
14370	**2393**	**6042**	**5185**	**1592**	**396**
32635	8436	18811	14883	505	37
45309	9664	23165	15720	0	19#
577	224	448	431	0	3*
91920	18577	46692	31116	1466	144#
145627	26556	64410	53614	2459	292
52550	10071	20910	17742	140	6#
3368	482	1003	1690	863	63
371987	**74010**	**175439**	**135196**	**5433**	**558**
1614	348	686	580	42	3*
34910	7200	15676	10620	577	257
11824	2031	4095	3474	399	85
17533	3375	7033	5373	578	189
65881	**12954**	**27489**	**20047**	**1554**	**518**
4405	872	3036	2058	806	136
205	39	78	0	0	3*
				84	15#
1437	164	349	277	0	2*
6047	**1075**	**3462**	**2335**	**890**	**152**
812	318	1031	529	266	62
459096	**90750**	**213464**	**163292**	**9777**	**1686**

The second component (Phase 3 & 4) of the double sampling consists of scientifically rigorous abundance estimation in select sampling units using a) remote camera trap based capture-recapture technique for estimating tiger and other carnivore abundance (Fig. 1.2) and b) line transect based Distance sampling for estimating prey abundance. c) Camera trap based habitat covariates and vegetation quantification on plots at each transect. This sampling was done by trained State Forest Department personnel, competent Non-Governmental Organizations and the Wildlife Institute of India (Appendix 1).

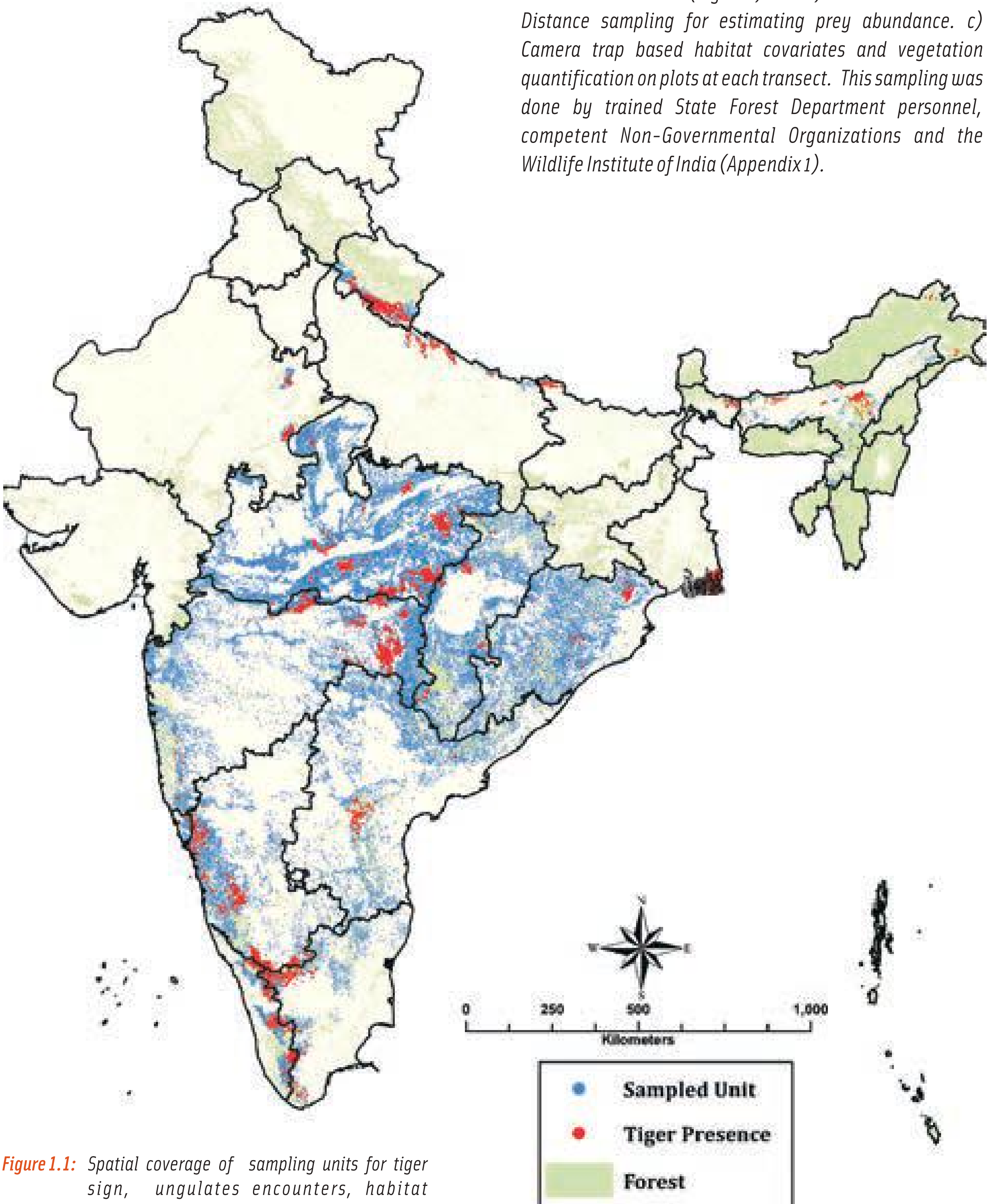


Figure 1.1: Spatial coverage of sampling units for tiger sign, ungulates encounters, habitat characteristics and human impacts. Sites where tiger signs were recorded are shown in red and provide an overview of tiger distribution in India.

Occupancy Modelling

Data from replicate ground surveys (phase 1) were transferred to 10 x 10 km grids in a Geographic Information System. Since data from habitat, prey, and human foot print were likely to be correlated, we extracted principal components (PC's) from all covariates used in modeling occupancy of tigers. The PC's were then used as covariates to model tiger occupancy which also accounted for imperfect detections (Yumnam et al. 2014).

Detection probability of tiger sign was likely to be a function of tiger abundance and was therefore modelled with tiger sign encounter rate as a covariate. Model selection and occupancy estimation was done in program PRESENCE (MacKenzie et al. 2006) using AIC. This analysis helps in understanding spatial extent of tiger populations, factors that influence tiger distribution and habitat connectivity between tiger populations. Naive estimates of occupancy were also arrived at for major carnivores and herbivores.

Abundance estimation of carnivores by camera trap surveys.

Camera trap surveys are now a well established methodology for abundance/density estimation of elusive carnivores. Development of Spatial capture-recapture methods have led to greater clarity in density estimation by integrating the spatial or "location" information of animal photo-captures and camera deployment.

The data is also amenable to analysis in a non-spatial framework and can be used for conventional mark-recapture analysis. However, it should be noted that the reverse is not true, i.e. data collected without relevant spatial information cannot be used in a spatial framework. Key features of the sampling design are outlined below.

Abundance Analysis: Camera traps were placed at 9,777 locations over 51 sites for mark recapture analysis (Table 1.1, Fig 1.2). Tiger/leopard photographs obtained from camera traps were digitized and analyzed using the program Extract-Compare (Hiby et al. 2009) and HotSpotter (Crall et al. 2013), a pattern recognition program specially developed to individually identify tigers and other animals from their coat pattern. We used likelihood based spatially explicit capture-recapture (Efford 2011, Brochers & Efford 2008) to estimate tiger and leopard abundance from camera trap data. Tiger and leopard sign abundance, habitat characteristics, prey availability and human footprint variables obtained from the ground surveys and remotely sensed data were used within SECR as covariates in a joint likelihood to model tiger density in program R. Covariate based abundance models were developed for each landscape to estimate tiger abundance within tiger and leopard occupied forests. Tiger/leopard population estimates from camera trapped areas were obtained from SECR, while in areas where tigers and leopards were detected but the area was not camera trapped; their numbers were estimated using the best covariate model developed for that landscape in SECR.

At Anshi-Dendeli, Bhadra, Nagarhole, Bandipur, and Biligiri Rangaswamy Tiger Reserves and at sites in Goa, and Wayanad Wildlife Sanctuary, the Phase 4 monitoring was done by Wildlife Conservation Society (WCS) and Center for Wildlife Studies (CWS). The site specific analysis for these sites was done as per the following section:

Spatial models of capture-mark-recapture (Spatially Explicit Capture Recapture - SECR) under a Bayesian framework using Markov-Chain Monte Carlo (MCMC) methods, implemented in program SPACECAP version 1.1.0 (Gopalaswamyet al. 2012). The models were run using 60000-70000 iterations (with initial burn-in of 20000-30000 values) and thinning rate for chains was set to 1. The augmentation value provided was 5-10 times the number of individuals used for analyses (Mt+1). Geweke diagnostic scores (Geweke 1992) built into program SPACECAP was used to check for convergence of chains. Violation of closure assumption was assessed in CAPTURE.

For site or Reserve-wise analysis, the Initial Encounter Frequency(λo), Scale parameter(σ) and Density (D) are estimated for the Effective Sampled Areas (ESAs), which are larger than the individual protected areas. The parameter estimates for Nagarahole correspond to the combined area of Nagarahole, adjacent reserve forests and Wayanad-Tholpetty. The parameter estimates for Bandipur correspond to the combined area of Bandipur and adjacent Wayanad-KSBM. The parameter estimates for Bhadra correspond to Bhadra reserve and adjacent reserve forests and coffee plantation matrix. The Population Estimate

(N) for the Protected Area in each case refers to the estimated population size strictly within the administrative boundaries of the respective protected areas.

Camera trap data from the WCS and CWS sites along with data from all the other collaborators (WWF, AARANYAK, WCT, WRCS and State Forest Departments) were provided to WII and used for the landscape scale analysis in joint likelihood framework along with covariates in package secr (Efford 2015) (program R) to estimate tiger density in all tiger occupied habitat.

Genetic Sampling: *At sites where it was not possible to undertake camera trapping due to very low tiger numbers or unfavourable law and order conditions, scat samples of carnivores were collected to estimate minimum number of tigers through genetic analysis. DNA was extracted from samples and then first screened for species identification using a tiger specific cytochrome-b marker that amplifies a 162 base pair fragment. Tiger positive samples were confirmed after samples were run along with a positive and negative control. Tiger positive samples were subsequently identified to individual tigers using a panel of 11 microsatellite markers. Details of the methodology and results of this analysis are provided in Chapter 8. Number of individual's tigers was used as an estimate of minimal population size.*

Maximum Entropy Models (MaxEnt): *In the states of Mizoram and Arunachal Pradesh except Pakke Tiger Reserve, we could not sample with appropriate mark recapture method due to logistic constraints. In these states we used confirmed tiger presence locations from tiger scat (confirmed by DNA profile) and opportunistic camera trap photos to model suitable tiger habitat using program MaxEnt. Minimal tiger density obtained from individually identified tigers within small intensively searched areas was extrapolated to suitable tiger habitat so as to provide a crude estimate of tiger numbers in these states.*

Prey density

Distance sampling (Buckland et al. 2001) on foot line transects of 2-4 km was used at several of the sites sampled for phase 3 and 4. Line transects were systematically distributed by sampling each forest beat by one or two transect sample depending on the size and habitat type of the beat (Jhala et al 2013). Each transect was walked with minimum of three temporal replicates mostly in the morning (6:30 to 8:30 am). Data was recorded on 1) species sighted, 2) group size, 3) the number of adult and young in each group 4) radial distance to the center of the group by a laser range finder, 5) bearing of the group using a see through compass, 6) walk bearing of the transect and 7) location of each sighting. Data were subsequently analysed in program DISTANCE verion 6.

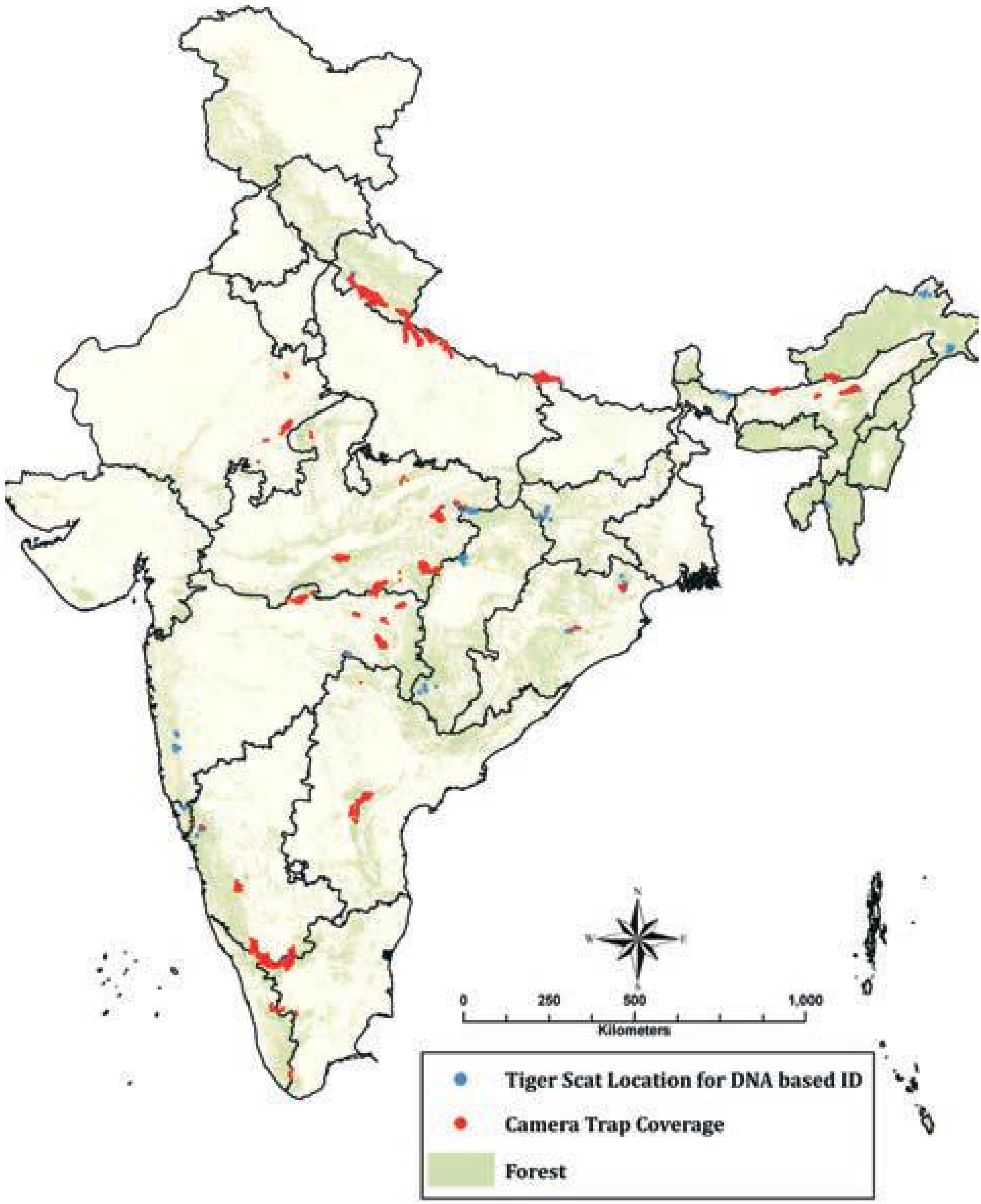
For the sites sampled by CWS and WCS (Anshi-Dendeli, Bhadra, Nagarhole, Bandipur, and Biligiri Rangaswamy Tiger Reserves and at sites in Goa, and Wayanad Wildlife Sanctuary) systematically designed line transects with square sampler geometry applicable to large terrestrial herbivores (Buckland et al. 2001; Karanth, Thomas & Kumar 2002) were marked and sampled to uniformly cover the area sampled. Each of the square transect was walked twice a day for a two hour duration (Morning walk was from 0600 to 0800 hours; Evening walk was from 1600 to 1800 hours). The temporal replicates ranged between 4 to 6 walks for each transect.

For phase 1 transect data, that was conducted across all tiger habitats, data on animal bearing and radial distance of sighted groups using a range finder were not collected. Thereby, providing information only on encounter rates of prey.

Analysis

Program DISTANCE version 6.0 was used to carry out all analyses. We first carried out exploratory analyses of the data to look for evidence of evasive movement prior to detection, 'rounding' and 'heaping' of data, and to truncate outlier observations to improve subsequent model-fitting. Detection probabilities were then estimated based on models of the detection process fit to the data. If the key function did not fit the data adequately, cosine adjustment terms were added sequentially to improve the fit. The fit of possible alternative models to each specific dataset was assessed using Akaike's Information Criterion (AIC) values, which trade-off the bias of simple models against the higher variance of more complex models. The goodness-of-fit tests generated by program DISTANCE, visual assessments of the fit of the proposed model to the observed distance data close to the transect line and the precision of estimated detection probabilities also helped guide model selection. Using the selected model in the program DISTANCE, the estimates of the following parameters were generated: group encounter rate (n/l), where n is the total number of clusters detected and l the total length of transects walked; probability of detection between the transect and truncation distance (P); effective strip width (ESW); cluster density (Ds); expected cluster size (Es) *and animal density (D). As there can be a tendency to detect relatively larger than smaller clusters farther away from the line, we expected the average of our cluster sizes to be a (positively) biased estimate of mean cluster size. We tested for this bias by assessing if the slope of a regression of log cluster size against detection probability was significantly different from zero (at an P of 0.15). If the regression was found to be significant, the average cluster size was corrected using the estimated slope parameter. Variance of mean density was estimated as a composite of the variances of group size, encounter rate and the probability of detection (Jathanna et al. 2008). Site-specific sampling efforts together with the parameter estimates are described in individual site sections.*

Figure 1.2: *Camera trap locations and tiger scat locations (DNA based ID) for population estimation.*



Results at a Glance 02

A total of 4,73,580 km² of forests in 18 tiger states were surveyed (Table 1.1, Fig.1.1). An unprecedented effort was invested in camera trapping and scat collection of tigers across India (Fig. 1.2) by a combined effort of Tiger Reserves managers, NGO partners and WII resulting in Photo Capture of 1686 tigers and 1647 leopards.

Tigers were observed to have expanded their occupied area substantially in the Shivalik-Gangetic plains with the overall habitat occupancy of 89,164 km² in India (Table 2.1; Fig. 1.1).

Table 2.1: *Estimated tiger numbers (>1.5 years of age) and area occupied by tigers in 2014 for landscapes and States compare with estimates for 2006 and 2010. Numbers in parenthesis are standard error limits.*

State	Tiger Population			Tiger km²		
	2006	2010	2014	2006	2010	2014
Shivalik Hills & Gangetic Plain Landscape						
Uttarakhand	178 (161-195)	227 (199-256)	340 (299-381)	1,901	3,476	6,576
Uttar Pradesh	109 (91-127)	118 (113-124)	117 (103-131)	2,766	2,511	2,519
Bihar	10 (7-13)	8	28(25-31)	510	750	922
Shivalik-Gangetic	**297 (259-335)**	**353 (320-388)**	**485 (427-543)**	**5,177**	**6,737**	**10,017**
Central Indian Landscape and Eastern Ghats Landscape						
Andhra Pradesh	95 (84-107)	72 (65-79)	68 (58-78)	14,126	4,495	4,686
Chattisgarh	26 (23-28)	26 (24-27)	46 (39-53)*	3,609	3,514	4,735
Madhya Pradesh	300 (236-364)	257 (213-301)	308 (264-352)*	15,614	13,833	15,156
Maharashtra	103 (76-131)	168 (155-183)	190 (163-217)*	4,273	11,960	11,643
Odisha	45 (37-53)	32 (20-44)	28 (24-32)*	9,144	3,398	3,981
Rajasthan	32 (30-35)	36 (35-37)	45 (39-51)	356	637	1,147
Jharkhand	-	10 (6-14)	3*	1,488	1,180	626
Central India	**601 (486-718)**	**601 (518-685)**	**688 (596-780)**	**48,610**	**39,017**	**41,974**
Western Ghats Landscape						
Karnataka	290 (241-339)	300 (280-320)	406 (360-452)	18,715	14,414	14,523
Kerala	46 (39-53)	71 (67-75)	136 (119-150)	6,168	6,804	7,137
Tamil Nadu	76 (56-95)	163 (153-173)	229 (201-253)	9,211	8,389	7,229
Goa	-	-	5*			622
Western Ghats	**402 (336-487)**	**534 (500-568)**	**776 (685-861)**	**34,094**	**29,607**	**29,511**
North Eastern Hills and Brahmaputra Flood Plains						
Assam	70 (60-80)	143 (113-173)	167 (150-184)	1,164	2,381	3,848
Arunachal Pradesh	14 (12-18)	-	28*	1,685	1,304	1,169
Mizoram	6 (4-8)	5	3*	785	416	100
Northern West Bengal	10 (8-12)	-	3*	596	799	704
North East Hills, and Brahmaputra	**100 (84-118)**	**148 (118-178)**	**201 (174-212)**	**4,230**	**4,900**	**5,821**
Sunderbans	**-**	***70 (64-90)***	***76 (62-96)***	***1,586***	***1,645***	***1,841***
TOTAL	**1,411 (1,165-1,657)**	**1,706 (1,507-1,896)**	**2,226 (1,945-2,491)**	**93,697**	**81,906**	**89,164**

* *From camera trap data and scat DNA*

Table 2.2: Population estimates of tigers in tiger reserves in the year 2014.

Tiger Reserve	State	Tiger Population	Lower SE Limit	Upper SE Limit
Achanakmar	Chhattisgarh	11	10	12
Annamalai	Tamil Nadu	13	11	14
Bandhavgarh	Madhya Pradesh	63	55	71
Bandipur	Karnataka	120	107	134
Bhadra	Karnataka	22	20	25
B R Temple	Karnataka	68	60	75
Bor	Maharashtra	5	3	6
Buxa*	West Bengal	2	2	2
Corbett	Uttarakhand	215	169	261
Dampa*	Mizoram	3	3	3
Dandeli-Anshi	Karnataka	5	3	6
Dudhwa	Uttar Pradesh	58	46	69
Indravati	Chhattisgarh	12	11	13
Kalakad-Mundanthurai	Tamil Nadu	10	9	11
Kanha	Madhya Pradesh	80	71	90
Kaziranga	Assam	103	91	115
Manas	Assam	11	9	12
Melghat	Maharashtra	25	21	30
Mudumalai	Tamil Nadu	89	79	99
Nagarahole	Karnataka	101	90	113
Nagarjunsagar	Andhra Pradesh	54	40	67
Namdapha	Arunachal Pradesh	11	5	11
Nameri	Assam	5	4	5
Nawegoan-Nagzira	Maharashtra	7	4	10
Pakke	Arunachal Pradesh	7	6	8
Palamau*	Jharkhand	3	3	3
Panna	Madhya Pradesh	17	17	17
Parambikulam	Kerala	19	17	21
Pench	Madhya Pradesh	43	36	49
Pench	Maharashtra	35	28	42
Periyar	Kerala	20	18	22
Pilibhit	Uttar Pradesh	25	19	30
Ranthambore	Rajasthan	37	30	41
Sahyadri*	Maharashtra	7	7	7
Sanjay-Dubri	Madhya Pradesh	8	7	10
Sariska	Rajasthan	9	9	9
Sathyamangalam	Tamil Nadu	72	64	80
Satkosia	Odisha	3	2	4
Satpura	Madhya Pradesh	26	22	30
Similipal	Odisha	17	14	19
Sunderban	West Bengal	68	57	86
Tadoba-Andhari	Maharashtra	51	44	58
Udanti-Sitanadi	Chhattisgarh	4	3	4
Valmiki	Bihar	22	17	26
Total		**1586**	**1343**	**1820**

* Minimum number of tigers recorded through scat DNA, in these cases a standard error on their estimate was not possible.

Notable improvements in tiger occupancy have occurred in the states of Uttrakhand, Madhya Pradesh, Goa, and Assam. While tiger population has significantly increased in the states of Uttrakhand, Bihar, Karnataka, Kerala, Tamil Nadu, and Assam. States that require more conservation investments are Odisha and Jharkhand.

Since the current analysis (2014) of tiger abundance was done in a spatially explicit framework, it was possible to provide abundance estimates for individual tiger reserves (Table 2.2). Corbett tiger reserve had the largest population at about 215 tigers, Bandipur, Nagarhole and Kaziranga each had over a hundred tigers, while Mudumalai, Kanha, Sundarban, and Satyamangalam had over 70 tigers each. These tiger reserves are important source populations for their landscapes. The remaining tiger reserves have smaller tiger populations and need to be managed in a metapopulation framework for their long-term survival. In these tiger reserves connecting habitat corridors need to become an integral part for their management strategy. Some reserves like Simlipal, Nagarjunasagar Sri Sailam, Palamau, Sanjay-Dubri, Manas, Buxa, and Kawal are below their potential and require resources and targeted management inputs.

Leopard population in the forested habitats of 14 Indian tiger states was estimated at 7910 (SE range 6566 to 9181; Table 2.3). These estimates are minimal estimates since leopards occur outside of sampled forests as well in each state. For the North East, Phase I sampling was not done and therefore leopard population could not be estimated. The estimates provided in Table 2.3 for the North East Landscape are the number of leopards actually photocaptured. The leopard population for Rajasthan is reported only for the tiger occupied forests i.e. the Ranthambore and Sariska Landscapes. The state of Madhya Pradesh had the largest leopard population followed by Karnataka.

Table 2.3: Leopard population estimates in forested habitats of tiger states.

Shivalik Hills and Gangetic Plains			
STATE	Population Estimate	Lower SE Limit	Upper SE Limit
Uttar Pradesh	194	185	203
Uttarakhand	703	633	773
Bihar	32	28	37
Total	929	846	1013
Western Ghats			
Kerala	472	367	577
Karnataka	1129	831	1427
Tamil Nadu	815	587	1043
Goa	71	61	81
Total	2487	1846	3128
Central India			
Andhra Pradesh	343	303	383
Chhattisgarh	846	689	1004
Jharkhand	30	26	32
Odisha	345	296	394
Rajasthan	171	138	204
Madhya Pradesh	1817	1615	2019
Maharashtra	905	807	1004
Total	4457	3874	5040
North East *	37	NA	NA
Country Total	7910	6566	9181

**Only the camera trapped number of individual leopards is provided as systemetic Phase I data for covariates across forested habitats was not done in the States of North East India.*

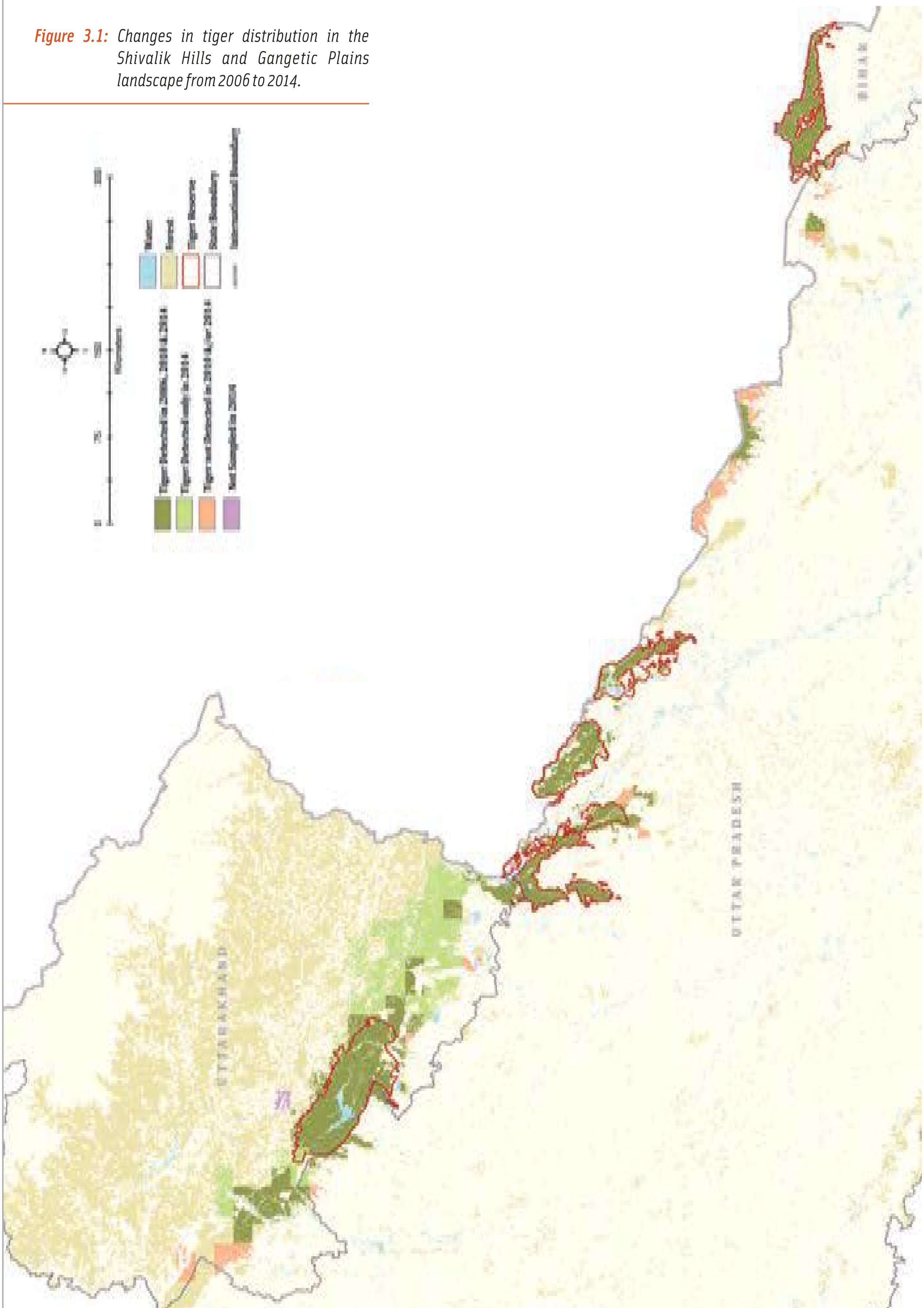
Shivalik Hills & Gangetic Plains Landscape 03

Qamar Qureshi, Y. V. Jhala, H. S. Negi, S. K. Pathak, and B. S. Bonal

Shivalik Hills & Gangetic plains landscape comprises of three parallel geological zones: the Shivalik Hills, the bhabhar tract and the terai plains. This tiger landscape traverses across the political boundaries of Uttarakhand, Uttar Pradesh, Nepal and Bihar. In this landscape, the total forested area surveyed in 2013-2014 assessment was 15,237 km^2. It is within this surveyed forest area that occupancy of each species is reported. Major Forest type found in this landscape includes Moist Shivalik Sal Forest, Dry Deciduous Scrub and grassland, Dry Plains Sal Forest, Northern Dry Mixed deciduous forest, West Gangetic Moist Deciduous Forest and Plantation (Champion and Seth 1968).

Figure 3.1 depicts areas where tiger have colonised, been persistently present, or their presence is no longer recorded since 2006. This landscape has recorded impressive gain in tiger occupancy which is now about 10,017 km^2, most of the increase is contributed by Uttarakhand (Fig. 3.1). Corbett Tiger Reserve has substantially contributed in recovery of tiger population in this landscape. Most of the Uttarakhand landscape is connected through the Shivalik hills and lower Himalayas for movement of tigers, but connectivity in the terai is a concern especially for elephants (Qureshi et al. 2014). It is equally important to have connectivity of Tiger Reserves of Uttar Pradesh and Bihar with forests in Nepal as in many places it is not possible to have connectivity restored in the Indian part. Development such as border roads on either sides should be done with inclusion of green infrastructure to avoid habitat fragmentation. High human density, intensive agriculture, boulder mining and other developmental activities pose a challenge to tiger conservation. The tiger population west of Ganga in Uttarakhand has rapidly declined, with Dholkhand tiger population in Rajaji National Park on the verge of local extinction. Urgent plan and attention is needed to supplement tigers in western part of Rajaji national park (now a tiger reserve) which has only two tigresses since 2006. Once Western Rajaji starts to act as a source population, tigers would disperse across Shivalik forest divison of Uttar Pradesh and into Kalesar Wildlife Sanctuary in Haryana and possibly into the forests of Himachal Pradesh. It is also crucial to develop plans to deal with human-tiger conflict in this landscape. Loss of tiger presence in this landscape is recorded in Shivalik Forest Division of Uttar Pradesh, primarily due to Western Rajaji losing its status as a tiger source. The other area where tiger presence has declined is in the vicinity of Suhelwa wildlife sanctuary in Uttar Pradesh on the border of Nepal (Fig. 3.1).

Figure 3.1: *Changes in tiger distribution in the Shivalik Hills and Gangetic Plains landscape from 2006 to 2014.*



Tiger occupancy was modelled using covariates of prey, habitat and anthropogenic disturbance. The variables were standardized using principal component analysis (PCA) (see method).

Six principal components explained 70 % of the variation of the original covariate data and each component could be ecologically interpreted based on the factor loadings (Table 3.1)

Table 3.1: Principal component loadings after varimax rotation of covariates from the Shivalik Hills and Gangetic Plains landscape. The cumulative percent variation explained by 6 components was 70%.

	PC-1-Terrain Chital, Nilgai	PC-2-Human Disturbance	PC-3-Mixed Prey	PC-4-Dense Veg. Hilly Terrain	PC-5-P.A. & Prey	PC-6-Small Prey & Urban Area
Ruggedness	-0.75			0.37		
Elevation	-0.73	0.31		0.35		
Encounter Rate of Nilgai	0.72					
Encounter Rate of Chital	0.72				0.36	
Pellet Count of Nilgai	0.54		0.49		-0.33	
Encounter Rate of Wild Pig	0.54	0.32				0.37
People Seen		0.93				
Livestock Seen		0.90				
Human Tail		0.82				
Pellet Count of Chital	0.39		0.77			
Pellet Count of Sambar			0.75		0.35	
Dung Count of Elephant			0.64			
Pellet Count of Barking Deer	-0.35		0.63			0.37
Pellet Count of Wild Pig			0.53			0.47
Mean NDVI for Pre-monsoon				0.91		
Mean NDVI for Post-monsoon				0.86		
Core Area				0.58	0.49	
Canopy Cover			0.40	0.46		
Encounter Rate of Sambar					0.75	
Distance from Protected Areas	-0.30				-0.63	
Encounter Rate of Elephant			0.37		0.58	
Nightlights Area						-0.73
Encounter Rate of Barking Deer					0.42	0.51

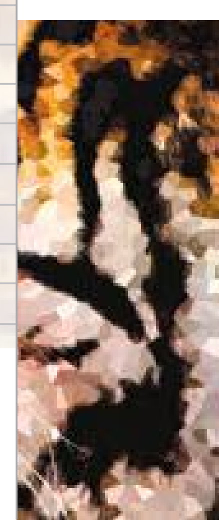


Table 3.2: Competing models tested and model selection using AIC for estimating tiger occupancy in Shivalik Hills and Gangetic Plains Landscape for detection bias and influence of covarites .

Model	AIC	deltaAIC	AIC wgt	No. of Parameter	-2Log (likelihood)
Ψ(PC2 + PC3), p(Tiger Sign)	2022.61	0.00	0.38	5	1006.30
Ψ(PC1 + PC2 + PC3), p(Tiger Sign)	2023.92	1.32	0.20	6	1005.96
Ψ(PC2 + PC3 + PC5), p(Tiger Sign)	2024.55	1.94	0.14	6	1006.27
Ψ(PC2 + PC3 + PC4 + PC5), p(Tiger Sign)	2025.59	2.98	0.09	7	1005.79
Ψ(PC1 + PC2 + PC3 + PC5), p(Tiger Sign)	2025.93	3.31	0.07	7	1005.96
Ψ(PC2 + PC3 + PC4 + PC5 + PC6), p(Tiger Sign)	2026.45	3.84	0.06	8	1005.22
Ψ (PC1 + PC2 + PC3 + PC4 + PC5), p(Tiger Sign)	2027.36	4.75	0.04	8	1005.68
Ψ (PC1 + PC2 + PC3 + PC4 + PC5 + PC6), p(Tiger Sign)	2028.23	5.62	0.02	9	1005.11
Ψ(PC1+PC2), p(Tiger Sign)	2032.22	9.62	0.00	5	1011.11
Ψ(.), p(Tiger Sign)	2049.94	27.33	0.00	3	1021.97
Ψ(PC1), p(Tiger Sign)	2051.89	29.28	0.00	4	1021.95
Ψ(.), p(.)	2560.04	537.43	0.00	2	1278.02

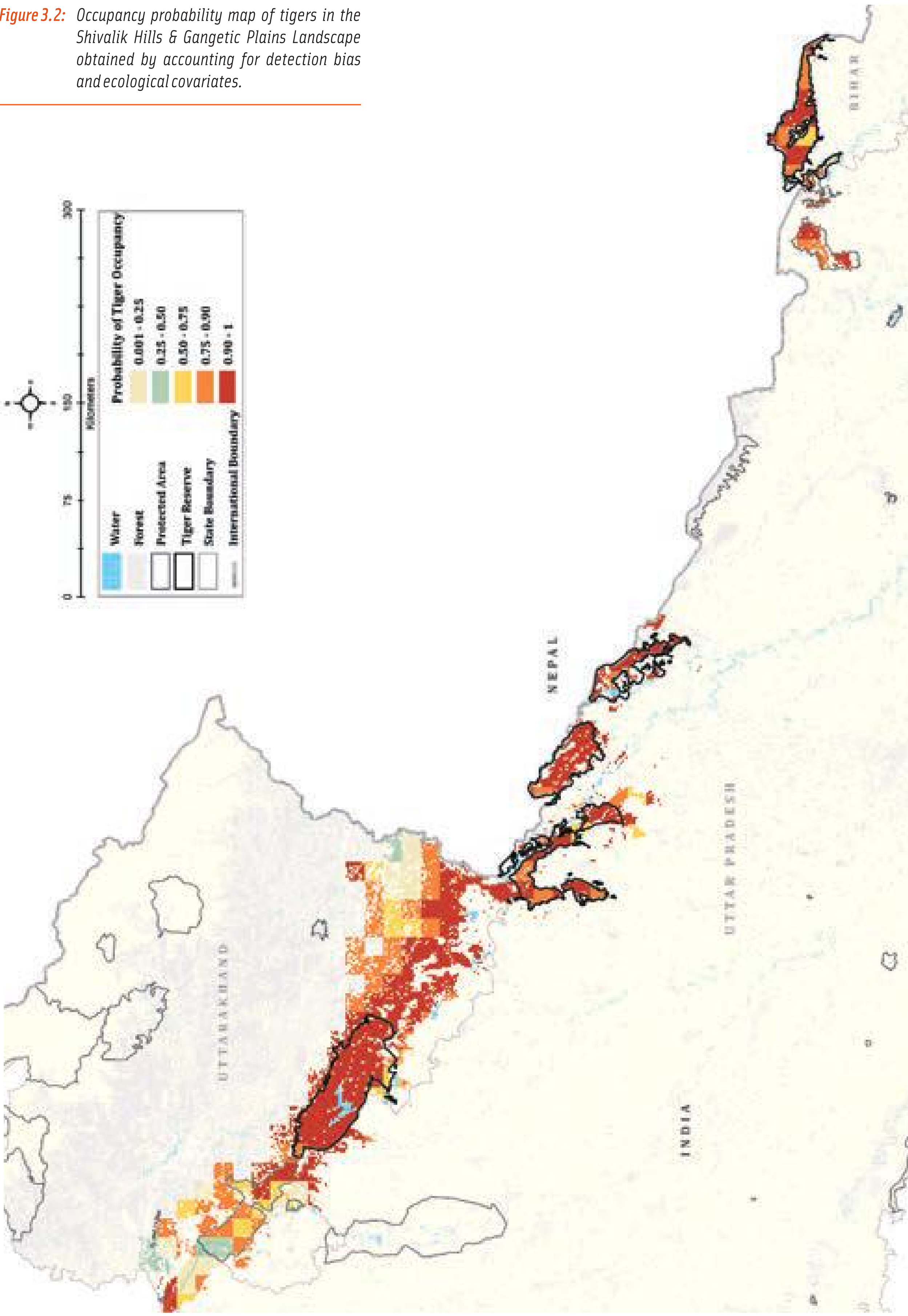
The coefficients of covariates that best explained tiger occupancy and detection probability (Table 3.2) were ecologically interpretable (Table 3.3). Tigers occurred in forested habitats that were away from urban sprawl, had low human impacts and good prey populations. Correcting for detection bias improved the naive estimate of occupancy by 6% (from 58.8 to 64.8 SE 3.3 %). The detection probability of tiger sign on a single survey was 49 (SE 1.2)% in the Shivalik Hills and Gangetic Plains landscape.

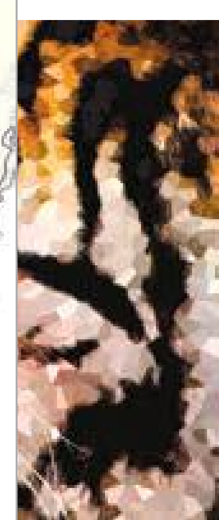
Table 3.3: Coefficients of the best model explaining tiger occupancy in the Shivalik Hills and Gangetic Plains

	Variables	Estimate	Standard Error
A1	■Constant	2.39	0.58
A2	■PC2	-1.37	0.34
A3	■PC3	1.15	0.45
B1	p1	-0.71	0.07
B2	p1.Tiger Sign	1.56	0.09

The detection corrected occupancy probability modelled with ecologically relevant covariates suggests lower occurrence probability west of Rajaji National Park and on the border of Uttarakhand and Nepal which forms the corridor habitat to Pilibhit Tiger Reserve in Uttar Pradesh and Shuklaphanta National Park though Lagga Bagga in Nepal (Fig. 3.2).

Figure 3.2: *Occupancy probability map of tigers in the Shivalik Hills & Gangetic Plains Landscape obtained by accounting for detection bias and ecological covariates.*





Tiger abundance estimation was based on extensive camera trapping in this landscape.

Total of 7,644 tiger photo captures were obtained from within this landscape. The best joint likelihood covariate model that explained tiger density had tiger sign intensity and prey abundance as covariates (Table 3.4, Table 3.5). The state of Uttarakhand has shown a remarkable increase in tiger population and occupancy. There is now contiguous tiger occupancy and reasonable abundance from Rajaji-Corbett-Haldwani-Pilibhit in Uttarakhand to Uttar Pradesh. Bihar too has recorded a substantial improvement in tiger numbers. In Uttar Pradesh, Pilibhit Tiger Reserve and adjoining Uttarakhand have improved, while tiger status has remained unchanged in Uttar Pradesh terai (Table 2.1, 2.2 & Fig. 3.3).

Table 3.4: Model selection for tiger density estimation using covariates in SECR for Shivalik Hills & Gangetic Plains landscape.

Model	Detection Function	No. Parameters	log Likelihood	AIC	ΔAIC
D-tigps + PreyER + PreyDung	Halfnormal	6	-8800.17	17612.33	0.00
D-tigps + PreyER + PreyDung + hl + footp	Halfnormal	8	-8799.97	17615.95	3.62
D-tigps + footp + PreyDung	Halfnormal	6	-8907.85	17827.70	215.37
D-tigps + hl + PreyDung	Halfnormal	6	-8908.20	17828.41	216.08
D-tigps + PreyDung + padist + footp	Halfnormal	7	-8907.64	17829.29	216.96
D-tigps + hl + PreyDung + padist	Halfnormal	7	-8908.03	17830.06	217.73

tigps = Tiger sign index, PreyER= Wild prey Encounter rate, Prey Dung = Wild Prey Dung index, hl = Human disturbance index from ground surveys, footp = Human footprint index, padist = Distance from Protected Area

Table 3.5: Model coefficients for the best covariate model in SECR for estimating tiger density in Shivalik Gangetic Landscape.

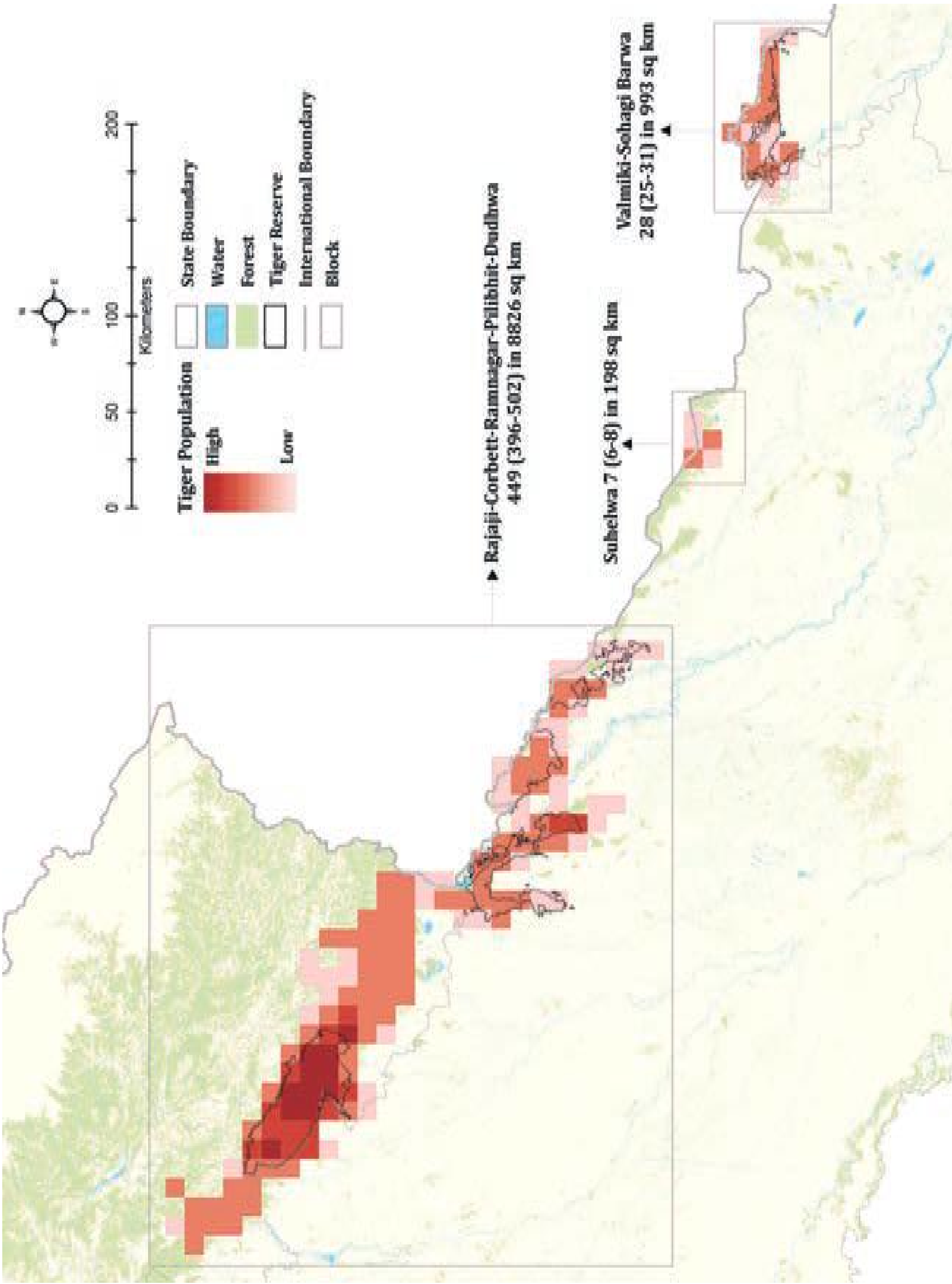
Parameter	beta	SE.beta
Density	-8.32	0.06
tigps	0.1	0.06
PreyER	0.21	0.07
PreyDung	0.41	0.05
g0	-3.85	0.03
Sigma	7.9	0.01

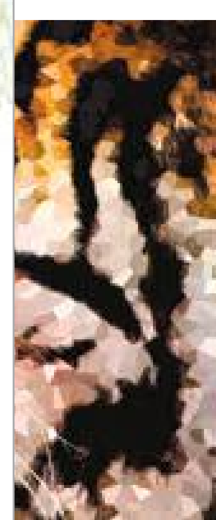
tigps = Tiger sign index, PreyER= Wild prey Encounter rate, PreyDung = Wild Prey Dung index

Maximum tiger density was observed in Corbett Tiger Reserve with the Tiger Reserve having about 215 tigers, making it the number one Protected Area with the largest tiger population. The total contiguous population from Rajaji to Dudhwa tiger reserve holds close to 450 tigers in over 8800 km^2 increasing the significance of this population in the Global recovery of the species. This population in the Terai Arc landscape now competes with the largest tiger population recorded in the Nagarhole-Mudumalai-Wayanad-BRT complex. Moderate tiger density was predicted in Suhelwa, this is probably an over estimate, since only occasional tiger presence is recorded in this area. Valmiki Tiger Reserve too has increased its tiger numbers significantly also suggestive of a good tiger population in adjoining Chitwan National Park of Nepal.

The landscape has potential to further its tiger population especially in the Western region. Supplimentation of tigers in Western Rajaji and restorative management inputs combined with incentivized voluntary relocation of Gujjars from the Shivalik forests can potentially expand the tigers recently extirpated range to Kalesar Widlife Sanctuary in Haryana and further into Himachal. In the landscape surrounding Corbett Tiger Reserve, dispersing tigers are likely to come into conflict with

Figure 3.3: Tiger density, extent and population blocks within the Shivalik Hills & Gangetic Plains Landscape





humans especially if habitat corridors for their dispersal east and westward become restrictive. Wildlife managers need to be equipped with trained personnel and equipment to address tiger-human conflict rapidly and decisively. Delays in response to conflict situations will jeopardize the long term survival of this high density tiger population.

Leopard: Panthera pardus (WPA: Schedule I; IUCN: Near threatened)

Leopard presence was found throughout the sampled Shivalik hills and Gangetic plains, ranging further up to in Himalayas. Leopard is also known to occur at higher altitudes in the Himalayas, but these areas were not sampled during 2013–14. Leopard presence was sparser in the terai grasslands. The major prey species available in this landscape were chital, sambar, hog deer, barking deer and wild pig. The overall forested area occupied by leopard was 12,896 km^2 comprising 85% of the sampled area (Fig. 3.4). Leopard density was computed from 12 camera trapped sites within this landscape. A total of 2497 leopard photo-captures were obtained from which 277 adult individuals were identified.

The covarites that best explained leopard density in a joint likelihood SECR framework were leopard sign encounter rate, prey abundance, tiger sign intensity and ruggedness of the terrain (Table 3.6 and 3.7) The total population of leopard within the sampled forested landscape of Shivalik-Gangetic plains was estimated at 929 (SE range 855-1004). Leopard numbers in the sampled forests of Uttarakhand were 703, in Uttar Pradesh were 194 and Bihar were 32 (Table 2.3). Leopard was the most widespread carnivore in this landscape and it is reported to use non-forested areas that include vicinity of human habitations, plantations and agricultural fields. These areas were not sampled in this exercise, therefore the above numbers should be considered as minimal population estimates. Public awareness and strategies of living with leopards need to be promoted to minimize conflicts with human.

Table 3.6: Covariate models and model selection in SECR for estimating leopard density in the Shivalik Hills and Gangetic Plains Landscape.

model	Detection Function	No. Pararameters	logLikelihood	AIC	■IC
D~leops + tigps + PreyDung + rugg	Halfnormal	7	-2253.7	4521.407	0
D~leops + preyDung	Halfnormal	5	-2273.1	4556.208	34.801
D~leops + rugg + preyDung	Halfnormal	6	-2272.45	4556.896	35.489
D~leops + elev	Halfnormal	5	-2273.56	4557.129	35.722
D~leops + hl	Halfnormal	5	-2273.76	4557.516	36.109
D~leops + tigps	Halfnormal	5	-2274.46	4558.915	37.508

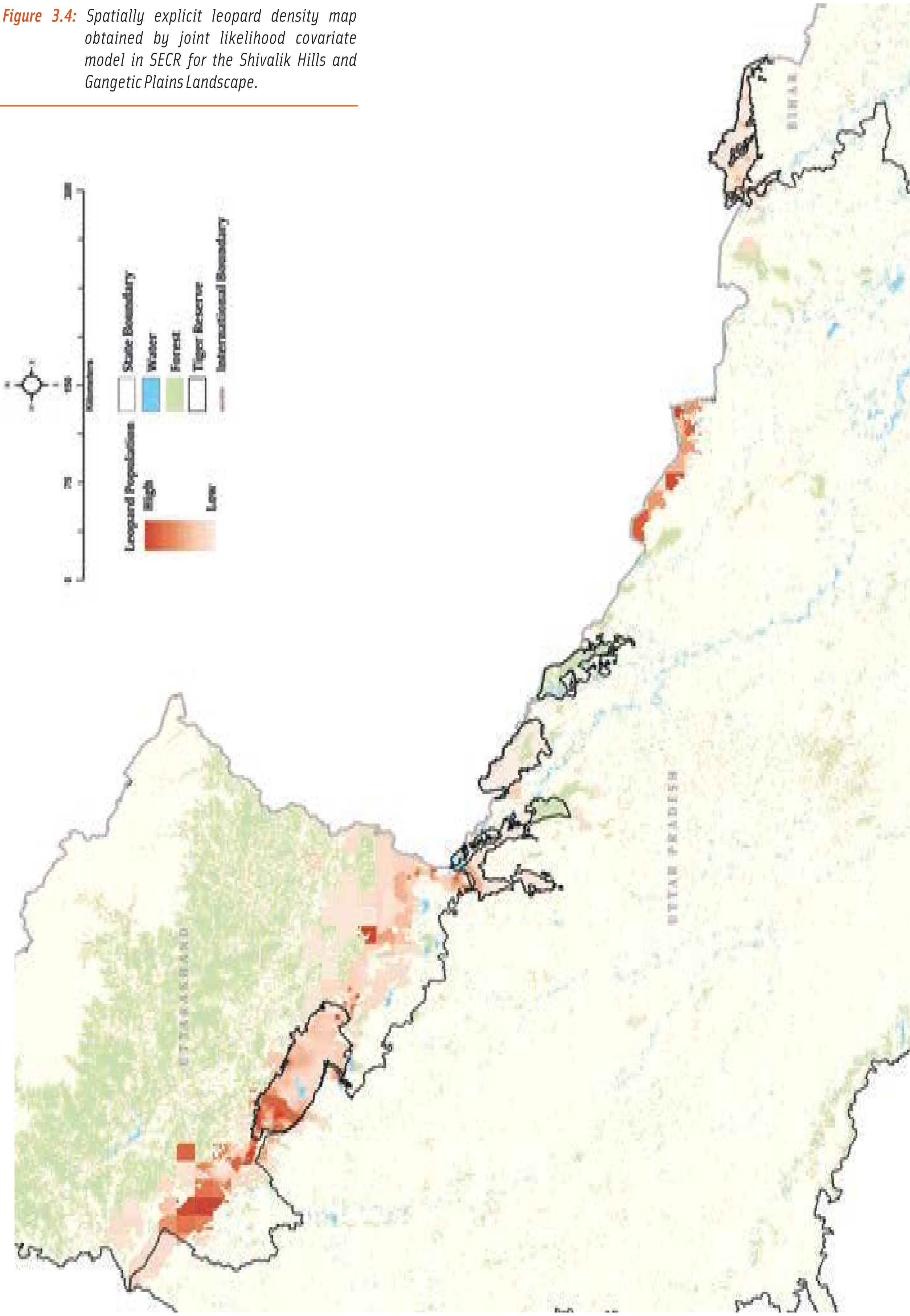
leops= Leopard sign index, hl = Human disturbance index, tigps= tiger sign index, rug= ruggedness,, ndvioct = NDVI post monsoon PreyER= Wild Prey Encounter rate, PreyDung = Wild Prey Dung index

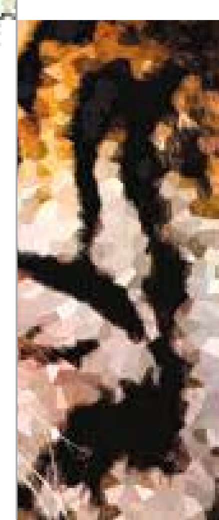
Table 3.7: Coefficients of the best covariate model in SECR for estimating leopard density in the Shivalik Hills and Gangetic Plains Landscape.

Parameter	Beta coefficients	Standard Error
Density	-7.879	0.105
leops	0.620	0.080
tigps	-0.458	0.085
preyDung	0.544	0.120
rugg	-0.113	0.166
g0	-6.301	0.073
Sigma	8.373	0.035

Few studies conducted in Terai Arc landscape have focussed on leopards. The Chilla range of Rajaji National Park had reported the density of leopard post Gujjar relocation as 9.76/100 km^2 (Hariahar et al 2011). While in Nandour Valley leopard density was reported as 9.57 /100 km^2 (WWF-India 2013). In a study in the Bhabhar tract of Parsa Wildlife Reserve, Nepal, the leopard density estimated through SECR was reported to be 3.78 (SE 0.85) (Thapa et al, 2014) while in the current study the adjacent Valmiki Tiger Reserve had 3.05 (SE 0.45) leopards per 100 km^2. Johnsingh et al. (2004) and WWF India (2014) report a high encounter rate of leopard sign in Suhelwa Wildlife Sanctuary. High levels of leopard-human conflict is reported from across the hills suggestive of a wide leopard distribution with reasonable density across Uttarakhand and Himachal Pradesh. However these areas were not sampled and population estimate for the higher elevation regions are currently not available.

Figure 3.4: *Spatially explicit leopard density map obtained by joint likelihood covariate model in SECR for the Shivalik Hills and Gangetic Plains Landscape.*





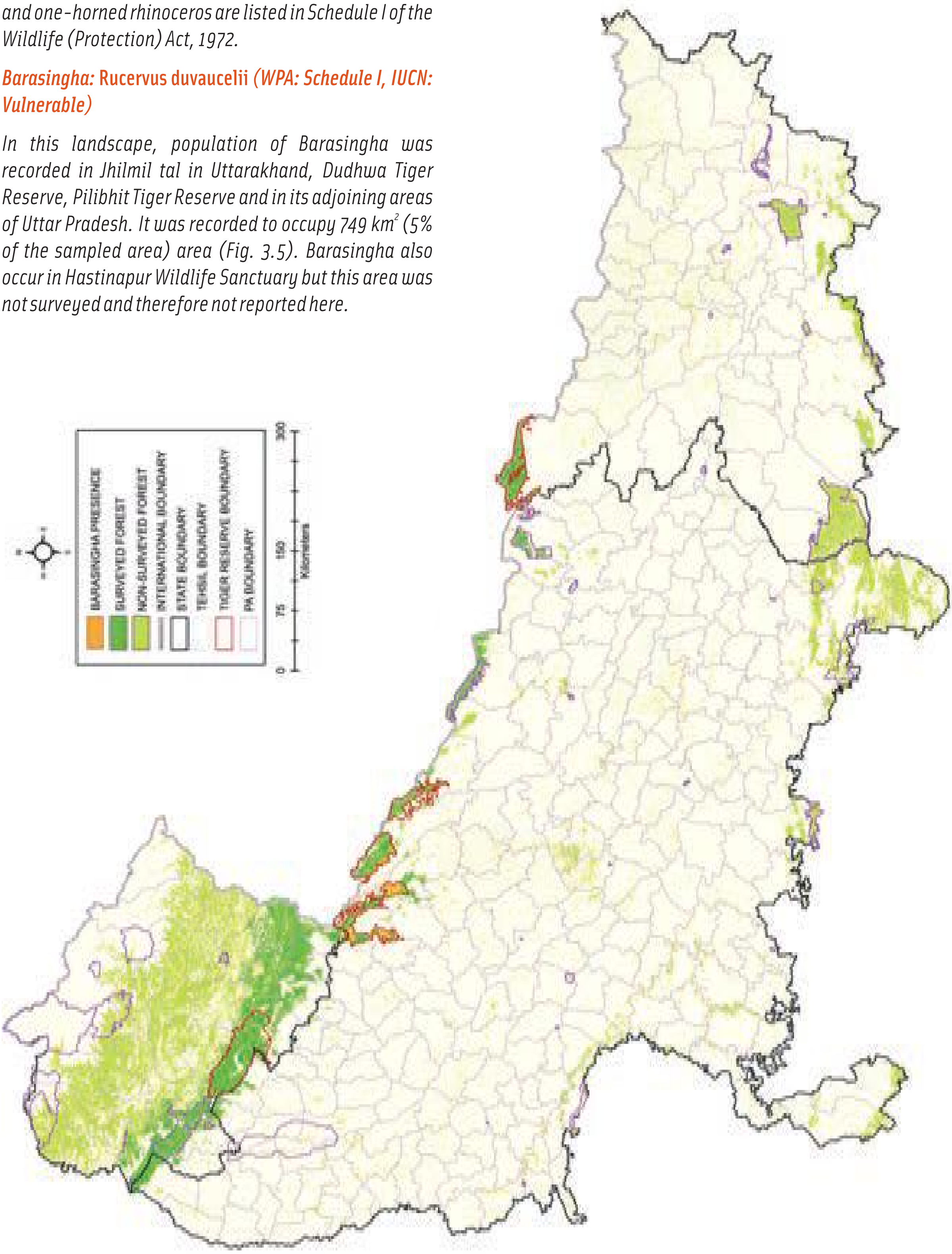
Occupancy of major prey species in Shivalik-Gangetic Plains Landscape

Major ungulates found in this landscape include chital, sambar, barking deer, elephant, gaur, hog deer, wild pig, nilgai, goral, barasingha and one-horned rhinoceros. Out of these, elephant, gaur, barasingha and one-horned rhinoceros are listed in Schedule I of the Wildlife (Protection) Act, 1972.

Barasingha:* Rucervus duvaucelii *(WPA: Schedule I, IUCN: Vulnerable)

In this landscape, population of Barasingha was recorded in Jhilmil tal in Uttarakhand, Dudhwa Tiger Reserve, Pilibhit Tiger Reserve and in its adjoining areas of Uttar Pradesh. It was recorded to occupy 749 km^2 (5% of the sampled area) area (Fig. 3.5). Barasingha also occur in Hastinapur Wildlife Sanctuary but this area was not surveyed and therefore not reported here.

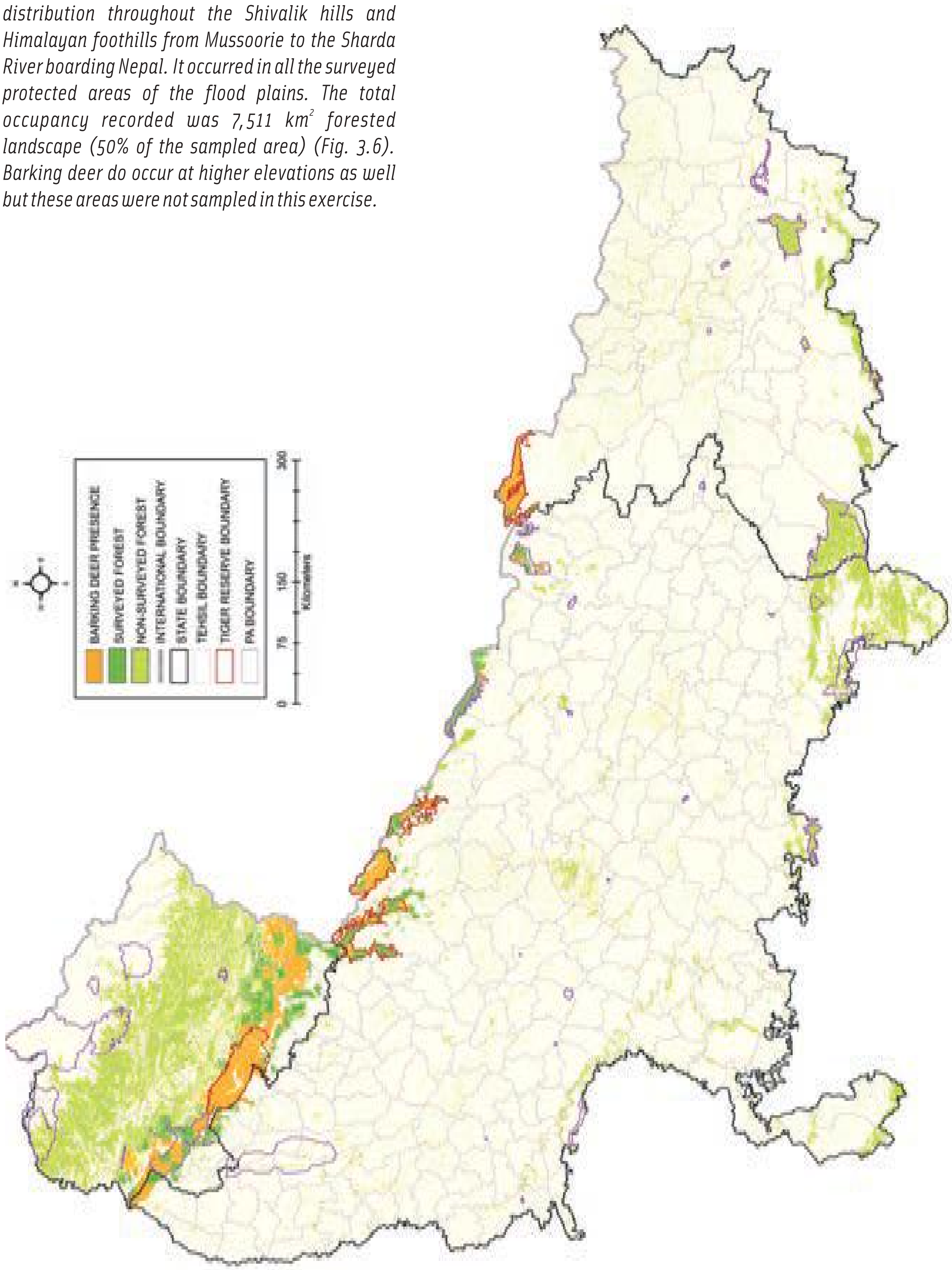
Figure 3.5: Distribution of Barasingha in the Shivalik Hills and Gangetic Plains Landscape

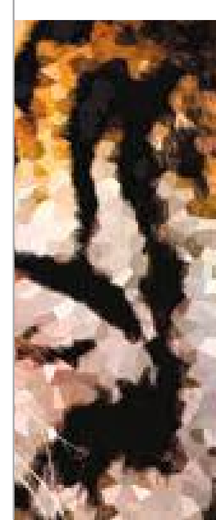


Barking Deer: Muntiacus muntjac *(WPA: Schedule III, IUCN: Least concern)*

It is one of the most widely distributed deer species in India. In the Shivalik Gangetic plains landscape, barking deer was recorded to have a continuous distribution throughout the Shivalik hills and Himalayan foothills from Mussoorie to the Sharda River boarding Nepal. It occurred in all the surveyed protected areas of the flood plains. The total occupancy recorded was 7,511 km^2 forested landscape (50% of the sampled area) (Fig. 3.6). Barking deer do occur at higher elevations as well but these areas were not sampled in this exercise.

Figure 3.6: Distribution of Barking deer in the Shivalik Hills and Gangetic Plain Landscape.

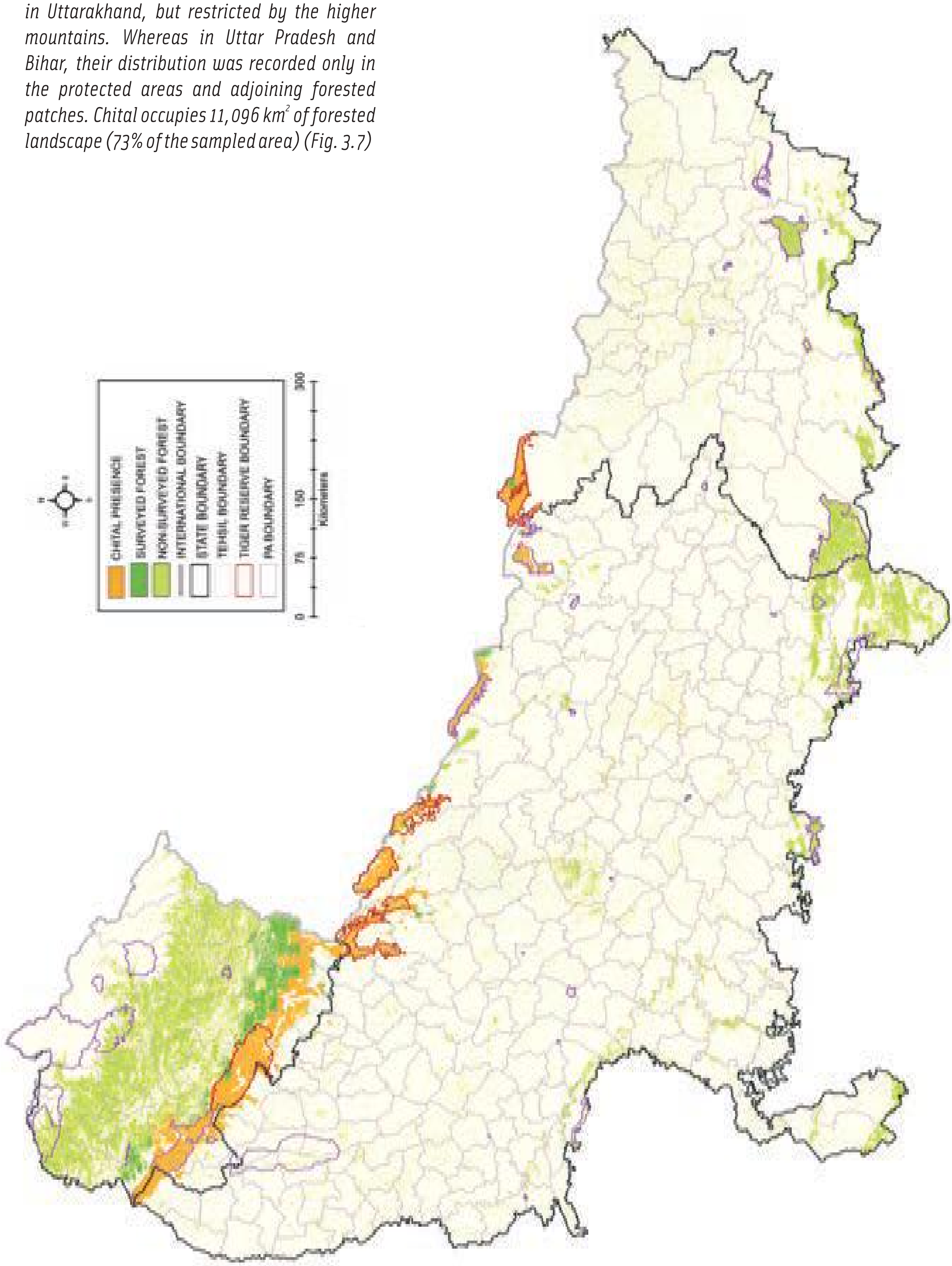




Chital: **Axis axis** ***(WPA: Schedule III, IUCN: Least concern)***

Chital were recorded to have a continuous distribution throughout the foothills of Shivalik in Uttarakhand, but restricted by the higher mountains. Whereas in Uttar Pradesh and Bihar, their distribution was recorded only in the protected areas and adjoining forested patches. Chital occupies 11,096 km² of forested landscape (73% of the sampled area) (Fig. 3.7)

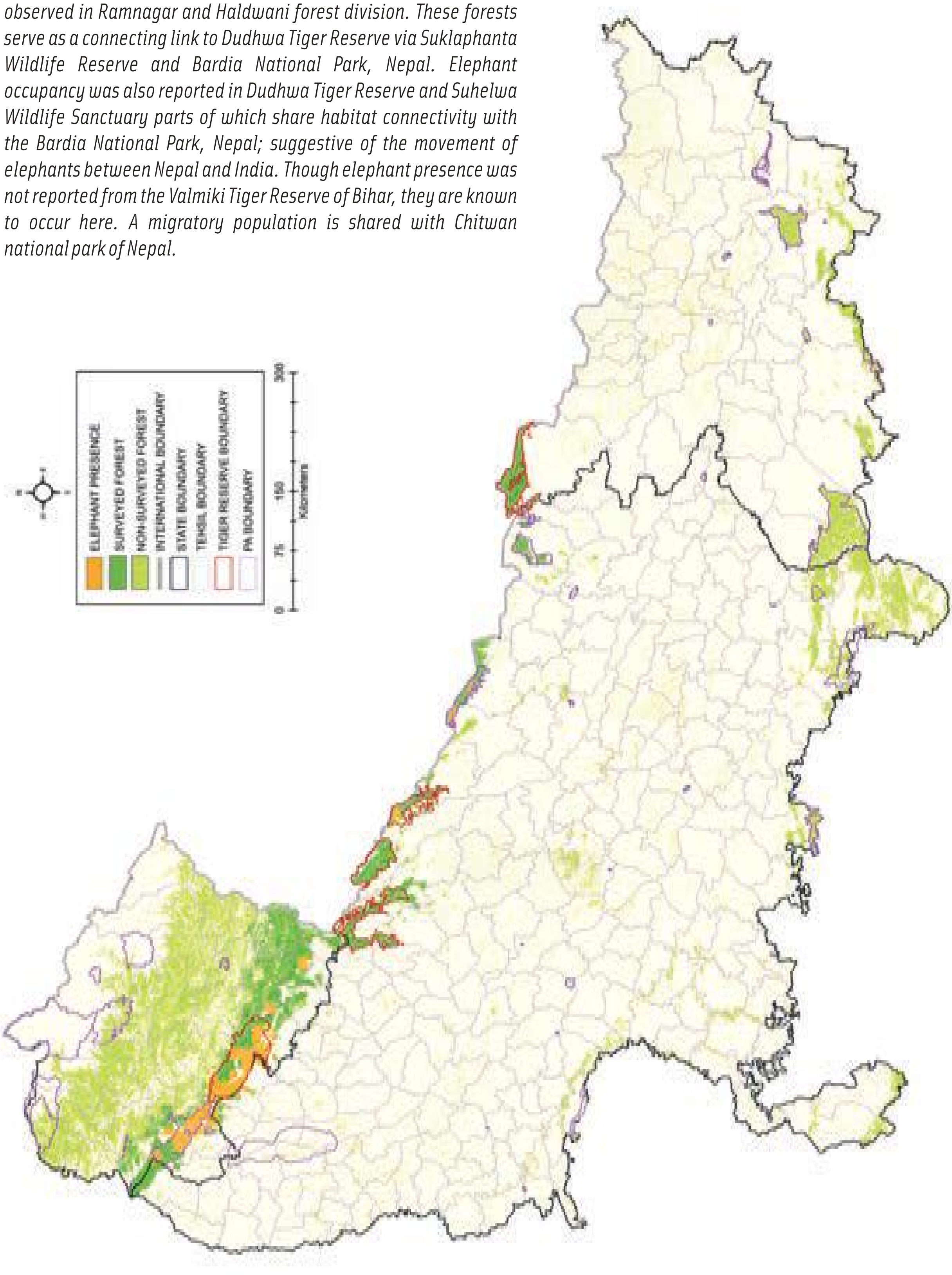
Figure 3.7: Distribution of Chital in the Shivalik Hills and Gangetic Plain Landscape.

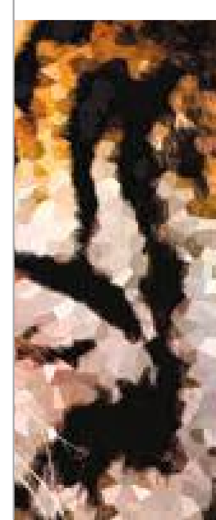


Elephant:* Elephas maximus *(WPA: Schedule I, IUCN: Endangered)

Elephants were reported to occupy an area of 2,766 km^2 of forested landscape (18% of the sampled area) (Fig 3.8). A continuous occupancy was observed in the Shivalik region of Rajaji National Park and Corbett Tiger Reserve. Further a patchy occupancy was observed in Ramnagar and Haldwani forest division. These forests serve as a connecting link to Dudhwa Tiger Reserve via Suklaphanta Wildlife Reserve and Bardia National Park, Nepal. Elephant occupancy was also reported in Dudhwa Tiger Reserve and Suhelwa Wildlife Sanctuary parts of which share habitat connectivity with the Bardia National Park, Nepal; suggestive of the movement of elephants between Nepal and India. Though elephant presence was not reported from the Valmiki Tiger Reserve of Bihar, they are known to occur here. A migratory population is shared with Chitwan national park of Nepal.

Figure 3.8: *Distribution of Elephants in the Shivalik Hills and Gangetic Plains Landscape.*

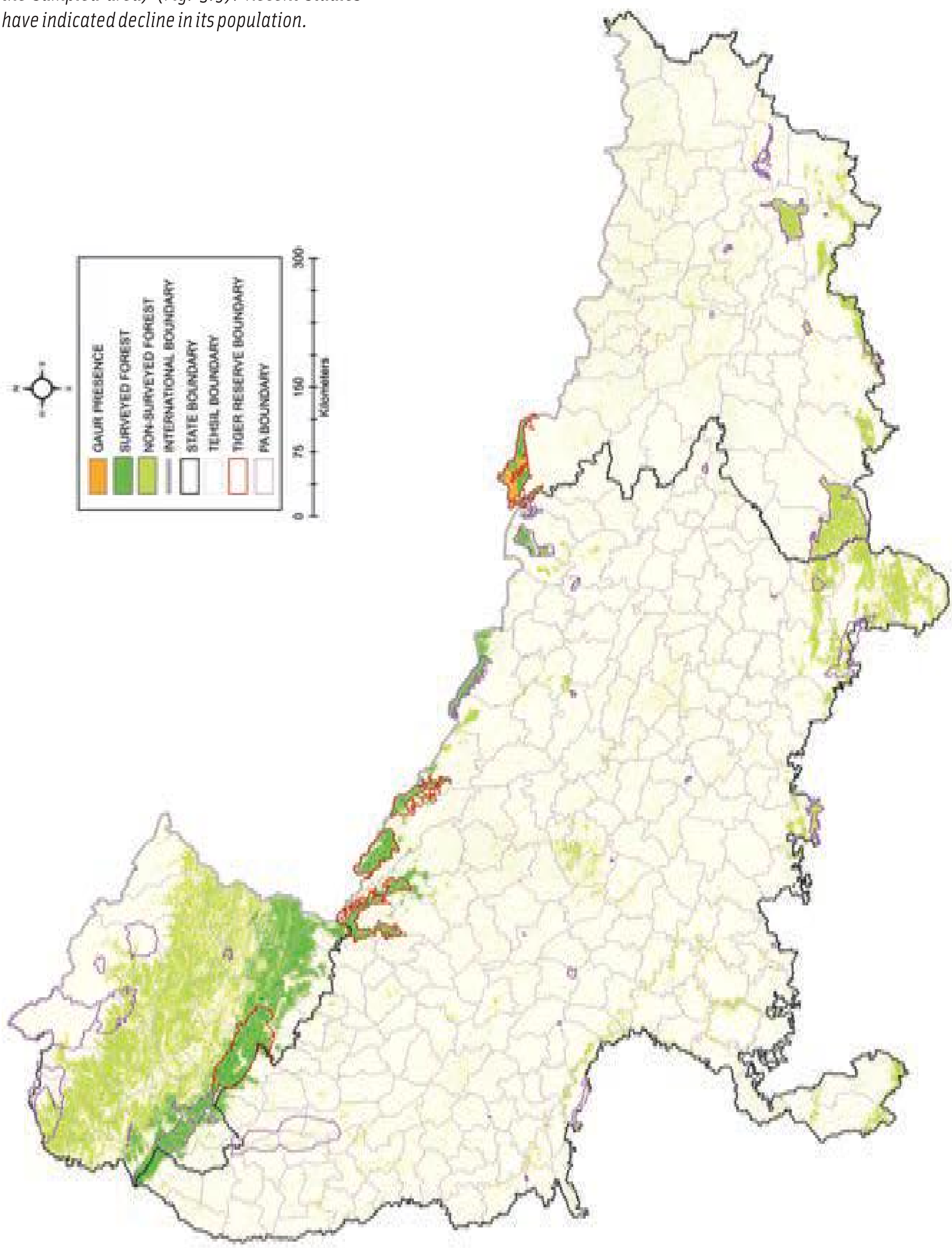




Gaur:* Bos gaurus *(WPA: Schedule I, IUCN: Vulnerable)

Gaur presence was reported only from the Valmiki Tiger Reserve within this landscape. It occupied 297 km² of forested landscape (2% of the sampled area) (Fig. 3.9). Recent studies have indicated decline in its population.

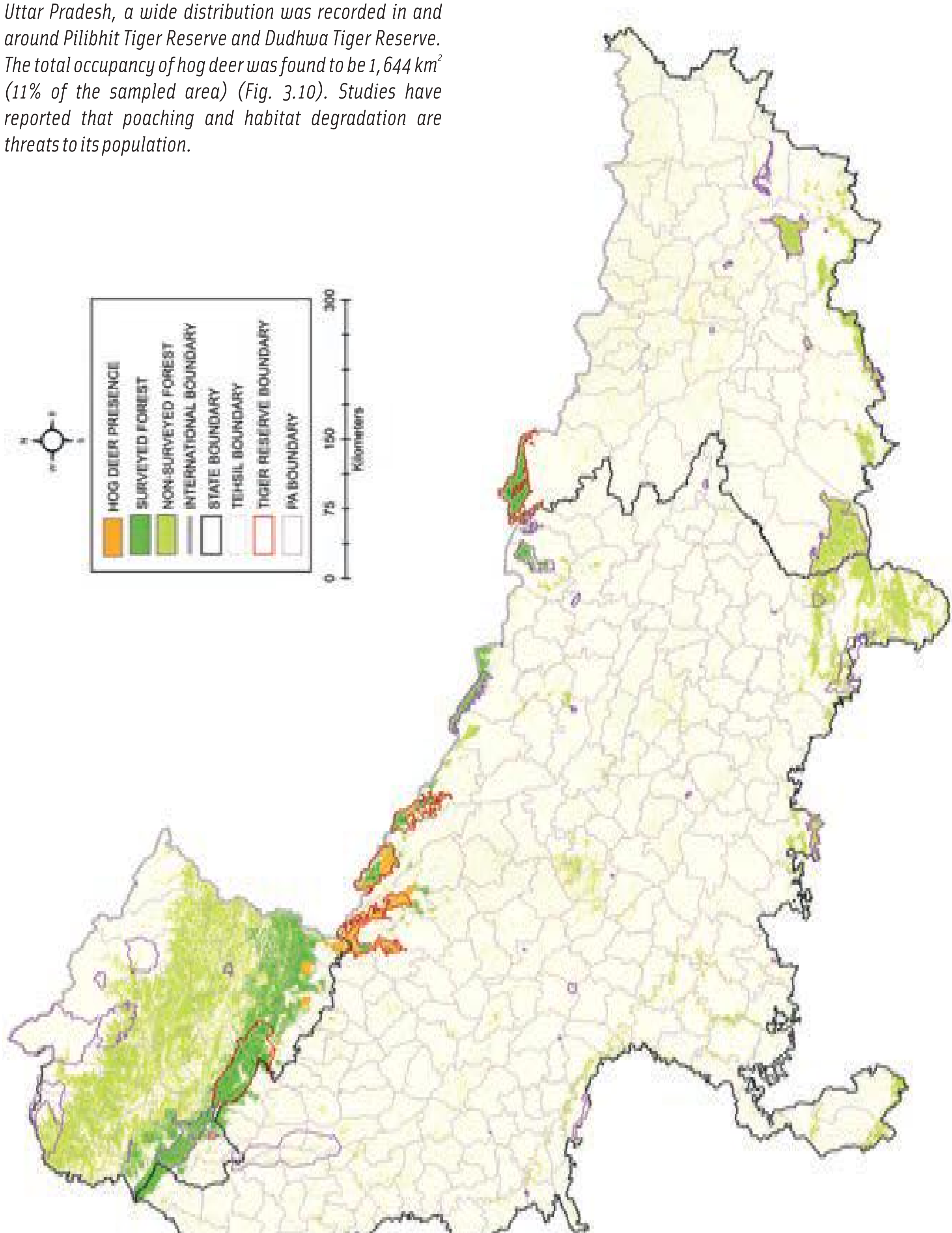
Figure 3.9: *Distribution of Gaur in the Shivalik Hills and Gangetic Plains Landscape.*

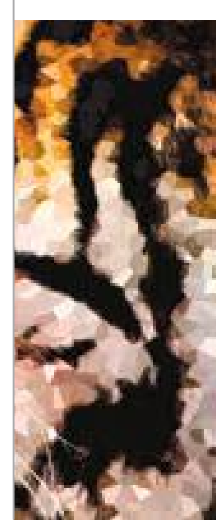


Hog Deer: Axis porcinus *(WPA: Schedule III, IUCN: Endangered)*

A patchy distribution of hog deer was recorded in the flood plain grasslands of Jhilmil Tal, Ramnagar and Haldwani division in Uttarakhand. In the flood plains of Uttar Pradesh, a wide distribution was recorded in and around Pilibhit Tiger Reserve and Dudhwa Tiger Reserve. The total occupancy of hog deer was found to be 1,644 km² (11% of the sampled area) (Fig. 3.10). Studies have reported that poaching and habitat degradation are threats to its population.

Figure 3.10: *Distribution of Hog deer in the Shivalik Hills and Gangetic Plains Landscape.*

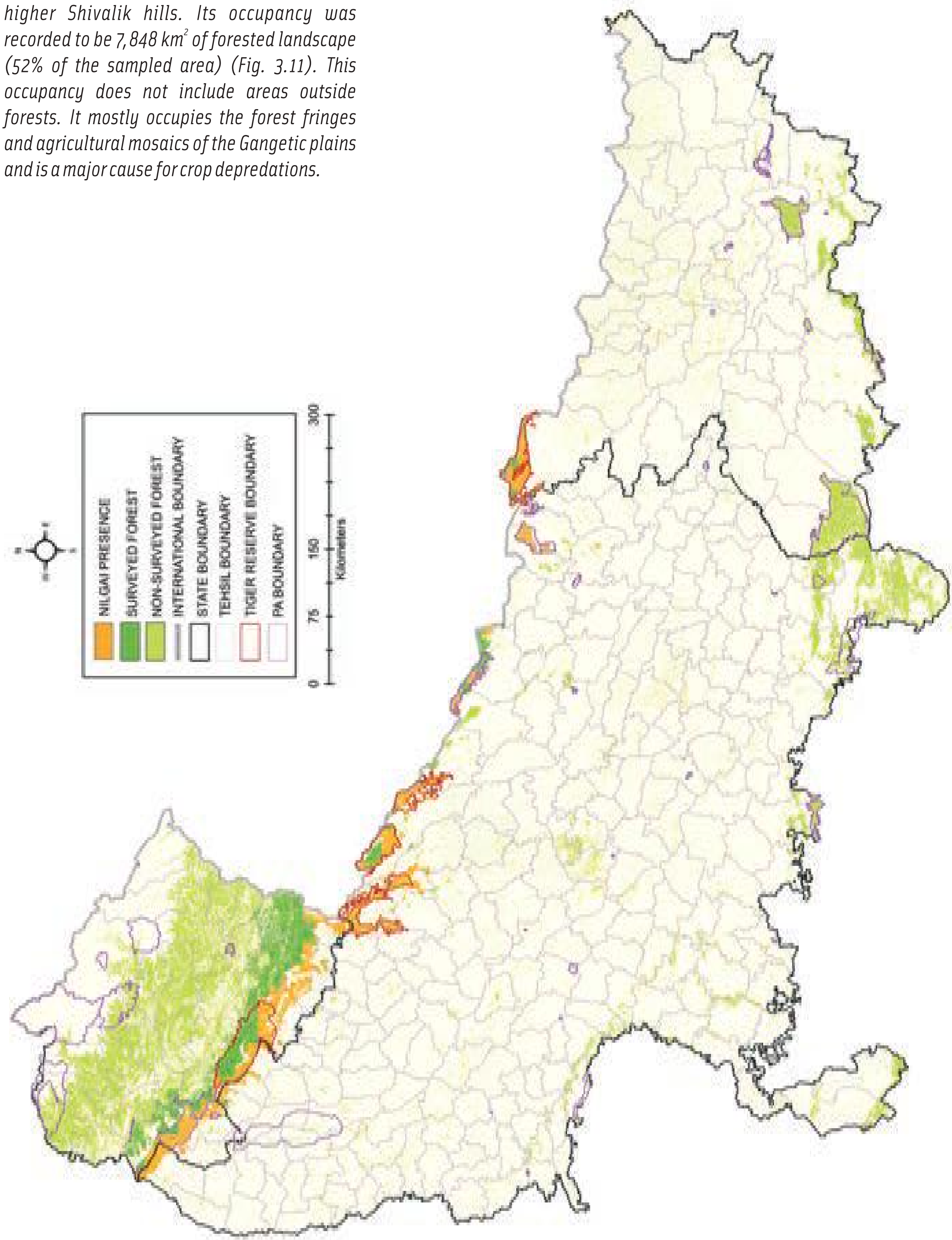




Nilgai: **Boselaphus tragocamelus** *(WPA: Schedule III, IUCN: Least concern)*

Nilgai was recorded to have a continuous distribution throughout the surveyed forests in the plains. Its distribution was limited by the higher Shivalik hills. Its occupancy was recorded to be 7,848 km² of forested landscape (52% of the sampled area) (Fig. 3.11). This occupancy does not include areas outside forests. It mostly occupies the forest fringes and agricultural mosaics of the Gangetic plains and is a major cause for crop depredations.

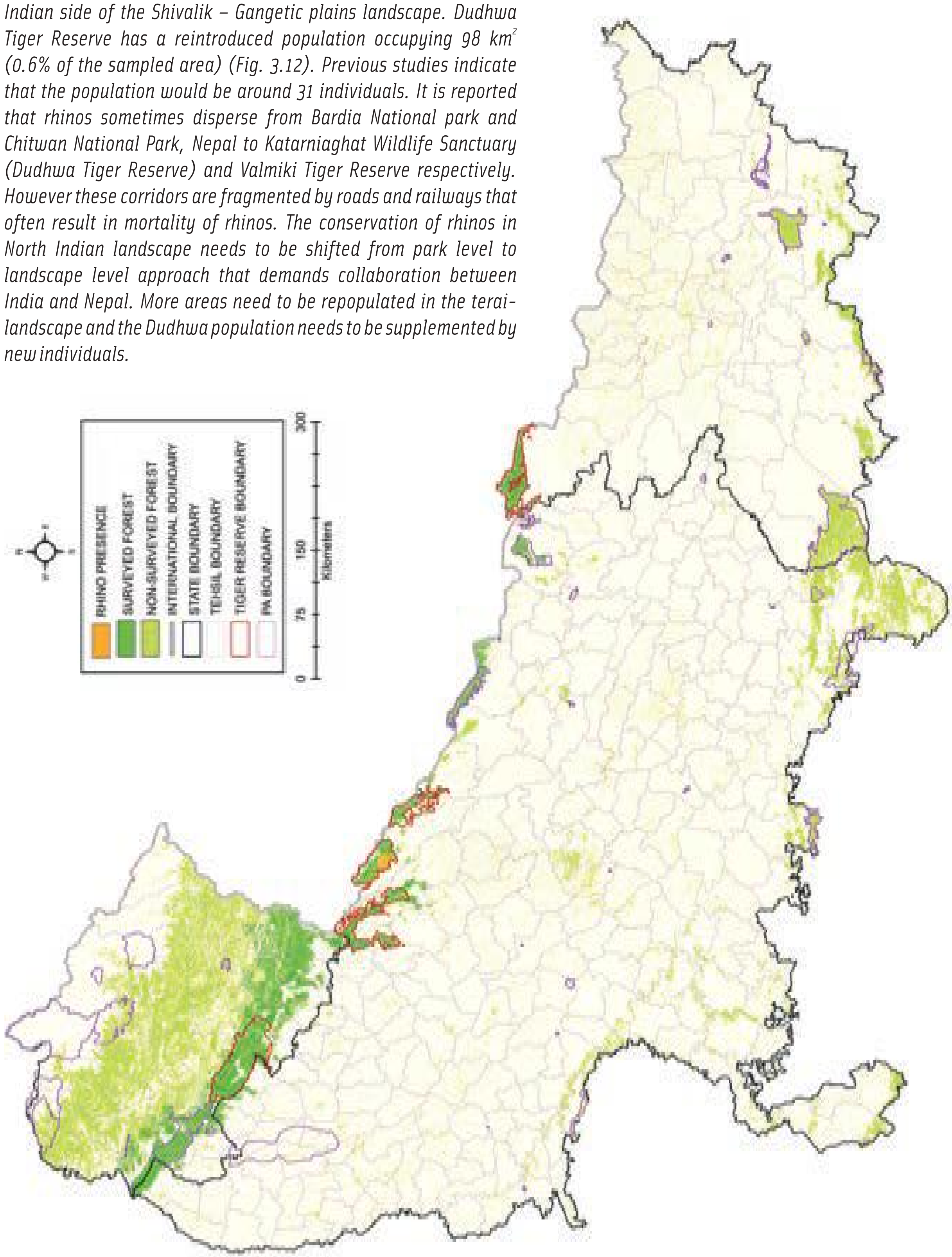
Figure 3.11: Distribution of Nilgai in the Shivalik Hills and Gangetic Plains Landscape.

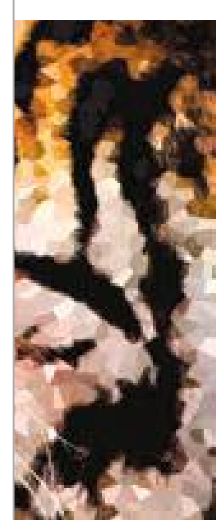


Greater One-horned Rhinoceros: Rhinoceros unicornis *(WPA: Schedule I, IUCN: Vulnerable)*

Rhinoceros were historically recorded to occur from the flood plains of Indus across the Gangetic terai to the Brahmaputra flood plains of Assam but now there are only two small populations occuring on the Indian side of the Shivalik – Gangetic plains landscape. Dudhwa Tiger Reserve has a reintroduced population occupying 98 km^2 (0.6% of the sampled area) (Fig. 3.12). Previous studies indicate that the population would be around 31 individuals. It is reported that rhinos sometimes disperse from Bardia National park and Chitwan National Park, Nepal to Katarniaghat Wildlife Sanctuary (Dudhwa Tiger Reserve) and Valmiki Tiger Reserve respectively. However these corridors are fragmented by roads and railways that often result in mortality of rhinos. The conservation of rhinos in North Indian landscape needs to be shifted from park level to landscape level approach that demands collaboration between India and Nepal. More areas need to be repopulated in the terai-landscape and the Dudhwa population needs to be supplemented by new individuals.

Figure 3.12: Distribution of Greater one horned rhinoceros in the Shivalik Hills and Gangetic Plains Landscape.

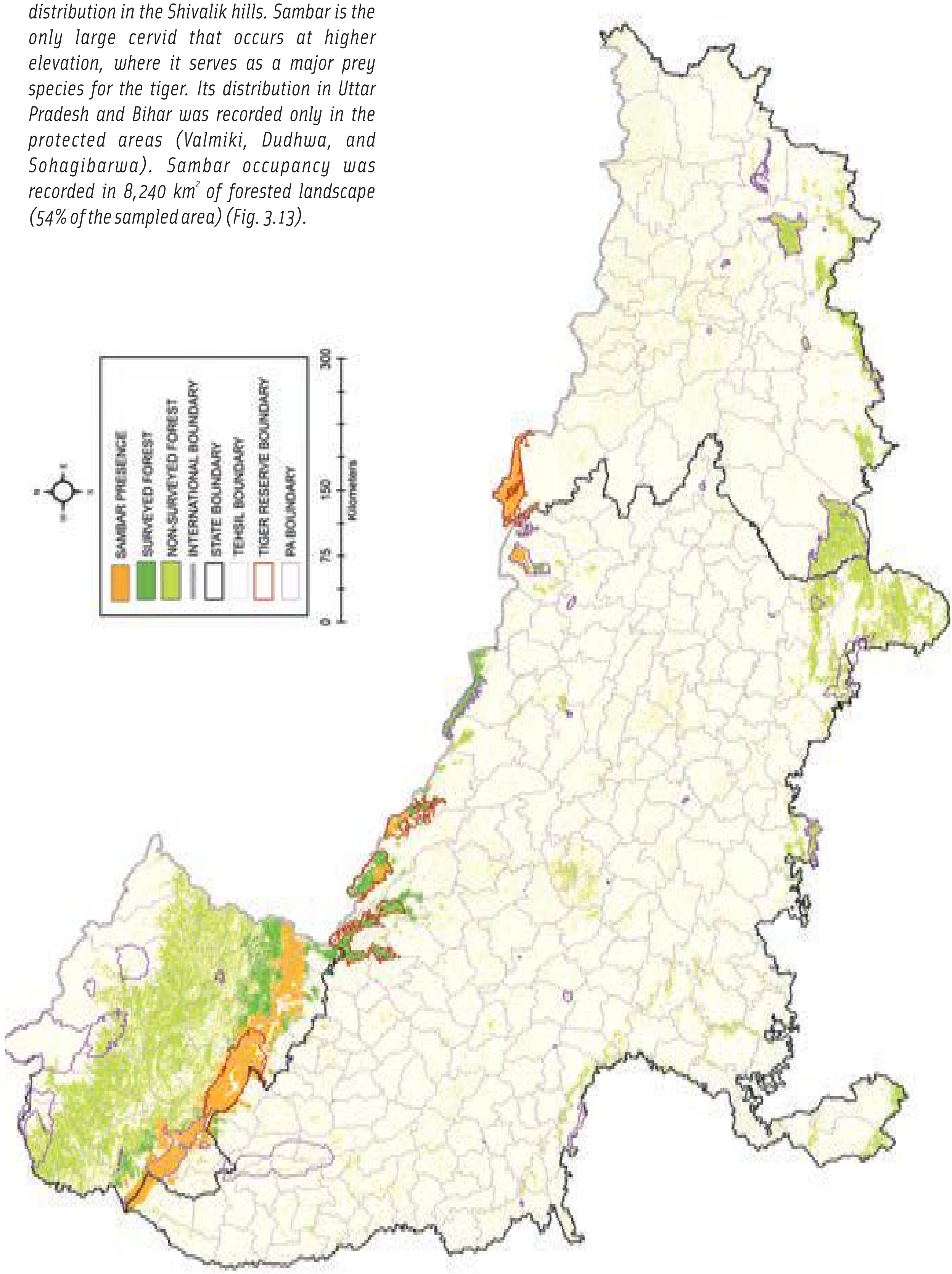




Sambar: **Rusa unicolor** ***(WPA: Schedule III, IUCN: Vulnerable)***

Sambar was recorded to have a continuous distribution in the Shivalik hills. Sambar is the only large cervid that occurs at higher elevation, where it serves as a major prey species for the tiger. Its distribution in Uttar Pradesh and Bihar was recorded only in the protected areas (Valmiki, Dudhwa, and Sohagibarwa). Sambar occupancy was recorded in 8,240 km² of forested landscape (54% of the sampled area) (Fig. 3.13).

Figure 3.13: *Distribution of Sambar in the Shivalik Hills and Gangetic Plains Landscape.*



Wild pig: Sus scrofa *(WPA: Schedule III, IUCN: Least concern)*

Wild pig was recorded to occur continuously throughout the surveyed area, covering the Himalayan foothills, Shivalik hills, Bhabhar tract and Terai plains. It has highest recorded occupancy of 11,346 km^2 in this landscape (75% of the sampled area) (Fig. 3.14). Wild pigs also occur in agricultural landscape and are a major concern for human-wildlife conflict due to their propensity to raid crops.

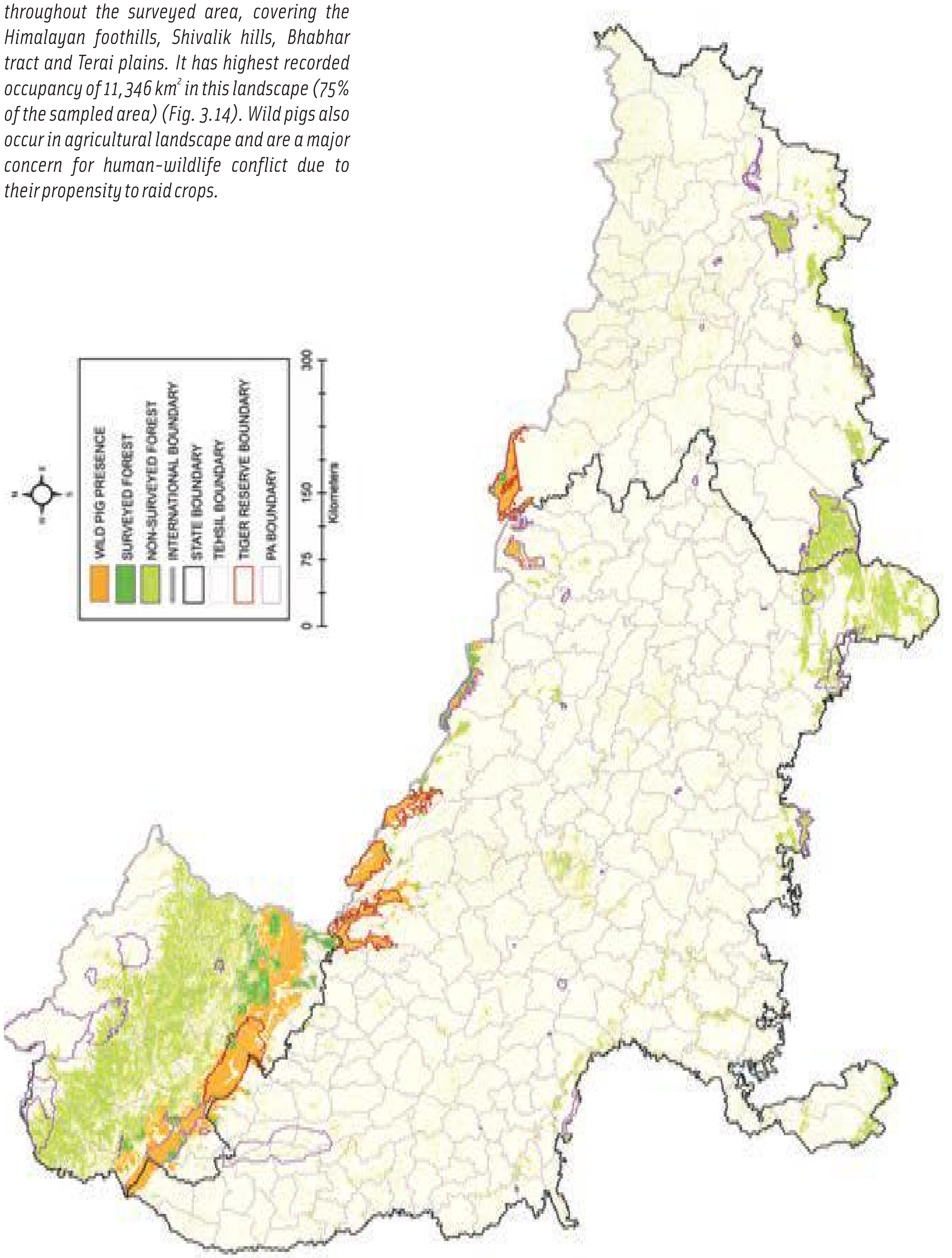
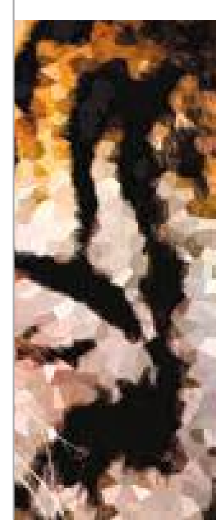


Figure 3.14: Distribution of Wild pigs in the Shivalik Hills and Gangetic Plains Landscape.



Major carnivores found in this landscape were striped hyena, wild dog, sloth bear and jackal.

Striped Hyena:* Hyaena hyaena *(WPA: Schedule III; IUCN: Near threatened)

During 2013–14 survey, the hyena was reported from Dudhwa, Valmiki, Suhelwa and Rajaji. Hyena was not reported inside Corbett National park but it occurs on the periphery of the protected area (in Lansdowne Reserve Forest). Its presence from Kaimur and Chandraprabha wildlife sanctuaries in the current assessment could not be ascertained since these areas were not sampled. In 2010, hyena was found to be abundant in Mirzapur forests, which was not sampled in the current year. The overall forested area occupied by hyena in Shivalik hills and Gangetic plains landscape was 1,644 km^2 comprising 11% of the sampled area (Fig. 3.15).

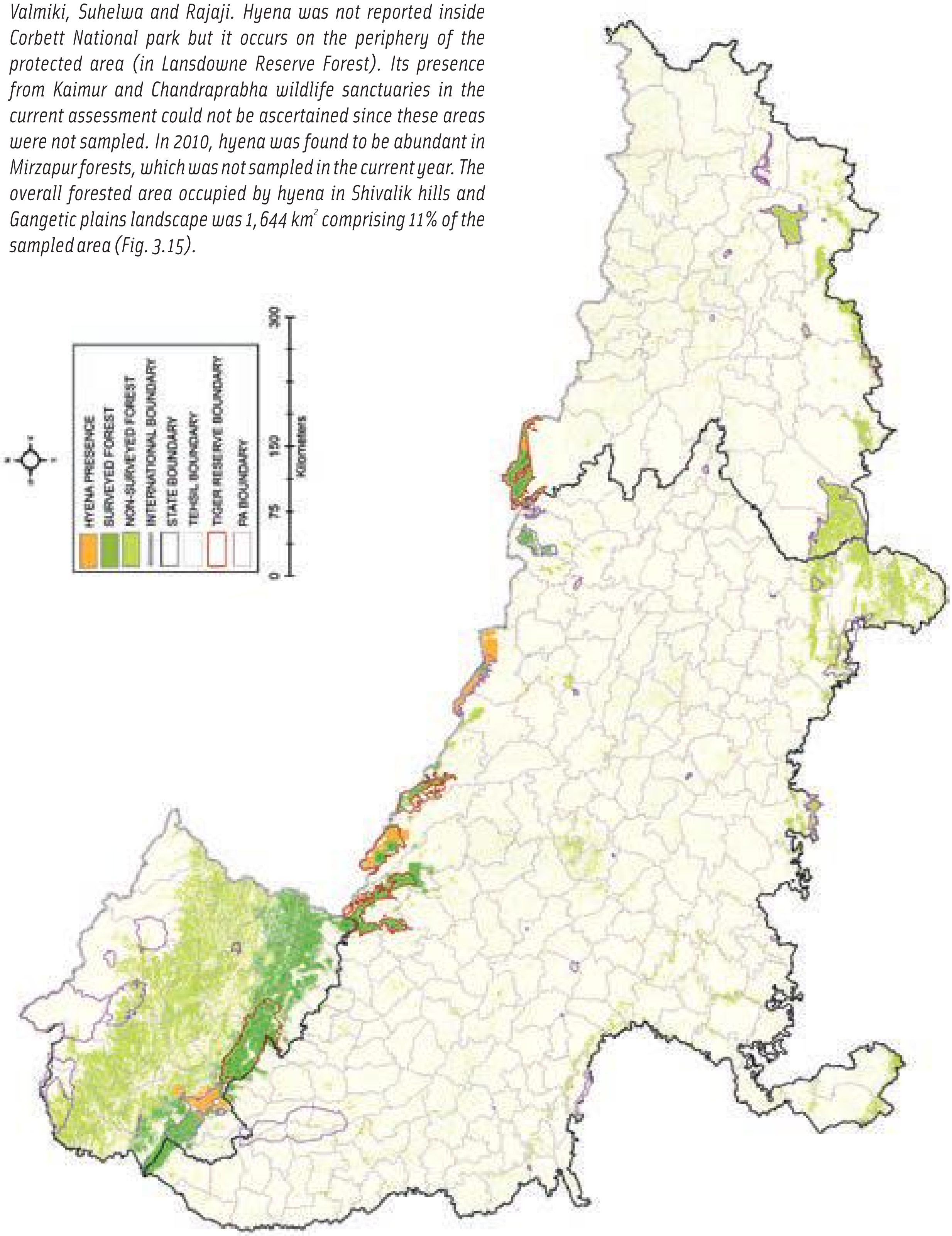
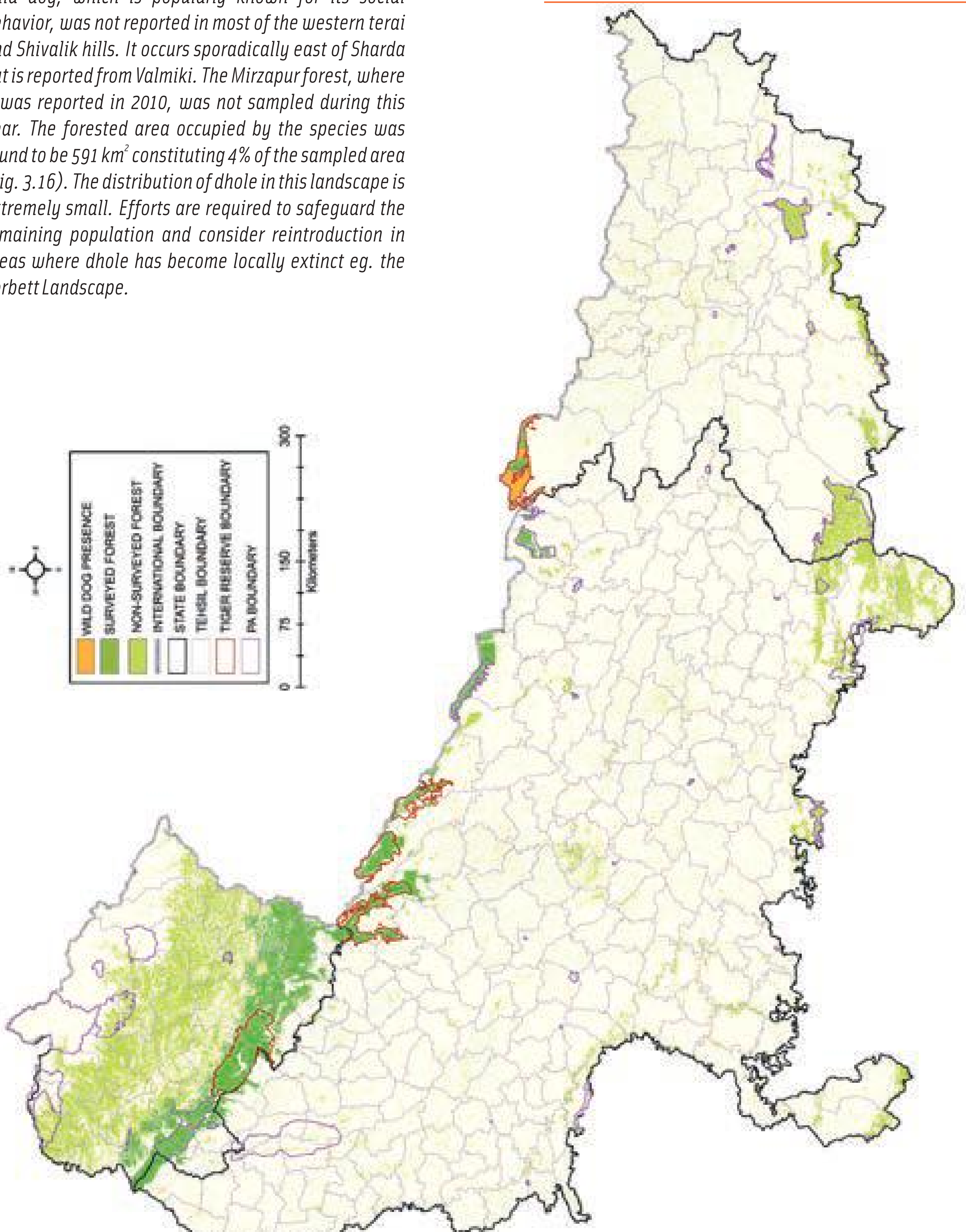


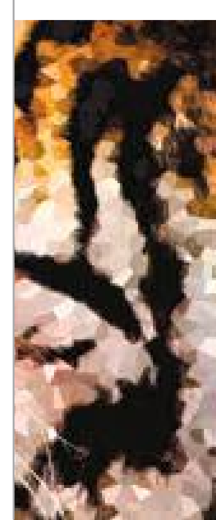
Figure 3.15: *Distribution of Hyena in the Shivalik Hills and Gangetic Plains Landscape.*

Wild Dog (Dhole): Cuon alpinus *(WPA: Schedule II; IUCN: Endangered)*

Wild dog, which is popularly known for its social behavior, was not reported in most of the western terai and Shivalik hills. It occurs sporadically east of Sharda but is reported from Valmiki. The Mirzapur forest, where it was reported in 2010, was not sampled during this year. The forested area occupied by the species was found to be 591 km² constituting 4% of the sampled area (Fig. 3.16). The distribution of dhole in this landscape is extremely small. Efforts are required to safeguard the remaining population and consider reintroduction in areas where dhole has become locally extinct eg. the Corbett Landscape.

Figure 3.16: Distribution of Wild dog (Dhole) in the Shivalik Hills and Gangetic Plains Landscape.

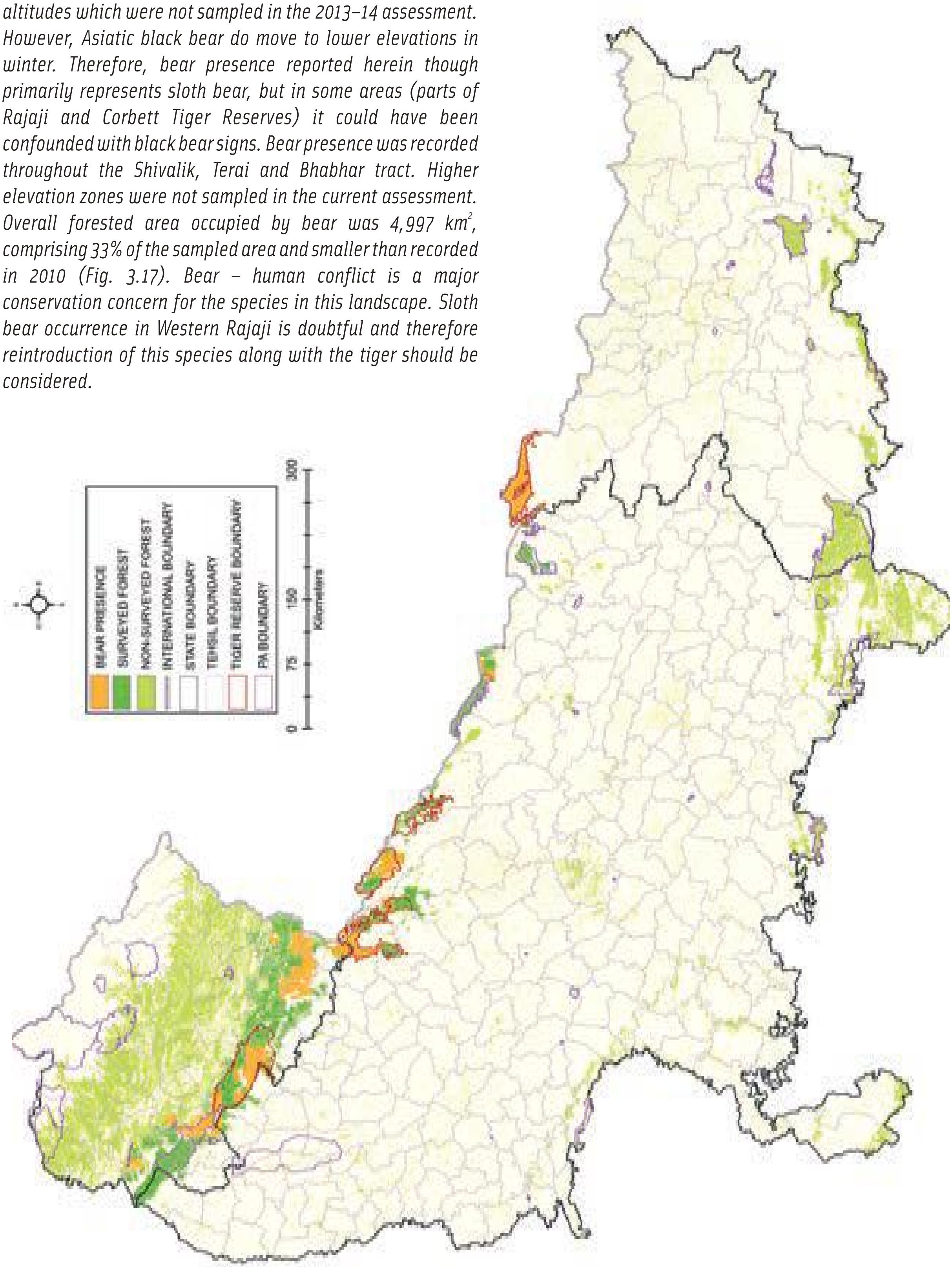




Sloth bear and Asiatic Black bear: Melursus ursinus & Ursus thibetanus *(WPA: Schedule II; IUCN Vulnerable)*

This landscape holds two species of bears viz., Asiatic black bear and sloth bear. Black bears range primarily in the higher altitudes which were not sampled in the 2013–14 assessment. However, Asiatic black bear do move to lower elevations in winter. Therefore, bear presence reported herein though primarily represents sloth bear, but in some areas (parts of Rajaji and Corbett Tiger Reserves) it could have been confounded with black bear signs. Bear presence was recorded throughout the Shivalik, Terai and Bhabhar tract. Higher elevation zones were not sampled in the current assessment. Overall forested area occupied by bear was 4,997 km², comprising 33% of the sampled area and smaller than recorded in 2010 (Fig. 3.17). Bear – human conflict is a major conservation concern for the species in this landscape. Sloth bear occurrence in Western Rajaji is doubtful and therefore reintroduction of this species along with the tiger should be considered.

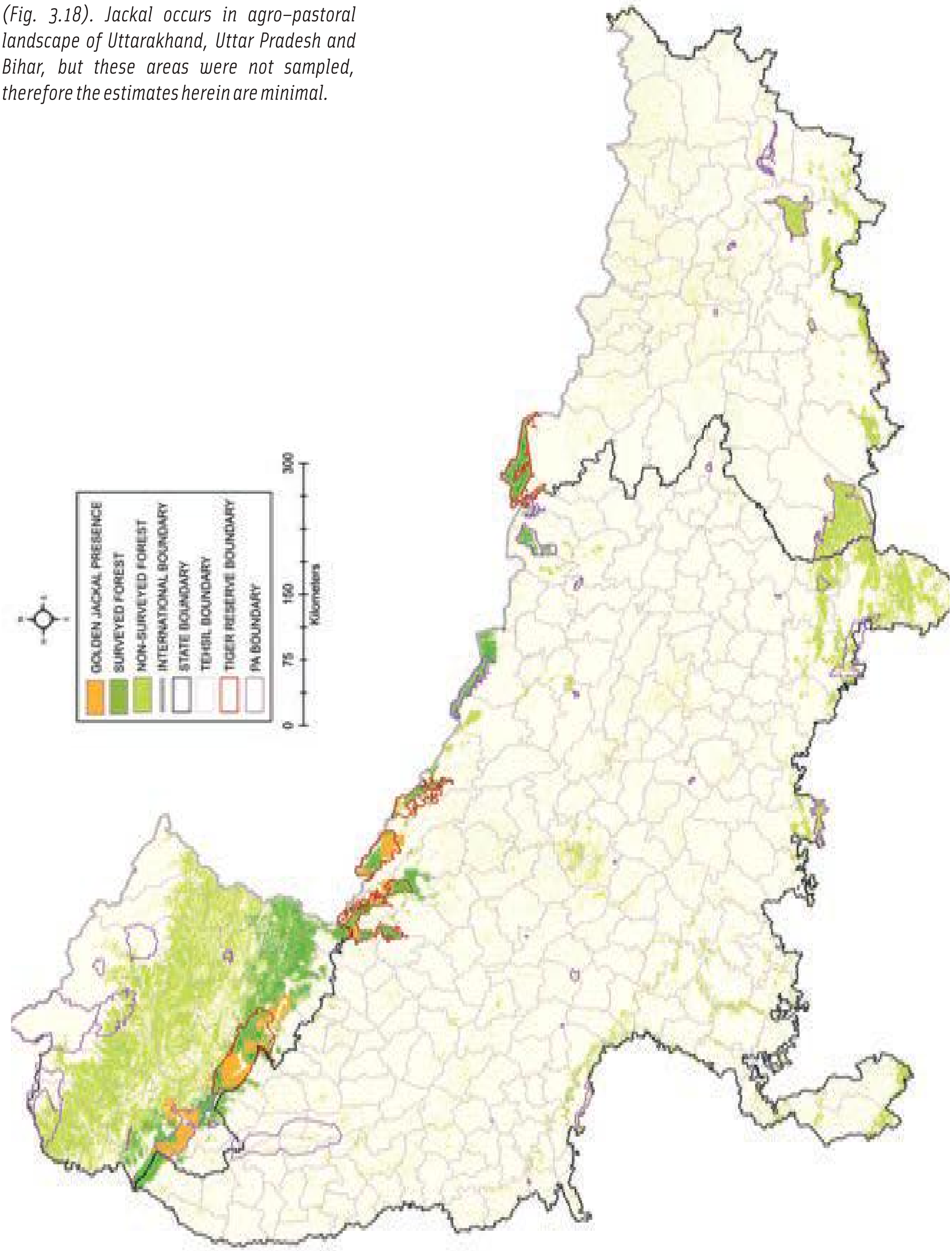
Figure 3.17: *Distribution of Bear (sloth and Asiatic black bear) in the Shivalik Hills and Gangetic Plains Landscape.*

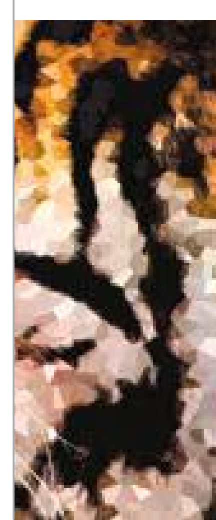


Golden Jackal: Canis aureus (WPA: Schedule II; IUCN: Least concern)

Jackal presence was recorded in an area of 3,033 km^2 comprising 20% of the sampled area (Fig. 3.18). Jackal occurs in agro–pastoral landscape of Uttarakhand, Uttar Pradesh and Bihar, but these areas were not sampled, therefore the estimates herein are minimal.

Figure 3.18: *Distribution of Golden jackal in the Shivalik Hills and Gangetic Plains Landscape.*





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Central Indian & Eastern Ghats Landscape

04

Y. V. Jhala, Qamar Qureshi, S. P. Yadav, H. S. Negi, R. Govekar, and Rajesh Gopal

Central India landscape comprises of the semi-arid zone of Rajasthan, central Indian plateau and includes parts of the Eastern Ghats. Parts of the Northern Western Ghats (Sahyadri) in Maharashtra are included here for convenience so as not to split the state into two landscapes. In this landscape, the total forested area surveyed in 2013-2014 assessment was 3,55,872 km^2. It is within this surveyed forest area that occupancy of each species is reported. Major Forest types found in this landscape are Dry Teak Forest, Moist Peninsular Sal Forest, Dry Deciduous Scrub and Grassland, Anogeissus pendula *and* Boswellia *Forest, Southern Dry Mixed Deciduous Forest, Northern Dry Mixed Deciduous Forest and Southern Moist Mixed Deciduous Forest (Champion and Seth 1968).*

The tiger occupies 41,974 km^2 with 688 (SE range 596-780) individuals in this landscape. Tiger status has improved in and around tiger reserves where existing habitat contiguity has permitted dispersing tigers to establish occupancy and in some places populations (Fig. 4.1). Notable improvements were observed in the state of Madhya Pradesh, while tiger populations of Maharashtra and Rajasthan have marginally increased. However, northern Andhra Pradesh, most parts of Odisha and Jharkhand continue to lose tiger occupancy and tiger abundance has declined here (Fig. 4.1). Chhattisgarh has shown an increase, but this is due to a commendable effort in surveying parts of Indravati Tiger Reserve, which was assessed for the first time in 8 years by sign surveys and genetic sampling.

This landscape has four significant populations namely Kanha-Pench, Tadoba-Navegaon-Nagzira, Satpura-Melghat, Bandhavgarh-Sanjay & Nagarjunasagar. All these populations depend on corridor connectivity for gene flow within each population block. Functionality of these corridors are challenged due to developmental projects like roads, railway, urban sprawl and mining. Appropriate mitigation measures are required to ensure that development projects do not become barriers to movement of wildlife. Simlipal harbours a unique population of melanistic tigers but faces major conservation challenges due to immense human pressure and poaching. This population requires urgent conservation attention as it is irreplaceable. Besides Simlipal other reserves where tiger populations can be augmented by restorative management are Sanjay Dubri, Palamau, Satkosia, Udanti-Sitanadi Tiger Reserves and Guru Ghasidas Nationa Park which needs to be brought under the Project Tiger umbrella. Sahyadri-Sindhudurg part of Western Ghats in Maharashtra is showing encouraging trends in tiger occupancy which is contiguous with Goa and Karnataka. Madhya Pradesh has done commendable work in relocating villages to restore habitat as well as providing special attention to the existing corridors. Madhya Pradesh has also successfully experimented with translocation of large herbivores like gaur, barasingha and blackbuck. Due to fragmented nature of Central Indian Landscape habitat corridors connecting tiger population are key to the future survival of these populations.

The tiger occupancy was modeled using variable defining prey and habitat quality.

Seven principal components explained 62% variation in the original covariate data of Central India. The component loadings were ecologically explainable as shown in Table 4.1.

The best model which explained tiger occupancy contained seven Principal Components which represented prey abundance, human-livestock impacts, remote protected forests, and urban sprawl (Table No. 4.2 & 4.3). Correcting for detection bias improved the naive estimate of occupancy by 2% (from 6.9 to 8.8, SE 0.36) %. The detection probability of tiger sign on a single survey was 27 (SE 0.4) % in the Central Indian & Eastern Ghat landscape.

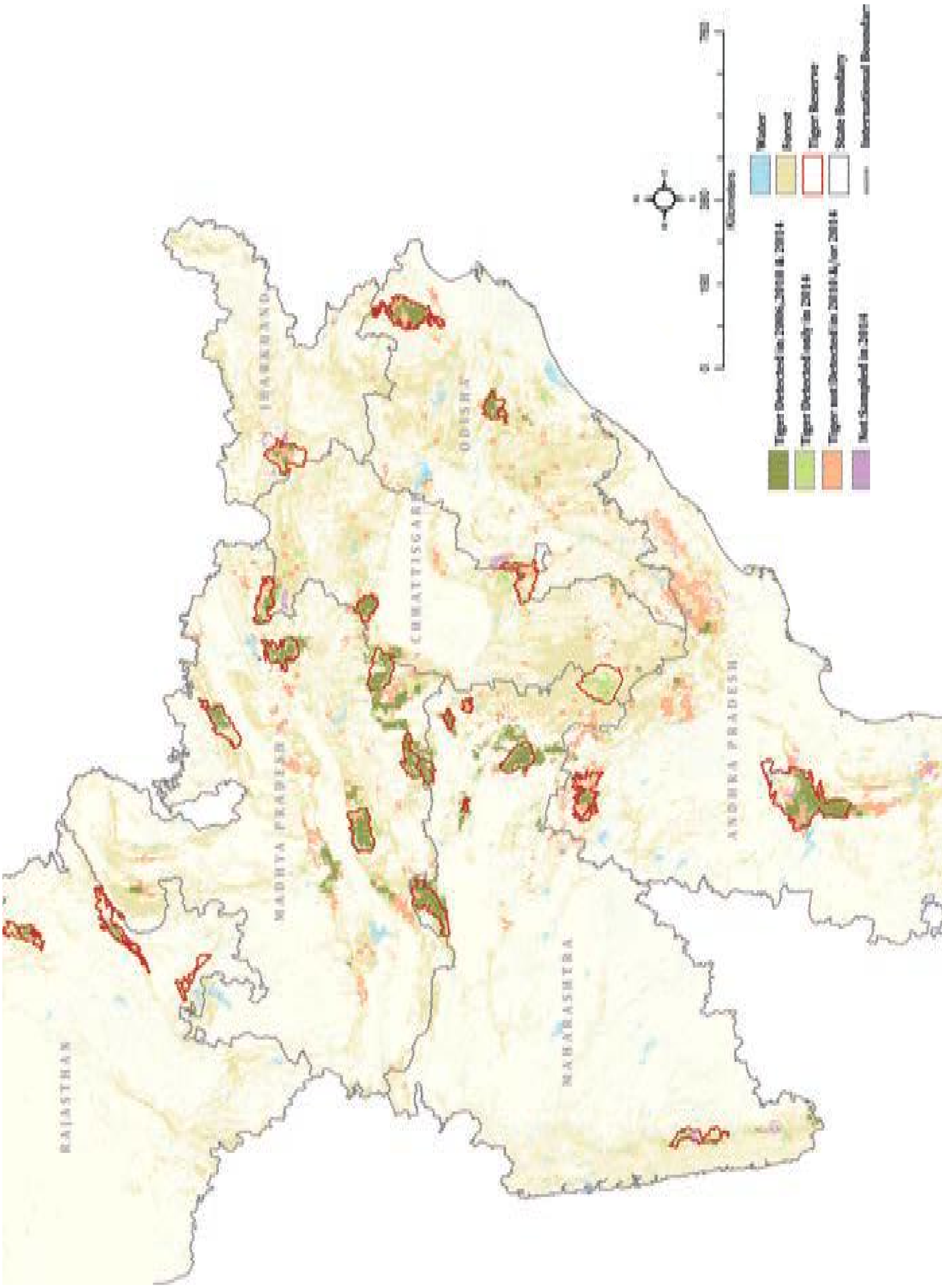
Table 4.1: Principal component loadings after varimax rotation of covariates from the Central Indian & Eastern Ghat landscape. The cumulative percent variation explained by 7 components was 62%.

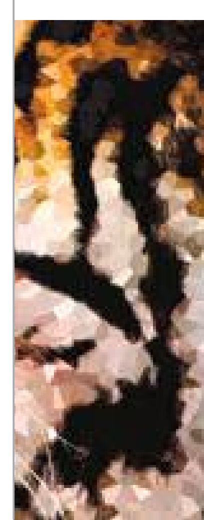
Variables	PC-1 - Protected Forest with wild prey	PC-2- Protected Dense Forest	PC-3- Human Disturbance	PC-4- Open forests -Nilgai	PC-5- Rugged High Elevation Terrain	PC-6- Small prey	PC-7- Gaur
Encounter Rate of Chital	0.80						
Pellet Count of Chital	0.76						
Encounter Rate of Sambar	0.71						
Pellet Count of Sambar	0.69						
Distance from Protected Areas	-0.47	-0.36					
Encounter Rate of Wild Pig	0.45					0.41	
Mean NDVI for Post-monsoon		0.81					
Mean NDVI for Pre-monsoon		0.81		-0.32			
Core Area	0.30	0.66					
Nightlights Area		-0.47		-0.46			
Canopy Cover		0.45					
People Seen			0.87				
Livestock Seen			0.83				
Human Tail			0.80				
Encounter Rate of Nilgai				0.78			
Pellet Count of Nilgai				0.76			
Elevation					0.95		
Ruggedness		0.39			0.84		
Pellet Count of Barking Deer						0.75	
Encounter Rate of Barking Deer						0.68	
Pellet Count of Wild Pig						0.54	
Pellet Count of Gaur							0.76
Encounter Rate of Gaur							0.74

Table 4.2: Competing models tested and model selection using AIC for modelling tiger occupancy in Central India to account for detection bias and influence of covariates.

Model	AIC	Δ AIC	AIC wgt	No. of Parameters	-2Log (likelihood)
Ψ(PC1 + PC2 + PC3 + PC4 + PC5 + PC6 + PC7), p(Tiger Sign)	12044.54	0.00	0.99	10.00	6012.27
Ψ(PC1 + PC2 + PC3 + PC4 + PC6 + PC7), p(Tiger Sign)	12053.85	9.30	0.01	9.00	6017.92
Ψ(PC1 + PC2 + PC3 + PC6 + PC7), p(Tiger Sign)	12058.22	13.68	0.00	8.00	6021.11
Ψ(PC1 + PC3 + PC6 + PC7), p(Tiger Sign)	12105.20	60.65	0.00	7.00	6045.60
Ψ (PC1 + PC3 + PC7), p(Tiger Sign)	12113.64	69.10	0.00	6.00	6050.82
Ψ(PC1 + PC3), p(Tiger Sign)	12150.46	105.92	0.00	5.00	6070.23
Ψ(PC1), p(Tiger Sign)	12254.35	209.81	0.00	4.00	6123.18
Ψ(.),p(Tiger Sign)	13002.10	957.55	0.00	3.00	6498.05
Ψ(.),p(.)	15273.84	3229.29	0.00	2.00	7634.92

Figure 4.1: Changes in tiger distribution in the Central Indian & Eastern Ghats Landscape from 2006 to 2014.





The modelled tiger occupancy represents habitat suitability for tigers based on landscape characteristics, prey abundance, and human disturbance (Fig. 4.2). The correction for detection bias only increased the estimated occupancy by 1.9% this marginal increase was because detection probability for tiger sign was high at 27% (SE 0.4%) for each survey with several replicate surveys in each grid. The camera trapping effort in this landscape is larger in comparison to previous sampling years.

Figure 4.2: Occupancy probability map of tigers obtained by accounting for detection bias and ecological covarites in the Central Indian and Eastern Ghat Landscape.

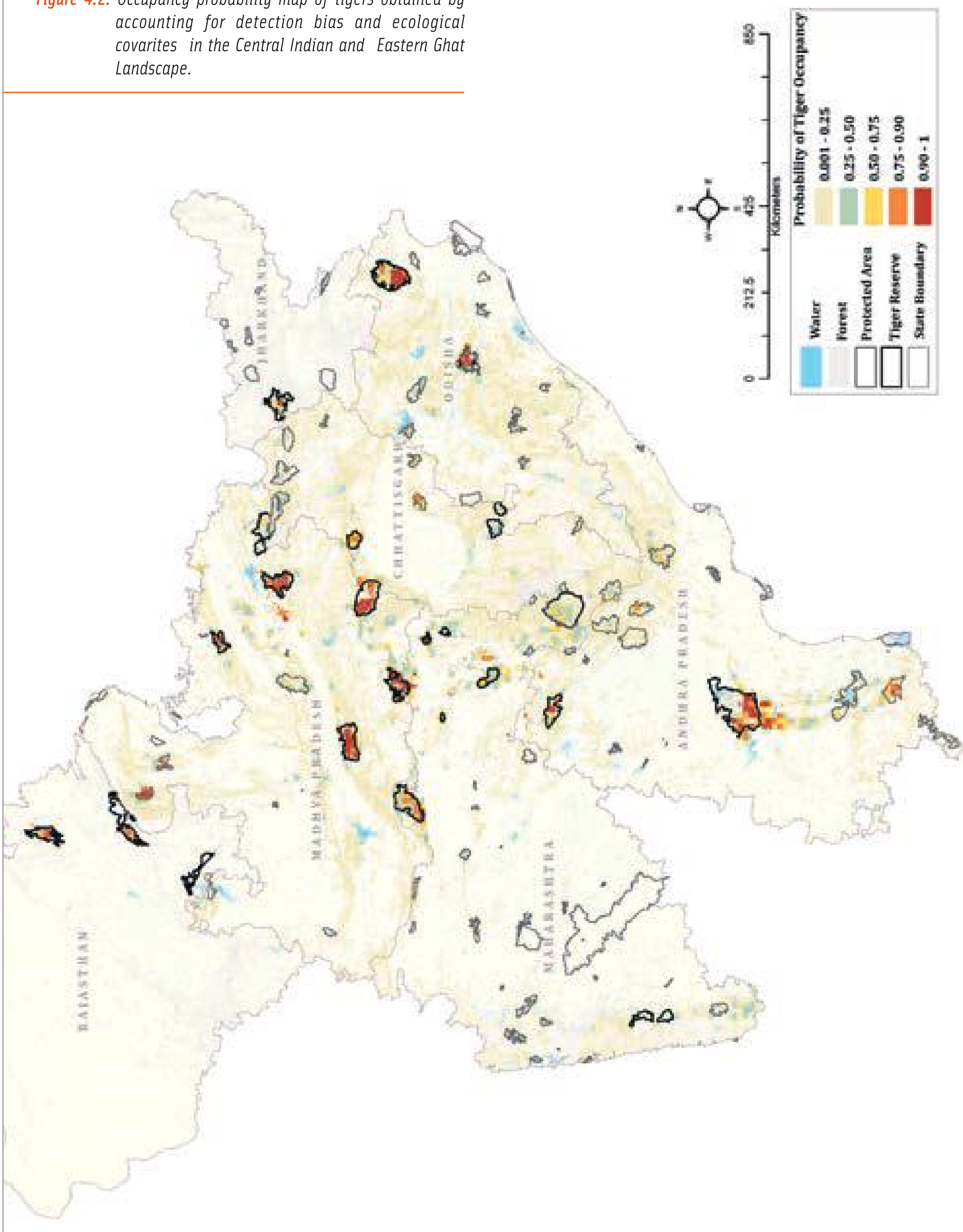


Table 4.3: *Coefficients of the best model explaining tiger occupancy in Central Indian & Eastern Ghat Landscape.*

	Variables	Estimate	Standard Error
A1	Constant	-2.71	0.07
A2	PC1	1.05	0.06
A3	PC2	0.38	0.06
A4	PC3	-0.61	0.08
A5	PC4	0.15	0.06
A6	PC5	0.20	0.06
A7	PC6	0.21	0.05
A8	PC7	0.23	0.04
B1	p1	-1.92	0.04
B2	p1.Tiger Sign	0.42	0.01

Total of 12,951 tiger photo-captures of 396 individual tigers were obtained from within this landscape. The best joint likelihood covariate model that explained tiger density had tiger sign intensity, prey abundance, and human footprint index as covariates (Table 4.4, Table 4.5).

Table 4.4: *Model selection for tiger density estimation using covariates in SECR for Central Indian & Eastern Ghat Landscape.*

Model	Detection Function	No. Parameters	Log Likelihood	AIC	ΔAIC
D~tigps + hl + PreyER	Halfnormal	6	-14181.55	28375.09	0
D~tigps + PreyDung + PreyER	Halfnormal	6	-14181.84	28375.69	0.60
D~tigps + PreyER	Halfnormal	5	-14183.21	28376.41	1.32
D~tigps + PreyDung	Halfnormal	5	-14188.58	28387.17	12.08

hl = Human disturbance index, tigps= tiger sign index, PreyER= Wild Prey Encounter rate

Table 4.5: *Model coefficients of best covariate model for estimating tiger density in Central Indian & Eastern Ghat Landscape.*

Parameter	beta	SE.beta
Density	-8.882	0.082
tigps	0.258	0.028
hl	-0.229	0.138
preyER	0.194	0.051
g0	-4.452	0.025
Sigma	7.992	0.011

hl = Human disturbance index, tigps= tiger sign index, PreyER= Wild Prey Encounter rate

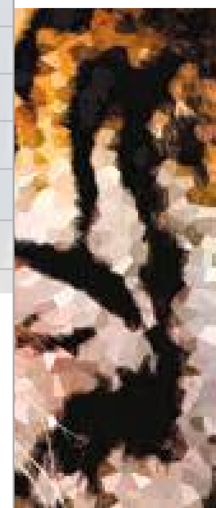
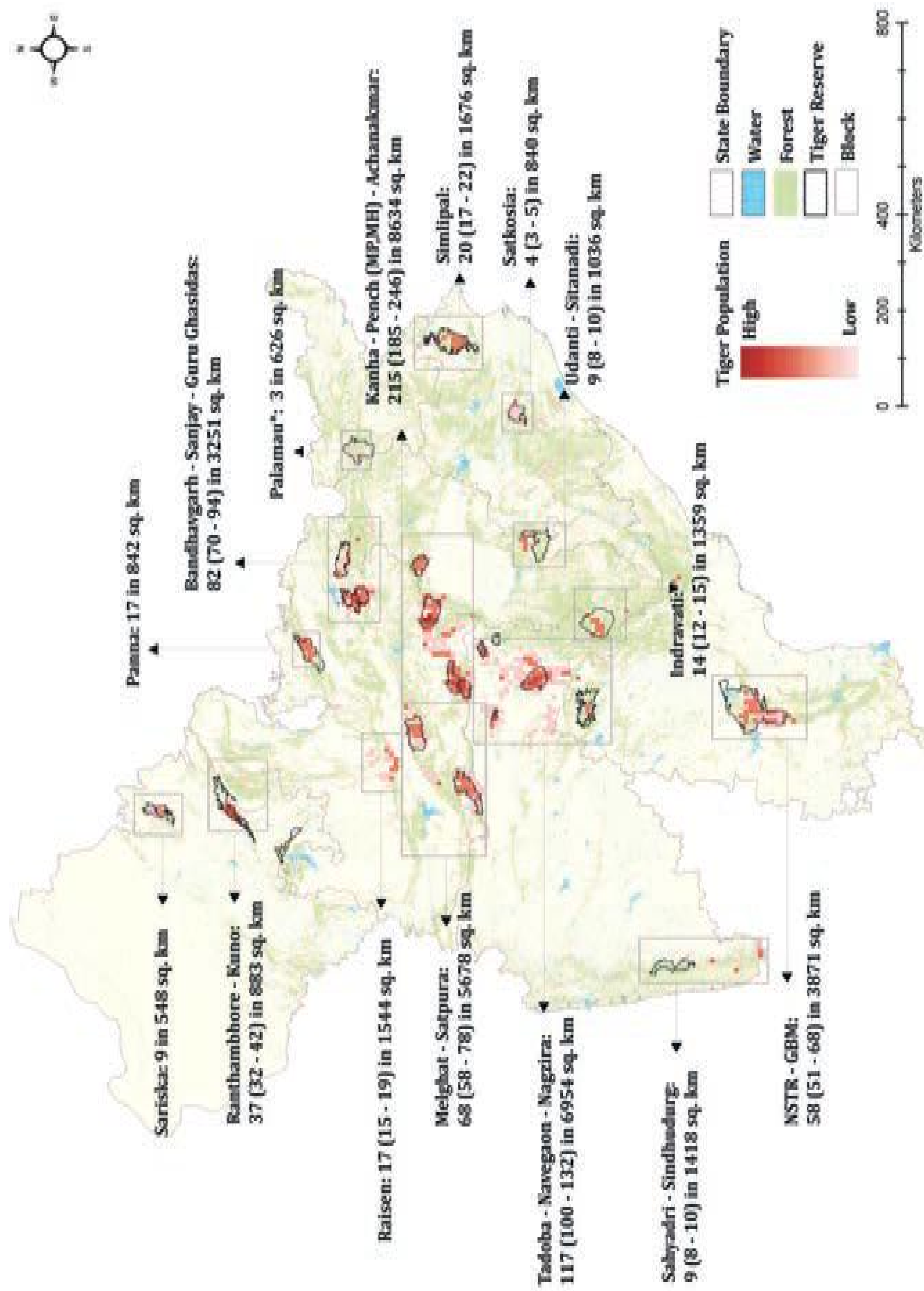


Figure 4.3: *Tiger density, extent and population blocks within the Central Indian & Eastern Ghats Landscape.*



The state of Madhya Pradesh and Maharashtra has shown a good increase in tiger population and occupancy. (Table 2.1, Fig 4.3). The Kanha-Pench source population now numbering around 215 tigers has repopulated much of the intervening habitat corridor and forests of Balaghat and Seoni. However, the eastward extension of this tiger population has been slow with tigers yet to establish populations in Phen Wildlife Sanctuary and subsequently disperse into Achanakmar Tiger Reserve. The corridor connectivity between Kanha-Achanakmar-Bandhavgarh is in poor condition and needs inputs to ensure gene flow in this part of the landscape. The Tadoba Tiger Population now encompasses Bor, Navegoan-Nagzira Tiger reserves and may have connectivity extending south into Kawal and eastwards into Indravati as well. This population block has about 117 tigers occupying over 6890 km^2. Both Panna and Sariska tiger reserves are on their way to recovery after reintroductions, but face new challenges from developmental projects and lack of resources for resettlement of habitation from core areas of the tiger reserves. Ranthambore tiger population would benefit from restorative management of the satellite reserves of Keladevi, Mukundhara, Ramgarh and Kuno Wildlife Sanctuary as well as maintenance of habitat connectivity between them. Bandhavgarh population has acted as a source to populate Sanjay and tigers now occur in Guru Ghasidas National Park as well and together contain over 80 tigers. Habitat connectivity between these protected areas is vital for long-term survival of tigers in this landscape. Development in the form of mining projects road and railways are likely to come up rapidly in the region, appropriate mitigation measures and conservation strategies need to be built into these projects right from the inception stage to minimize their impacts on tigers and the biodiversity values they represent in this landscape.

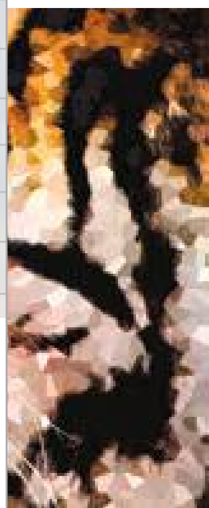
Leopard:* Panthera pardus *(WPA: Schedule I; IUCN: Near threatened)

Leopard distribution was almost contiguous across the forested landscape of central India (Fig. 4.4). Eastern portion of Rajasthan (Ranthambhore, Ramgarh Bisdhari) along with North-Western part of Madhya Pradesh (Kuno WLS) comprises a geographically seperate population whereas the rest of the Madhya Pradesh, eastern Maharashtra, Chhattisgarh, Jharkhand, Odisha, and northern Andhra Pradesh has a contiguous leopard distribution which probably exhibits a meta-population structure. The Northern Western Ghats in Maharashtra were almost contiguously occupied by the species forming a large population. On the eastern slopes of Western Ghats and the adjoining Deccan plateau, leopards are known to occupy the agro pastoral landscape and fragmented forest and scrub patches. There might be a potential connectivity amongst different populations of leopards in central India through Vindhyan ranges, Aravalli hill ranges and central highlands; which are connected by forested landscape. Leopards are also known to use and persist in an agro-pastoral matrix when these are close to a source population in a forested region. The total area occupied by leopard was 1,09,512 km^2 comprising 31% of the sampled area (Fig. 4.4). The tolerance of local communities towards leopards in the proximity of their settlements is high compared to hill communities of Uttarakhand and Himachal Pradesh. This also suggests that conflict levels with leopard are relatively low.

Leopard density in this landscape was computed from a total of 23 camera trapped sites. A total of 9679 leopard photo-captures were obtained from which 665 individual leopards were identified. The best models selected in SECR had human footprint index, prey abundance, canopied forests, and tiger sign intensity as covariates (Tables 4.6 & 4.7). The total population of leopard in the sampled forests of Central Indian landscape was 4457 (SE range 3873-5040).

Table 4.6: *Covariate models and model selection using a joint likelihood framework in SECR for estimating leopard density in the Central Indian & Landscape.*

Model	Detection Function	No. Parameters	Log Likelihood	AIC	■AIC
D~leops + hl + PreyER + ndvioct	Halfnormal	7	-9551.25	19116.51	0
D~leops + tigpst + hl + PreyDung + ndvioct	Halfnormal	8	-9550.75	19117.5	0.99
D~leops + hl	Halfnormal	5	-9576.58	19163.15	46.64
D~leops + ndvioct	Halfnormal	5	-10332.2	20674.4	1557.89
D~leops + rugg + PreyDung	Halfnormal	6	-10360.4	20732.82	1616.31
D~leops	Halfnormal	4	-10372.6	20753.28	1636.77



In Sariska leopard density before release of tigers was 5.7/100 km^2 which reduced to 3.3/100 km^2 post tiger reintroduction (Monadal et al 2012). Leopard density in Satpura was reported to range from 7.3 to 9.3/100 km^2 (Edgaonkar, 2008), the current study estimates it at 8.27/100 km^2. The leopard density was also estimated in human-dominated landscape in Maharashtra as 4.8/100 km^2 (Athreya, 2013).

Table 4.7: *Coefficients for the best covariate model in SECR for estimating leopard density in Central Indian & Eastern Ghat Landscape.*

Parameters	betaSE.beta
Density	-7.600.06
leops	0.090.02
hl	0.240.05
PreyER	0.050.05
ndvioct	-0.300.04
g0	-4.090.03
Sigma	7.710.01

leops= Leopard sign index , hl = Human disturbance index, PreyER= Wild Prey Encounter rate, ndvdvioct = NDVI post monsoon.

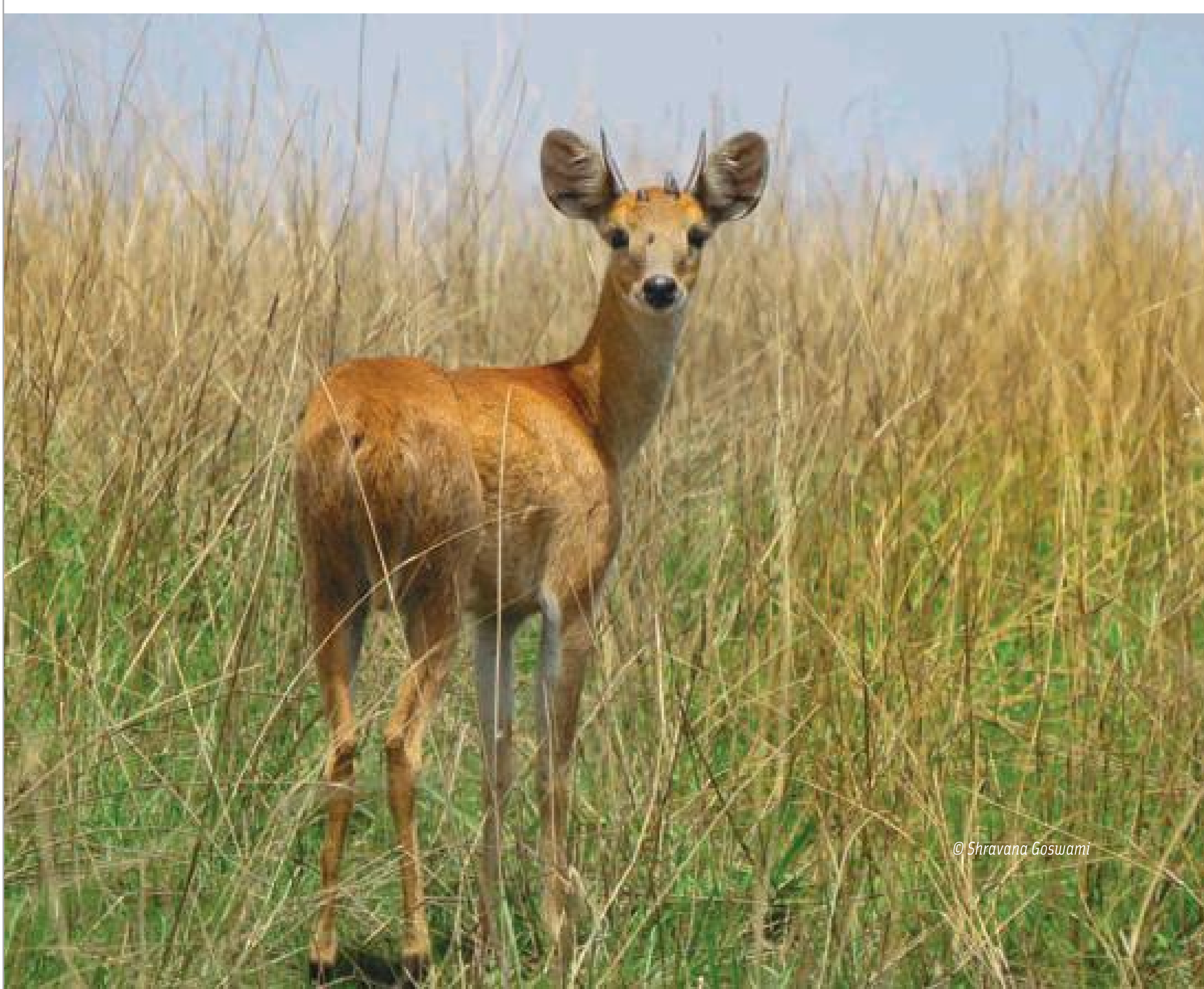


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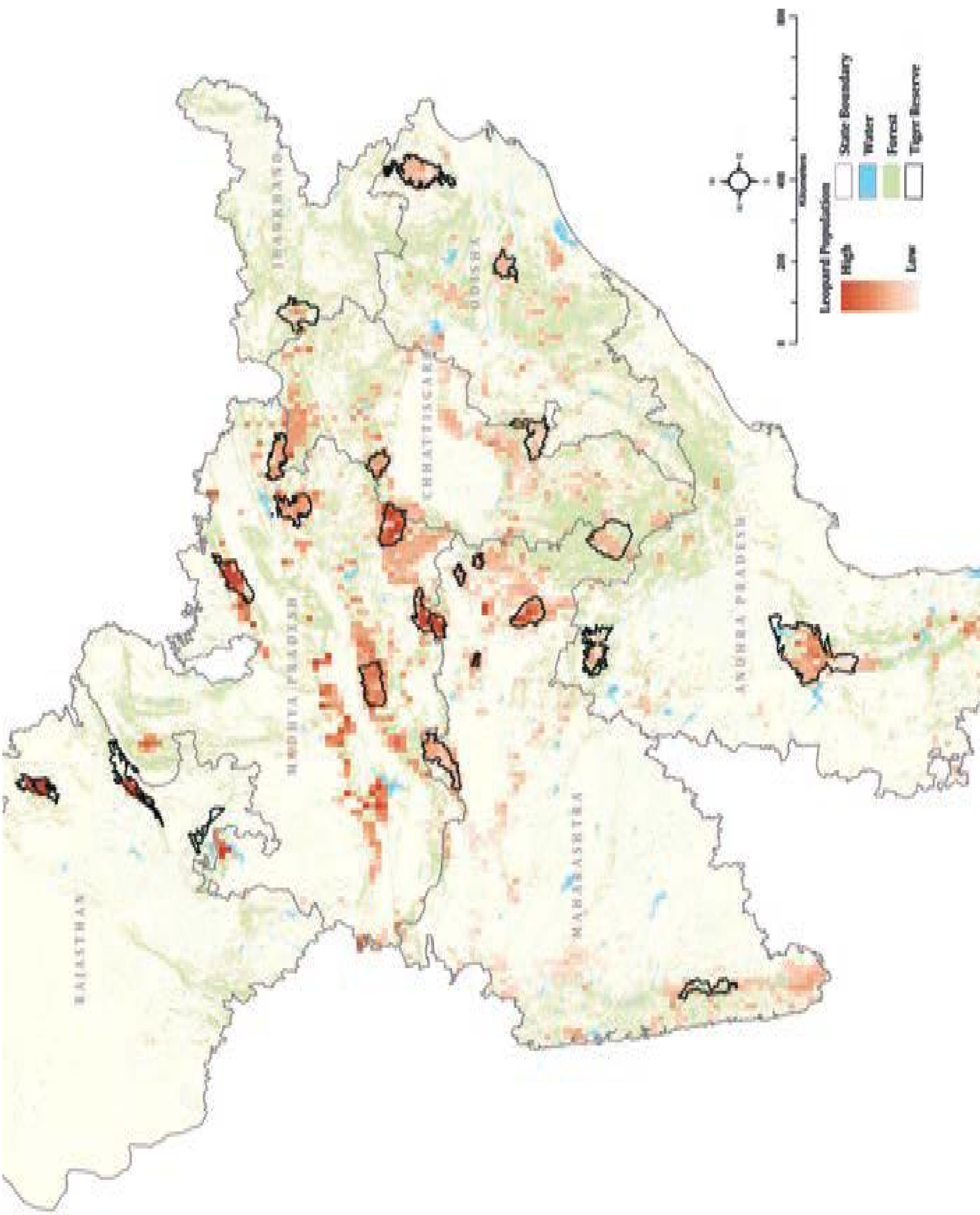
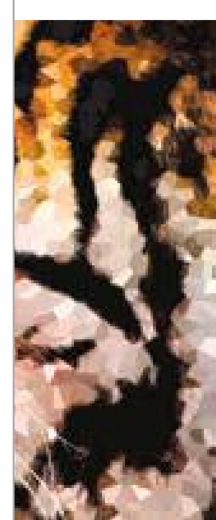
Figure 4.4. *Spatially explicit leopard density map obtained by joint likelihood covariate model in SECR for Central Indian & Eastern Ghat Landscape*



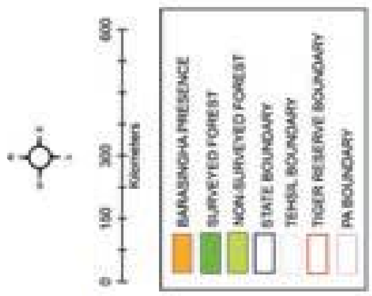


Occupancy of major prey species in Central Indian & Eastern Ghats Landscape

Major ungulate species found in this landscape are chital, sambar, barking deer, barasingha, gaur, elephant, wild buffalo, chausingha, wild pig and nilgai. Out of these, wild buffalo, gaur, elephant, barasingha are listed in Schedule I of the Indian Wildlife (Protection) Act, 1972.

Barasingha: Cervus duvaucelii *(WPA: Schedule I, IUCN: Vulnerable)*

The only population of hard ground Barasingha in India is present in the Kanha Tiger Reserve of this landscape. Barasingha was recorded to occupy 564 km² (0.2% of the sampled area) (Fig. 4.5). It prefers marshes and grasslands, or woodlands with understory of grasses. Once on the verge of extinction, in-situ predator proof fencing has helped to rebuild the free ranging population which was continuously augmented from the enclosures. Based on habitat similarity and site assessment another population has been recently reintroduced in the Satpura Tiger Reserve within the same landscape.



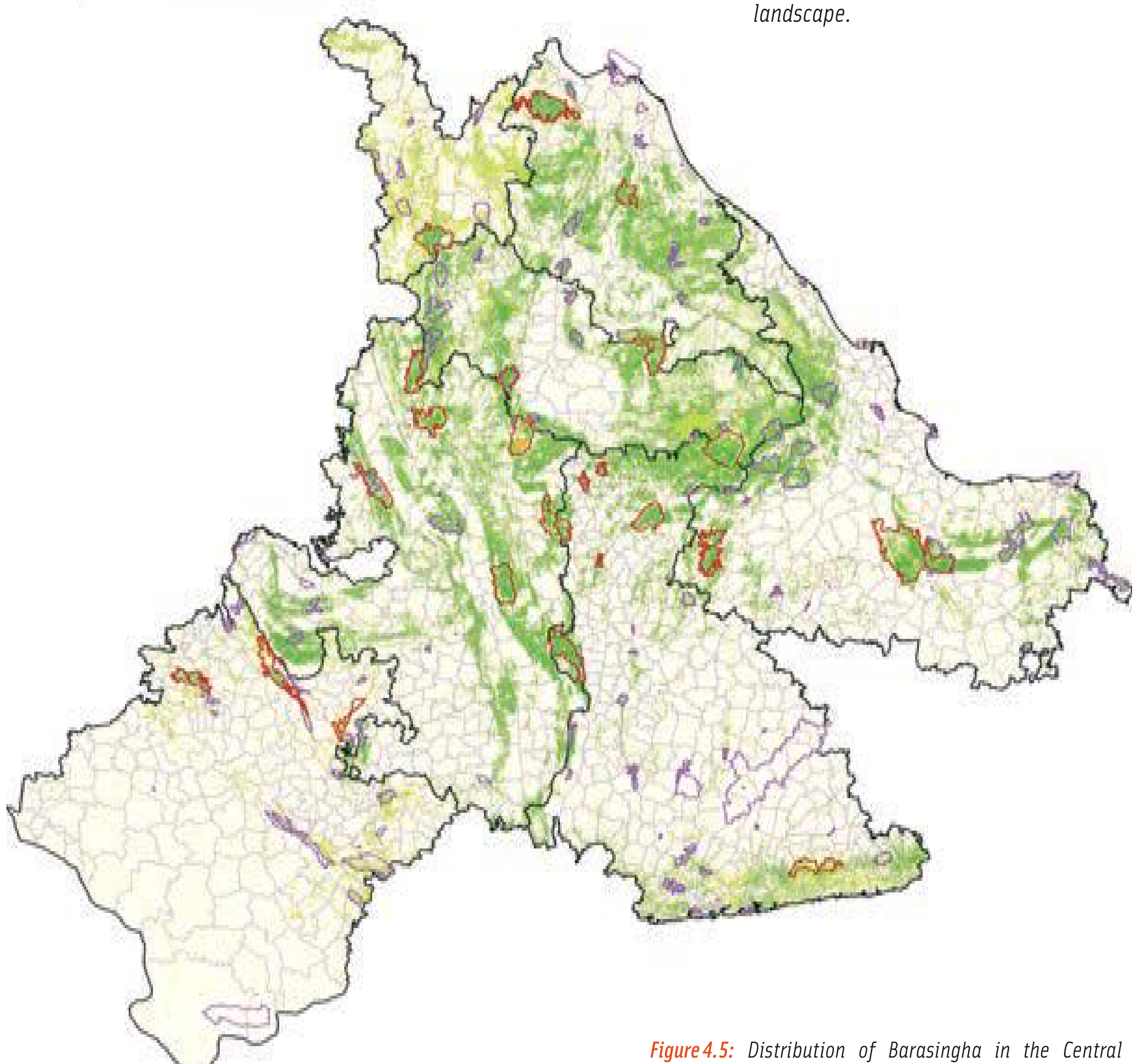
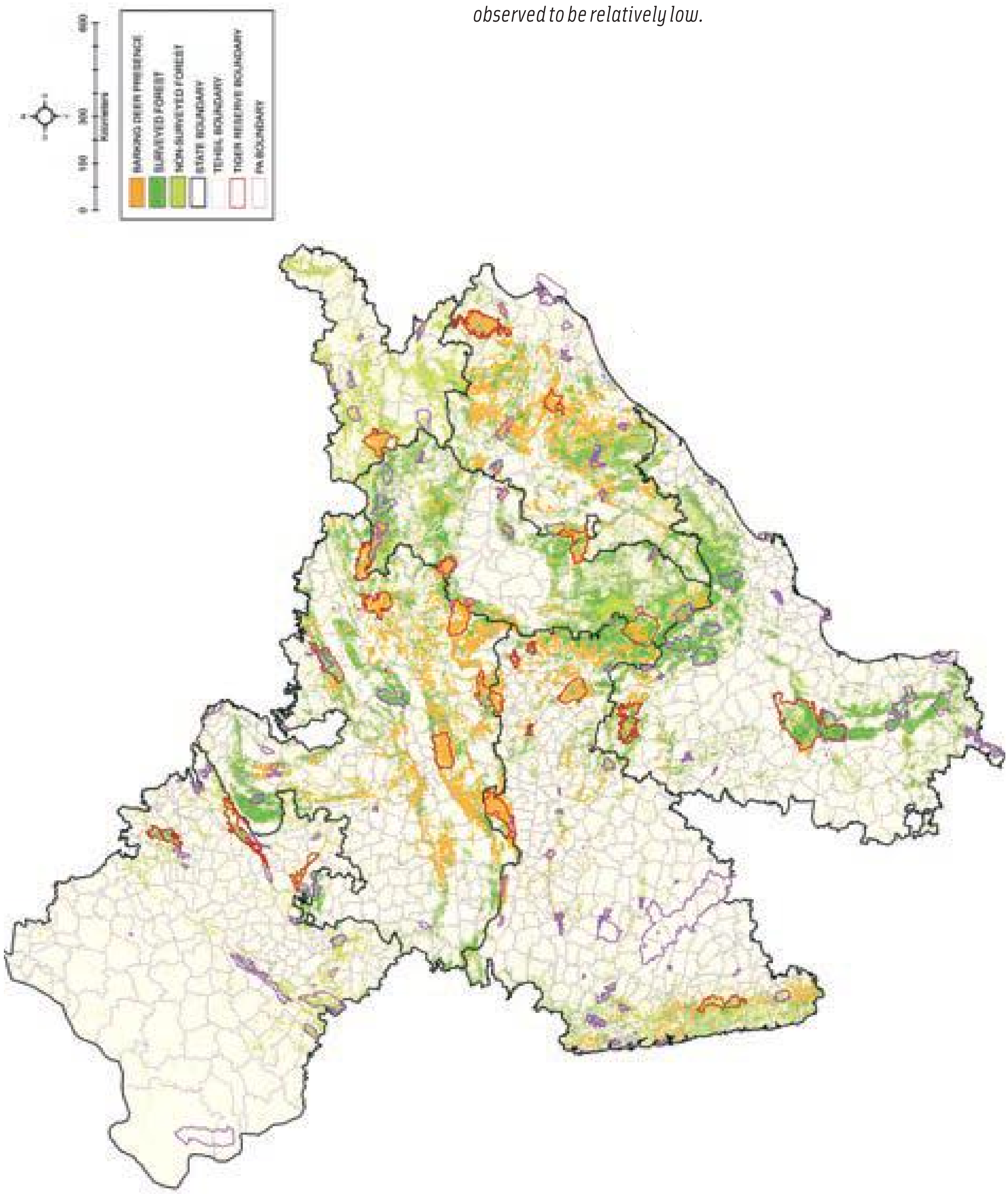


Figure 4.5: Distribution of Barasingha in the Central Indian & Eastern Ghat Landscape.

Figure 4.6: *Distribution of Barking deer in the Central Indian & Eastern Ghat Landscape.*

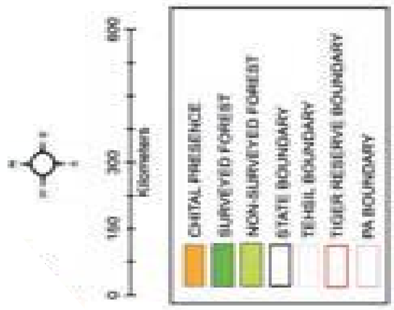


Barking Deer: Muntiacus muntjac *(WPA: Schedule III, IUCN: Least concern)*

Barking deer was recorded to have a wide distribution in all the surveyed areas excluding the surveyed parts of Rajasthan and Kuno Wildlife Sanctuary. It occupies 120,264 km² of forested landscape (34% of the sampled area) (Fig. 4.6). In central India and Northern Western Ghats barking deer was reported to occur in and around the protected areas and in corridor habitat. Its occurrence in Southern Chhattisgarh and Eastern and Southern Andhra Pradesh was observed to be relatively low.

Chital: Axis axis (WPA: Schedule III, IUCN: Least concern)

Chital was distributed throughout the surveyed area and was recorded to occupy 109,488 km^2 of forested landscape (31% of the sampled area) (Fig. 4.7). In Rajasthan chital occupancy was restricted only to the Tiger Reserves due to sampling inadequacy; while in other parts of the landscape, chital was distributed in the forested areas around the protected areas and in many of the corridor habitats as well. The recorded occupancy was highest in the South Eastern Madhya Pradesh and Eastern Maharashtra landscape. Northern-Western Ghats and Odisha has relatively low occupancy of chital.



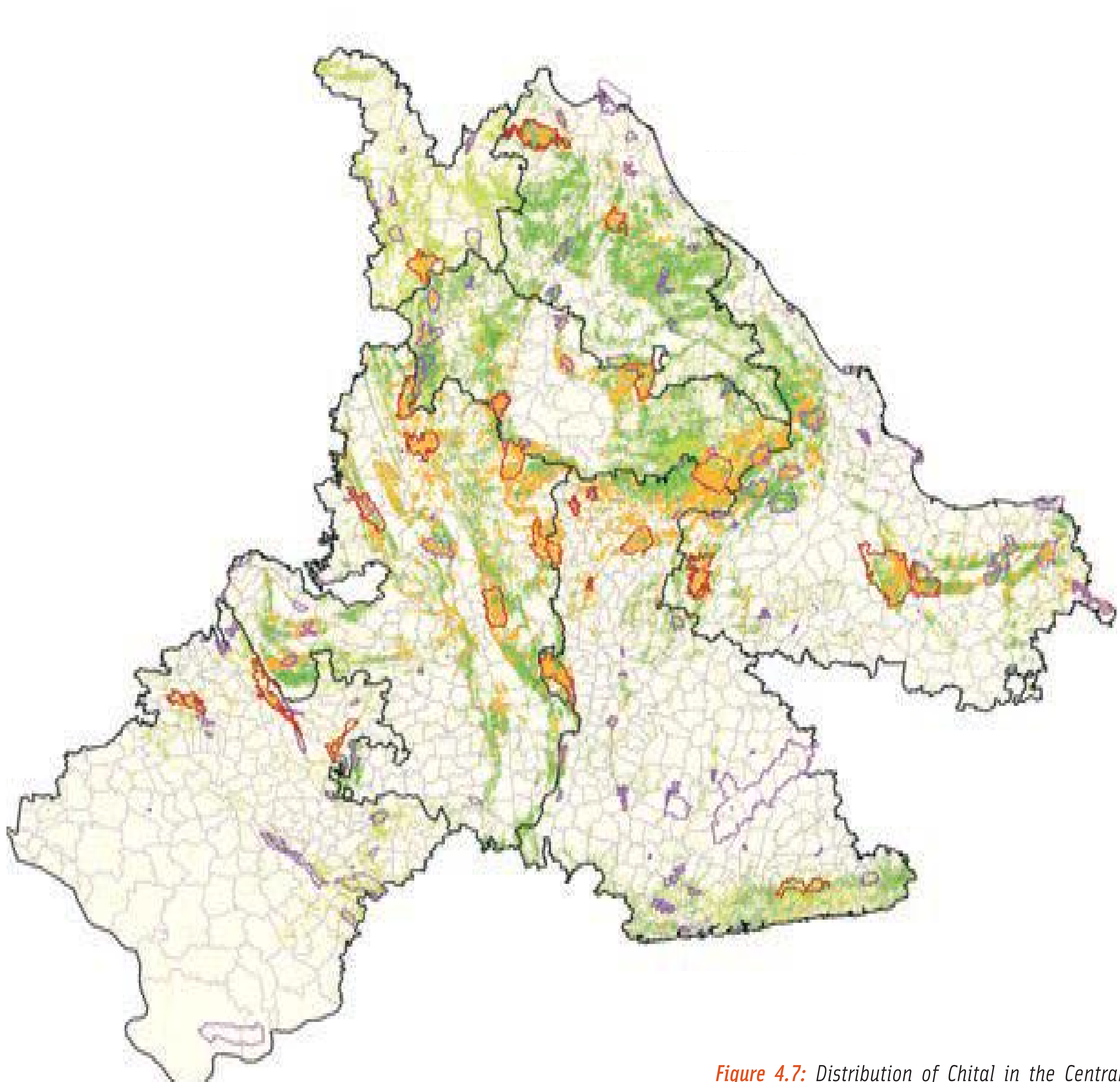
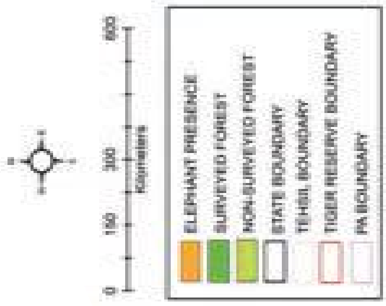


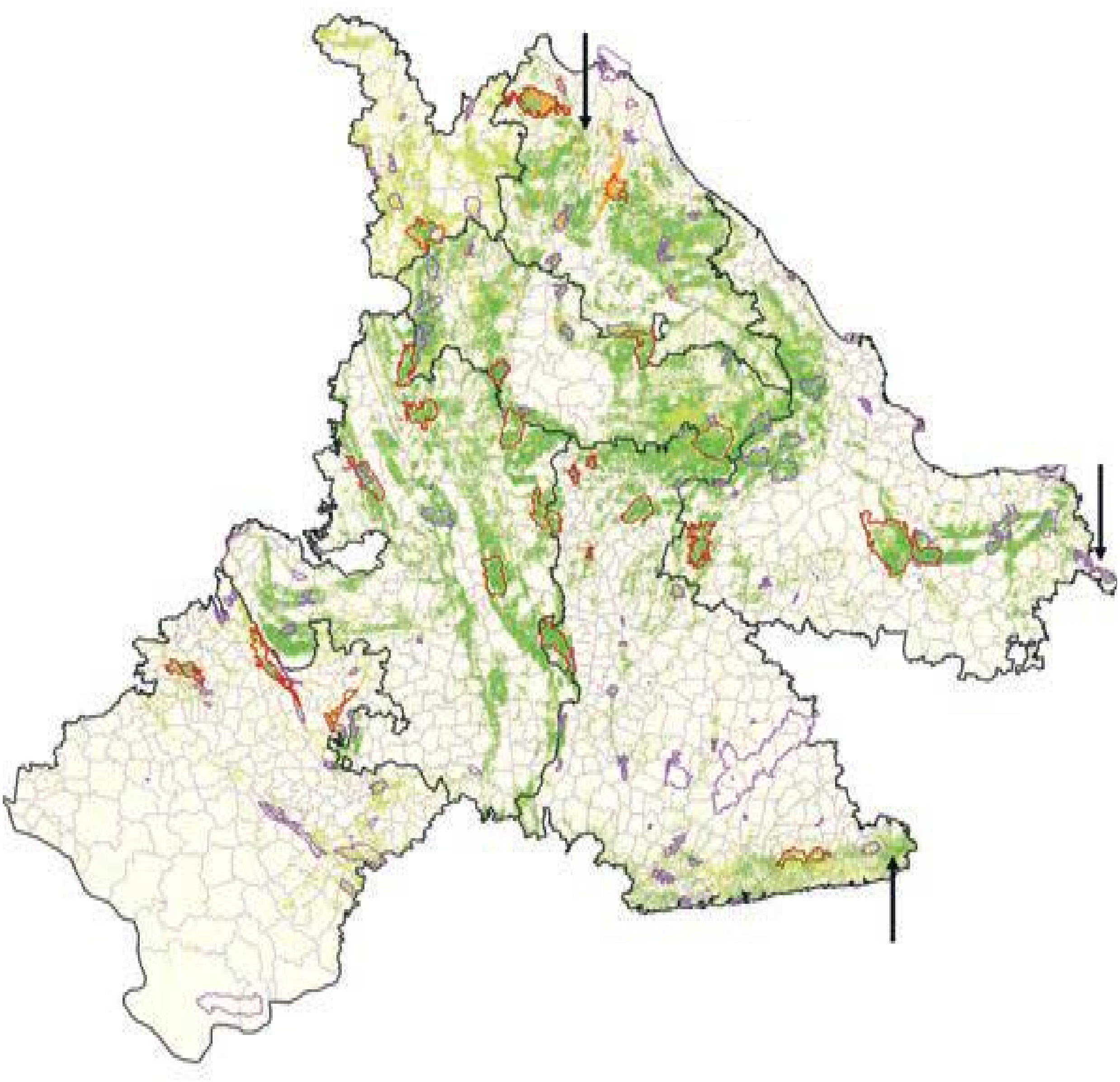
Figure 4.7: Distribution of Chital in the Central Indian & Eastern Ghat Landscape.

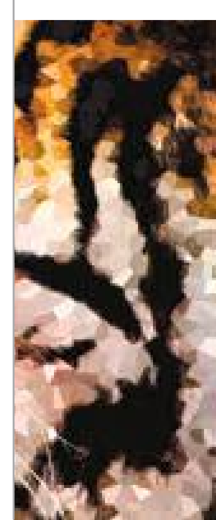
Figure 4.8: *Distribution of Elephant in the Central Indian & Eastern Ghat Landscape.*



Elephant: Elephas maximus *(WPA: Schedule I, IUCN: Endangered)*

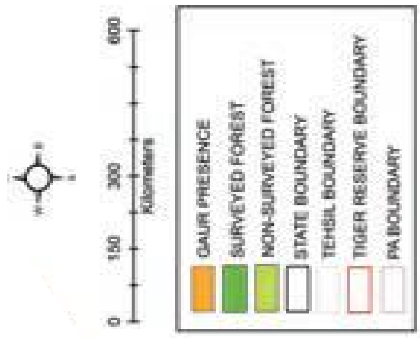
Elephants were reported to exist in central India in three different populations; the largest one being that of Odisha extending into Jharkhand to Northern Chhattisgarh; another in the Kolhapur and Sindhudurg districts of Maharashtra and the third is at Kaundinya Wildlife Sanctuary of Andhra Pradesh (As shown by arrow in Fig. 4.8). The total occupancy of elephant recorded in these 3 areas was 7,882 km² (2.2% of the sampled area) (Fig. 4.8). Elephants have recently colonized parts of northern Bilaspur district of Chhattisgarh and are found to be colonizing the forests adjoining Achanakmar Tiger Reserve and coming into Eastern Madhya Pradesh. Similarly they have also been reported to expand into the northern Western Ghats of Maharashtra where they are attributed to cause severe crop depredations. This exploratory movement of long lived species like the elephant is likely due to forest degradation in their native ranges.





Gaur:* Bos gaurus *(WPA: Schedule I, IUCN: Vulnerable)

Gaur were recorded to occupy 22,373 km² of forested landscape (6.3% of the sampled area) (Fig. 4.9). All of the recorded distribution was towards the South of river Narmada, excluding the Bandhavgarh population which was reintroduced recently. Gaur presence was reported in the Kanha – Pench – Navegaon – Nagzira – Tadoba complex which represents a potential metapopulation. Another continuous distribution was found in Sahyadri – Radhanagri – Madei complex of Northern Western Ghats. All other populations are scattered in and around protected areas. Gaur display seasonal migrations and are landscape dependant species therefore functional wildlife corridors are crucial elements for their long term survival in the landscape. Mitigation measures for linear infrastructural development in this landscape need to be gaur friendly as they are large, shy and skittish animals which require specific designs for wildlife passage ways.



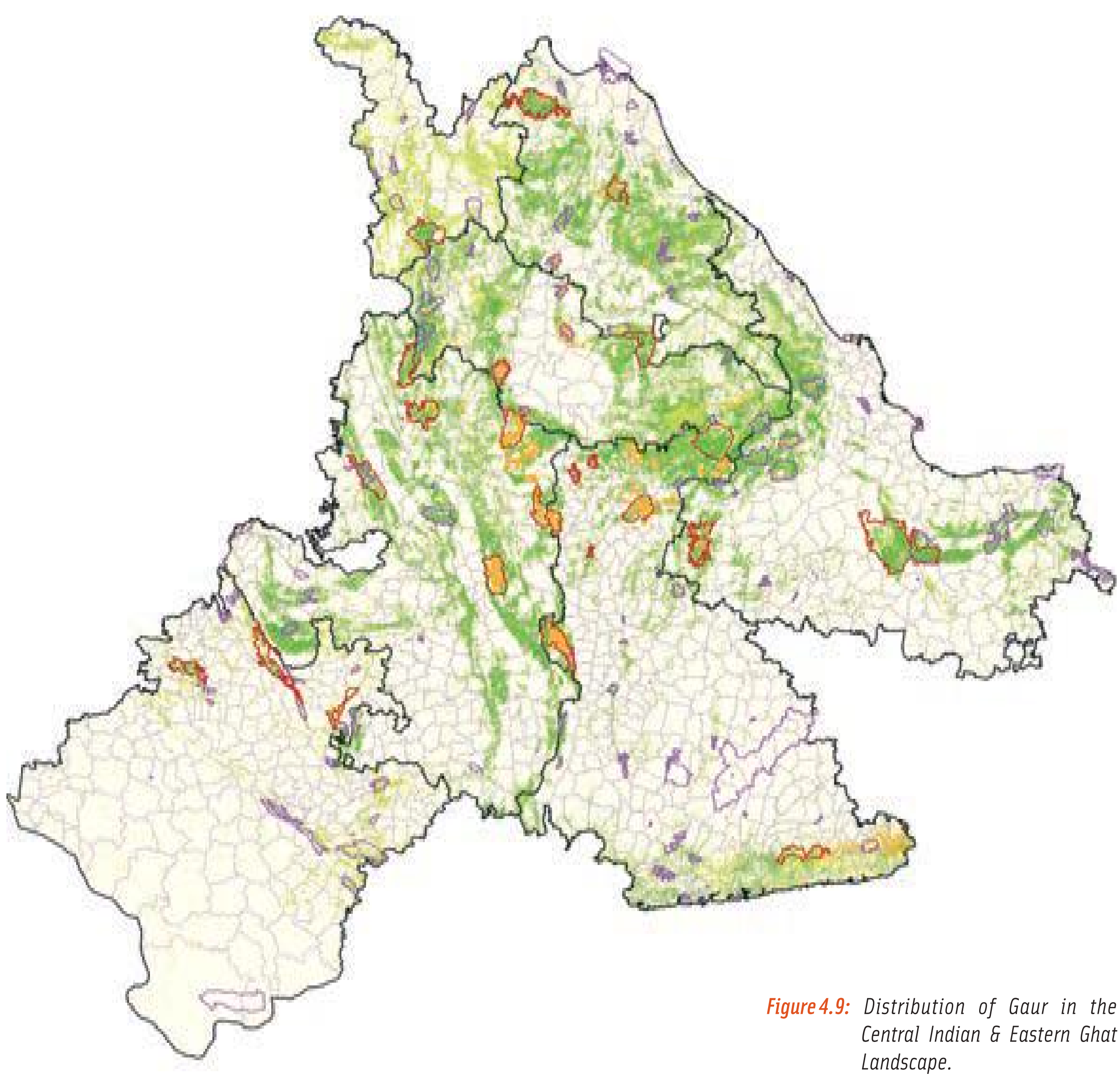
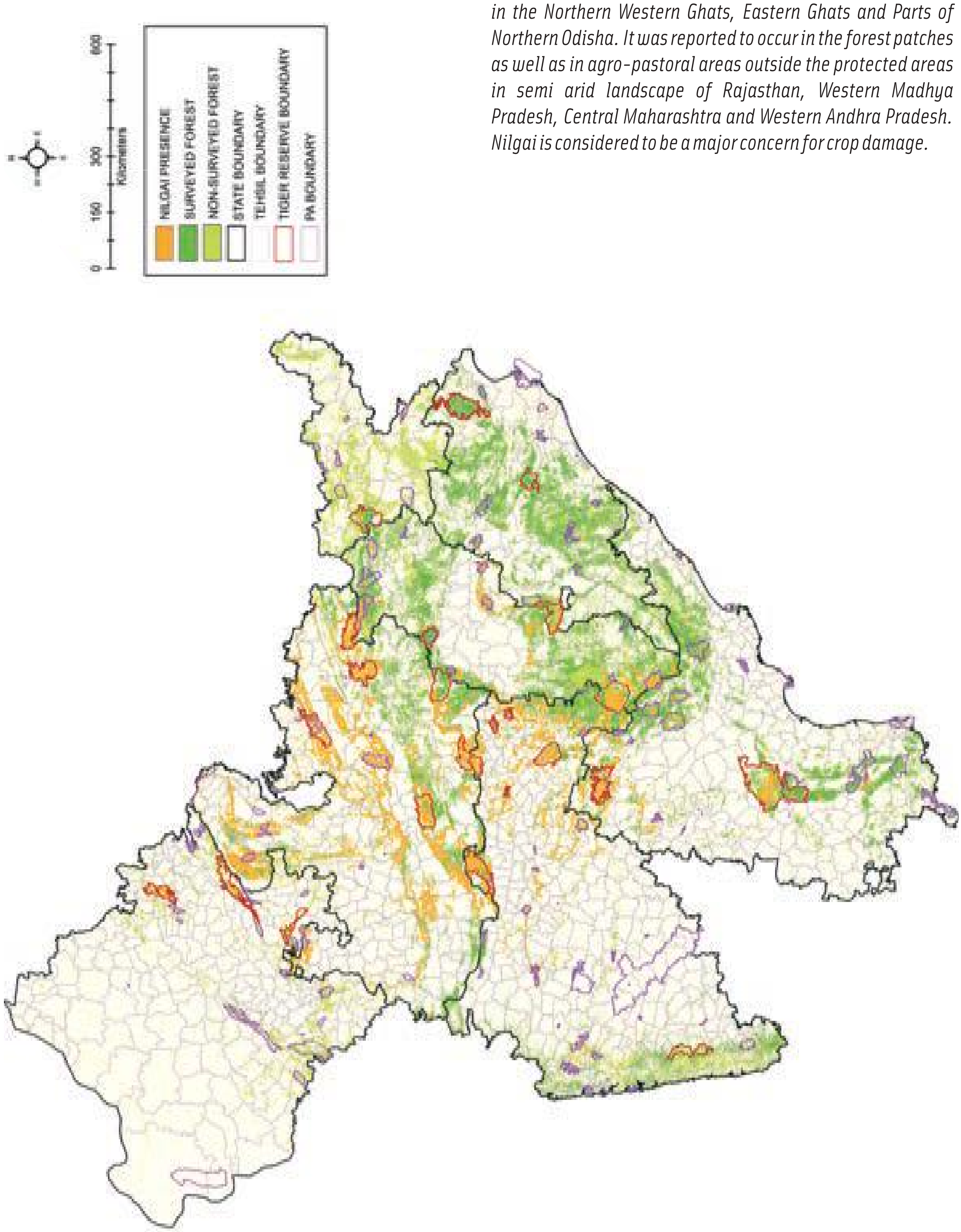


Figure 4.9: *Distribution of Gaur in the Central Indian & Eastern Ghat Landscape.*

Figure 4.10: *Distribution of Nilgai in the Central Indian & Eastern Ghat Landscape.*



Nilgai: Boselaphus tragocamelus *(WPA: Schedule III, IUCN: Least concern)*

Nilgai distribution was recorded in all the states with occupancy of 112,302 km^2 of forested landscape (32% of the sampled area) (Fig. 4.10). Its distribution was relatively low in the Northern Western Ghats, Eastern Ghats and Parts of Northern Odisha. It was reported to occur in the forest patches as well as in agro-pastoral areas outside the protected areas in semi arid landscape of Rajasthan, Western Madhya Pradesh, Central Maharashtra and Western Andhra Pradesh. Nilgai is considered to be a major concern for crop damage.

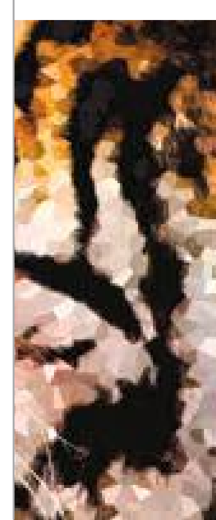
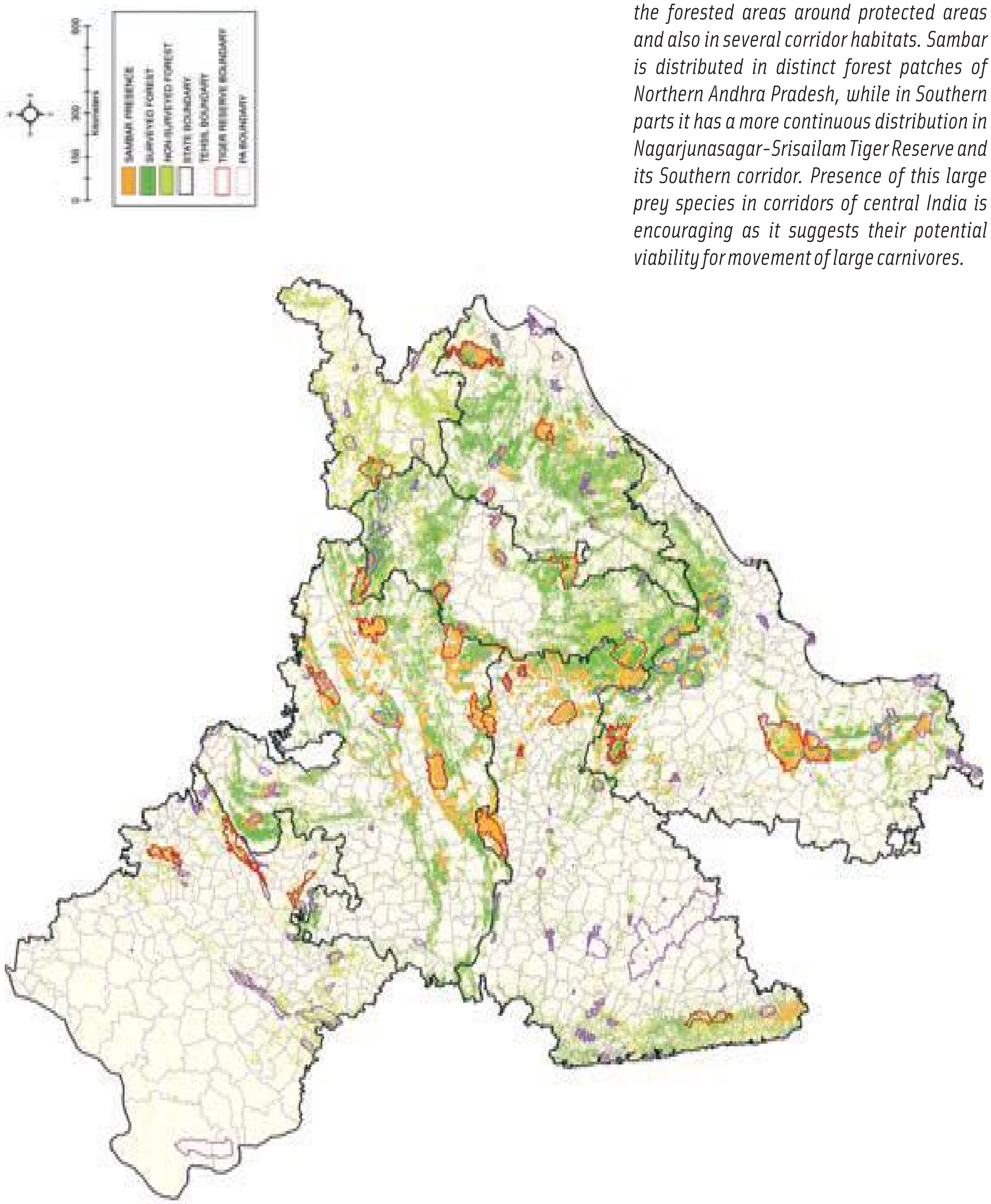


Figure 4.11: *Distribution of Sambar in the Central Indian & Eastern Ghat Landscape.*



Sambar: Rusa unicolor *(WPA: Schedule III, IUCN: Vulnerable)*

Sambar occupied 79,005 km² forests in the surveyed area (22% of the sampled area) (Fig. 4.11). In Rajasthan sambar occupancy was recorded only in the Tiger Reserves as only these were sampled while in Madhya Pradesh and Maharashtra, it is distributed in the forested areas around protected areas and also in several corridor habitats. Sambar is distributed in distinct forest patches of Northern Andhra Pradesh, while in Southern parts it has a more continuous distribution in Nagarjunasagar-Srisailam Tiger Reserve and its Southern corridor. Presence of this large prey species in corridors of central India is encouraging as it suggests their potential viability for movement of large carnivores.

Wild Buffalo: Bubalus arnee *(WPA: Schedule I, IUCN: Endangered)*

Wild buffalo was recorded to exist in two different pockets in India; one in North Eastern India and another within this landscape of Central India. The total area occupied in Central India was 331 km² (0.1% of the sampled area) (Fig. 4.12). Its distribution was reported only from Indravati Tiger Reserve and Gadchiroli district of Maharashtra. Recent observations suggest that the population in this landscape to be around 50 individuals. The species mainly inhabits well watered and swampy grasslands. However these areas are facing degradation and serious law and order issues due to extremism. Forest department have invested efforts for maintaining water bodies and managing the invasive weeds in this habitat. However, more effort and intensive planning is needed to conserve the species which is highly endangered. This population is of immense economic value as it is considered to be the only pure wild gene pool of water buffalo in the world. Conservation efforts like those done for Barasingha where buffalo are allowed to increase within large secure enclosures in well protected Tiger Reserves seems to be the only option. The current population is threatened by insurgency and poaching by Akhand shikar practices in the region.

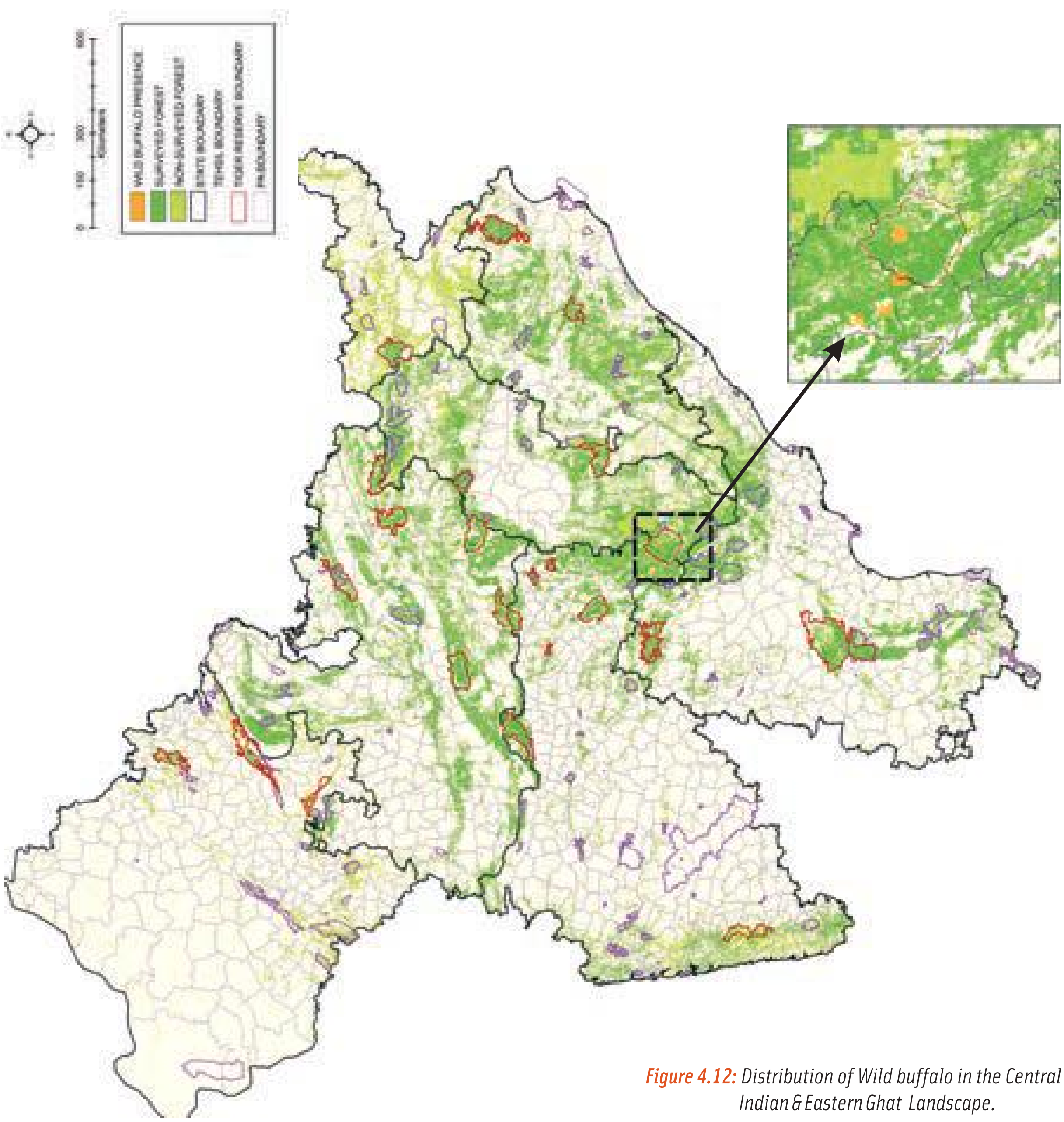


Figure 4.12: Distribution of Wild buffalo in the Central Indian & Eastern Ghat Landscape.

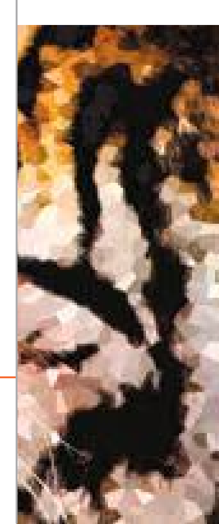
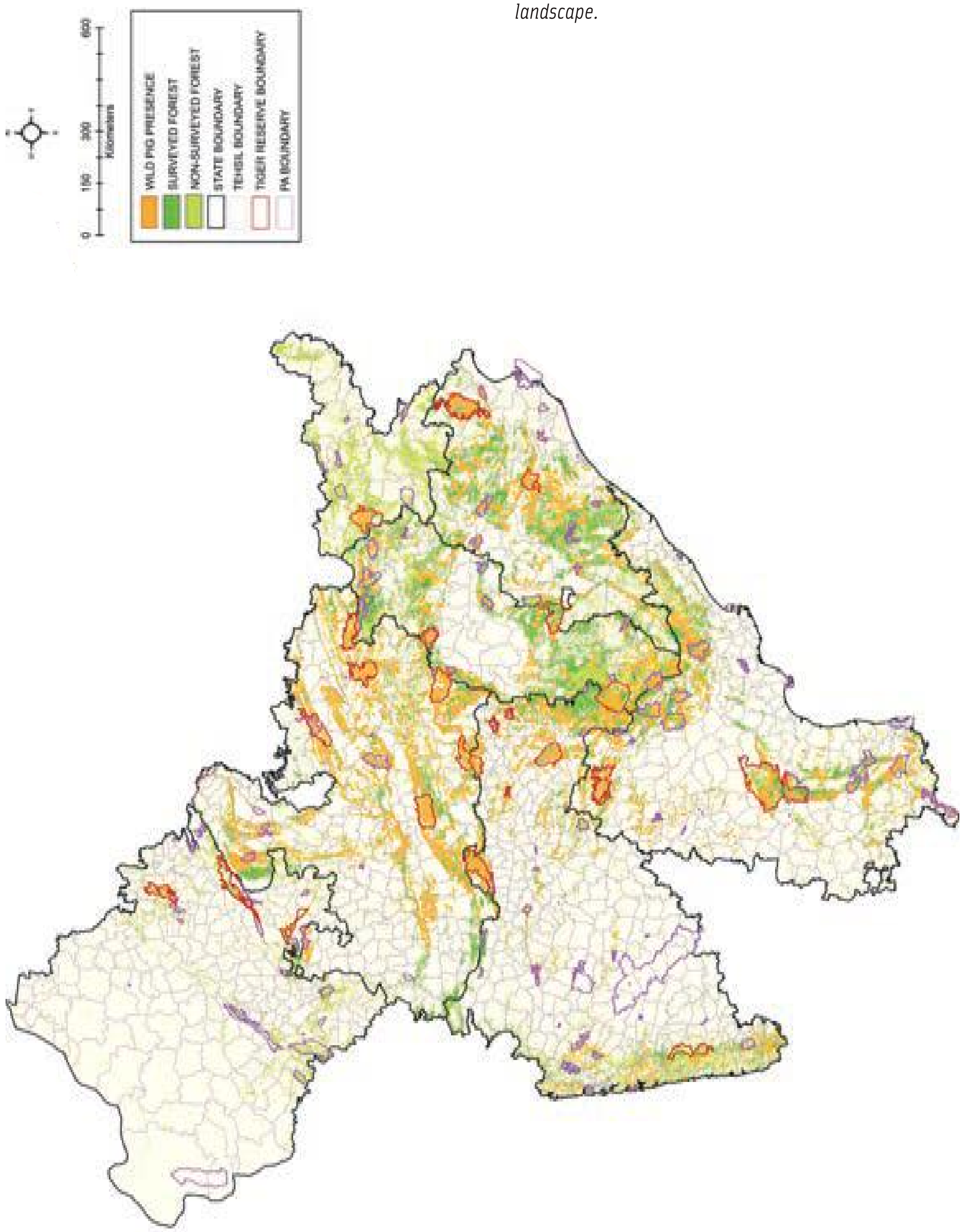


Figure 4.13: Distribution of Wild pig in the Central Indian & Eastern Ghat Landscape.



Wild pig:* Sus scrofa *(WPA: Schedule III, IUCN: Least concern)

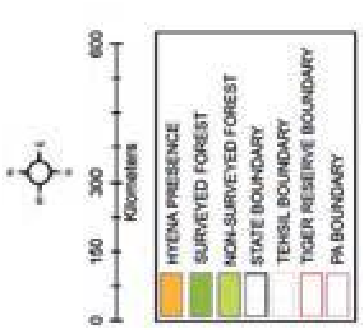
It is the most widely distributed ungulate in this landscape which was recorded to occupy 2,01,492 km² of forested landscape (57% of the sampled area) (Fig. 4.13). It was found in most of the surveyed forests in this landscape. It is attributed to cause severe crop depredation in parts of this landscape.

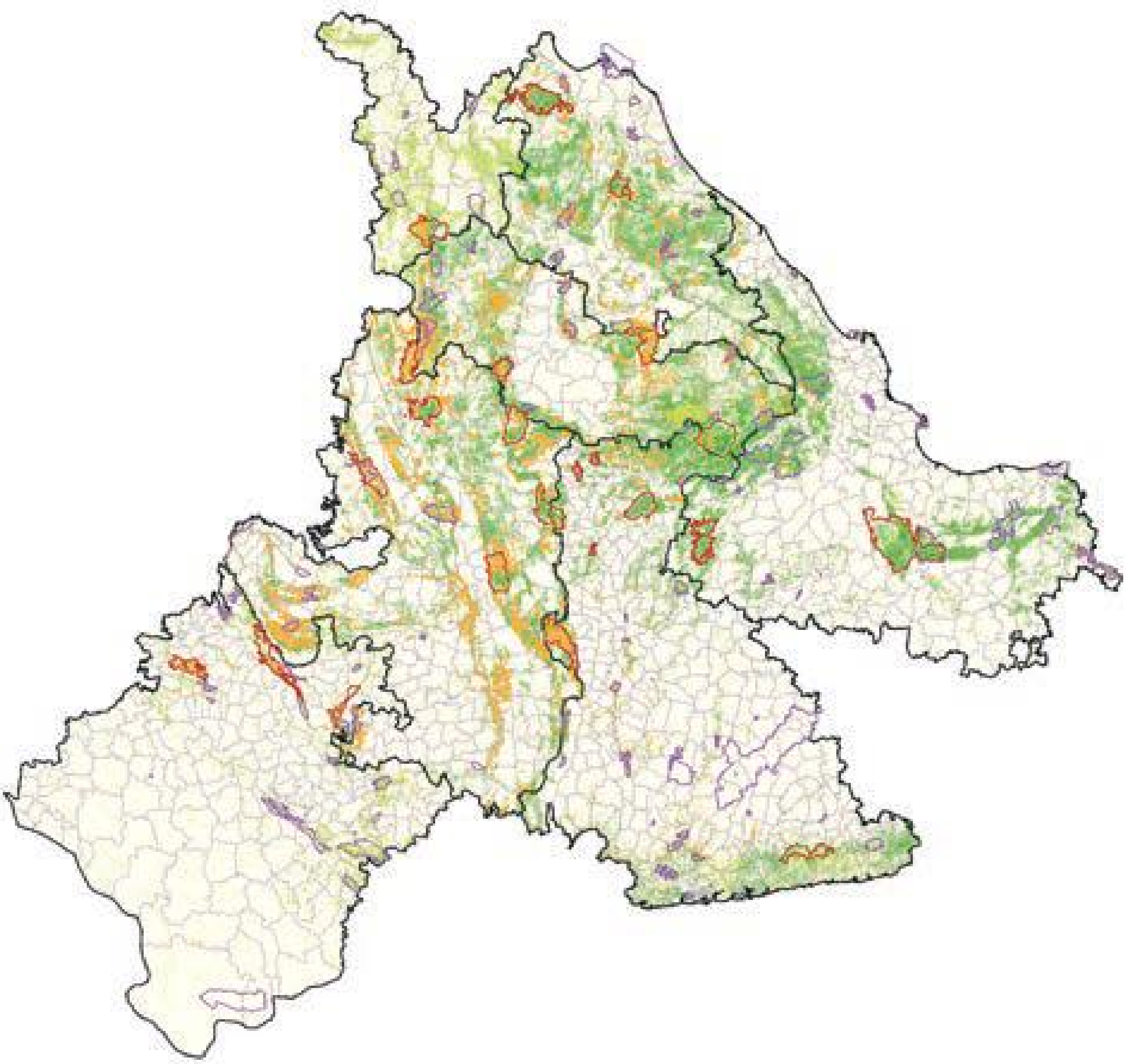
Major carnivores in this landscape were striped hyena, wild dog, sloth bear, wolf and jackal.

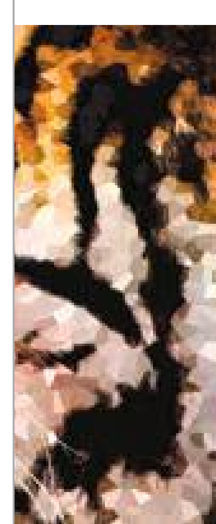
Striped Hyena: **Hyaena hyaena** *(WPA: Schedule III; IUCN: Near threatened)*

A wide distribution of hyena was recorded in Madhya Pradesh and Rajasthan. The species was not recorded in Tadoba, Nagarjunsagar-Srisailam and Kawal. In the Northern Western Ghats of Maharashtra hyena signs were only recorded from the open and fragmented forests on its eastern slope. Hyena in western Madhya Pradesh and Central Maharashtra occupied small fragmented patches of forests and scrub and are known to use agro-pastoral landscape as well. Hence conservation of such patches that are outside the protected area network are important elements for the conservation of hyena and wolves. Hyena signs were recorded from 1,04,453 km^2 comprising 30% of the sampled habitat (Fig. 4.14).

Figure 4.14: *Distribution of Hyena in the Central Indian & Eastern Ghat Landscape.*







Wild Dog (Dhole): Cuon alpinus *(WPA: Schedule II; IUCN: Endangered)*

Dhole sign was observed across Madhya Pradesh, Chhattisgarh, Jharkhand and parts of Odisha. The distribution of wild dog in Chhattisgarh, Odisha and the northern Western Ghats of Maharashtra was scattered in the forests outside protected area network and hence needs special conservation efforts to safe guard the species in these forests. The area occupied by wild dog was 78,703 km^2 comprising 22% of the sampled area (Fig. 4.15).

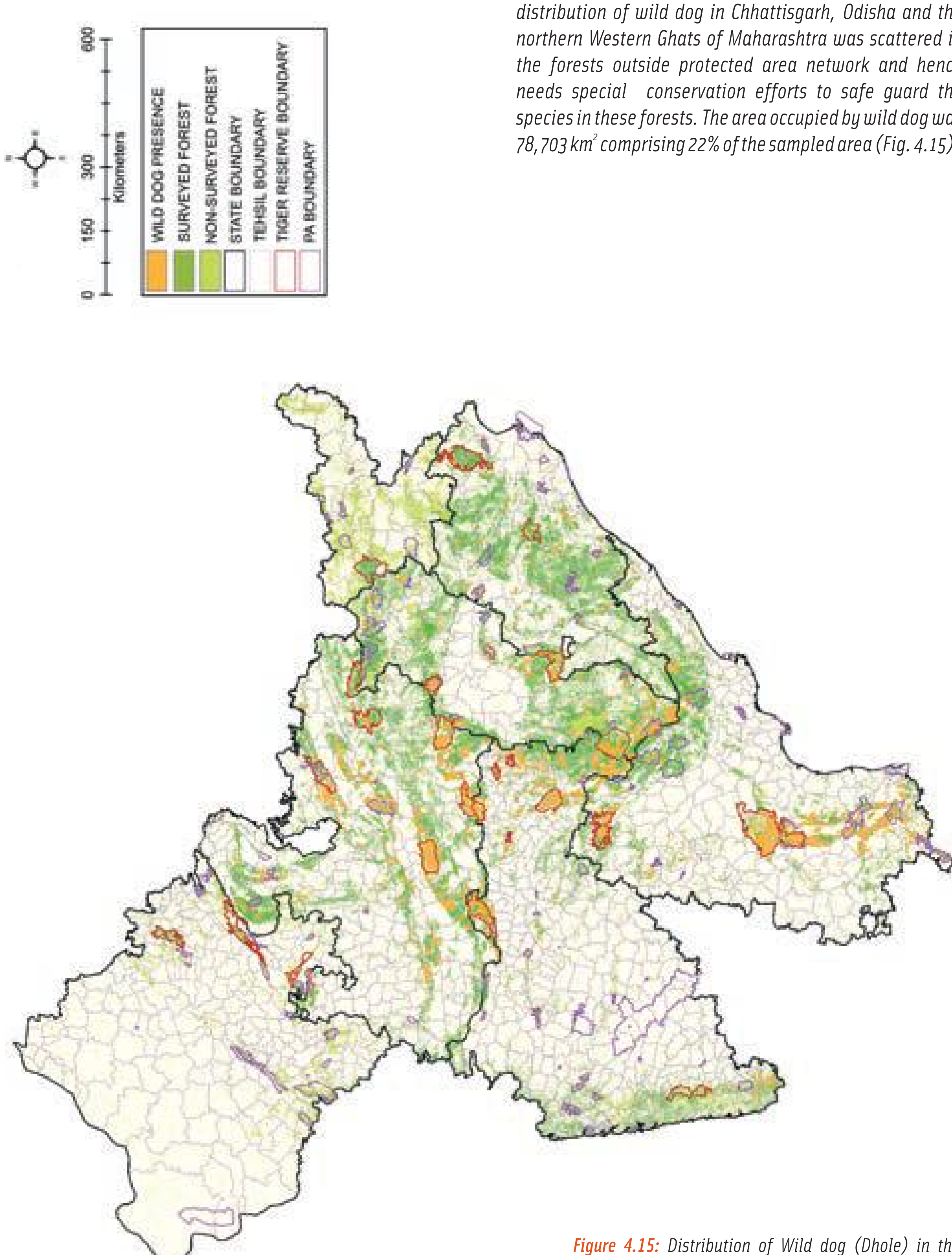
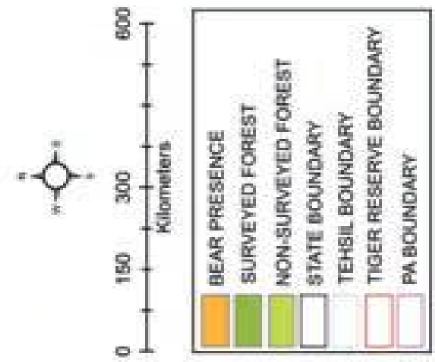


Figure 4.15: Distribution of Wild dog (Dhole) in the Central Indian & Eastern Ghat Landscape.

Sloth Bear: Melursus ursinus *(WPA: Schedule II; IUCN Vulnerable)*

Bear signs were recorded in most of the sampled forests of Central Indian landscape. Madhya Pradesh forest corridor habitats had continuous distribution of bear which represents potential connectivity of protected areas. Considerable occupancy of bear outside the protected areas and corridors was reported in Raisen district of Madhya Pradesh, fragmented forests and scrublands of Eastern Maharashtra, Northern Odisha and Chhattisgarh. A continuous distinct population was observed extending from NSTR to the forest of Sri Venkateshwara. The overall forest area occupied by sloth bear was 1,83,063 km^2 comprising 52% of the sampled area, making it second most widely distributed carnivore of this landscape (Fig. 4.16).



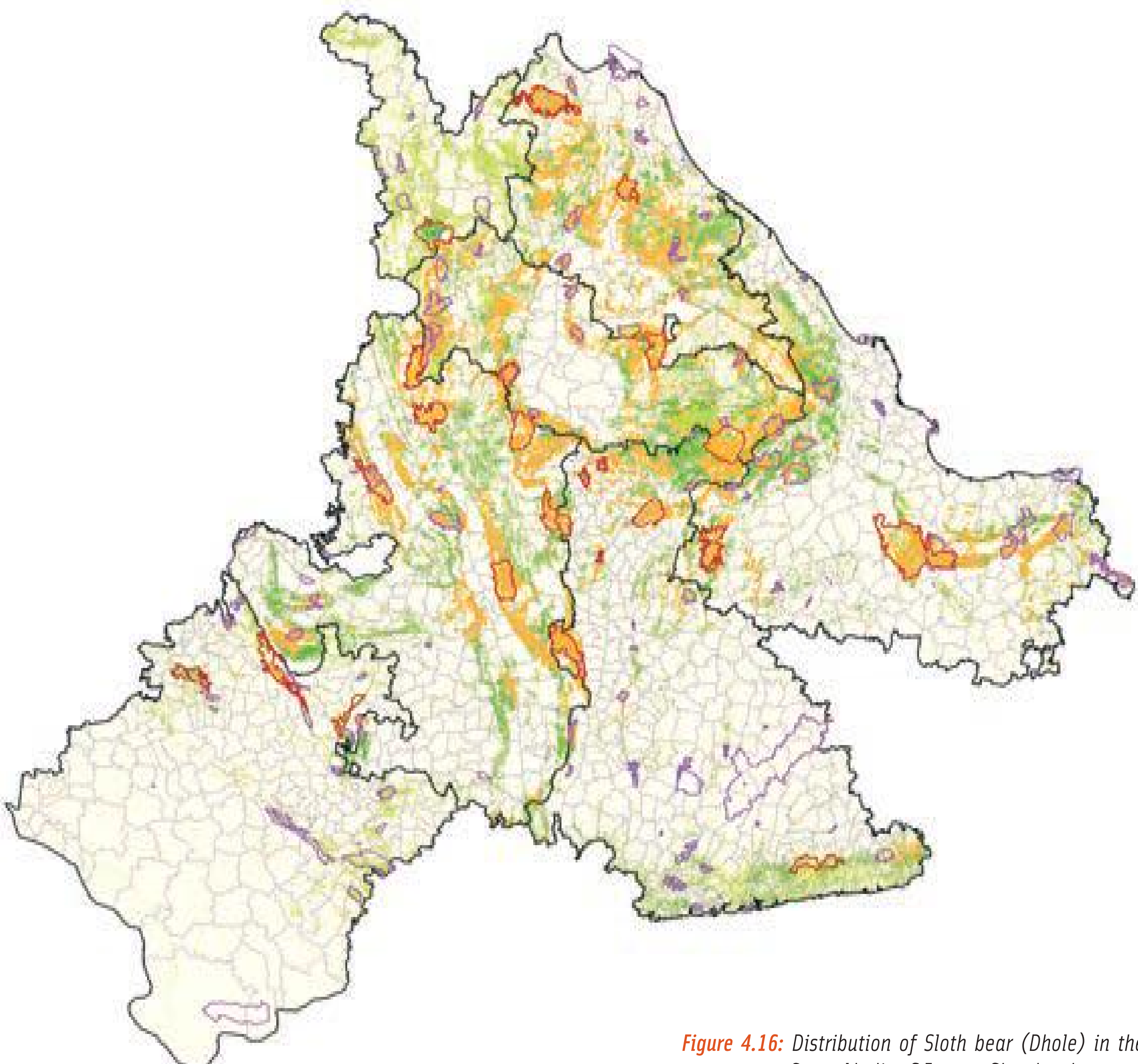
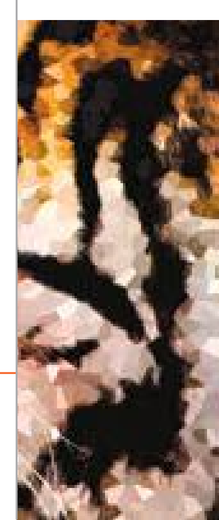
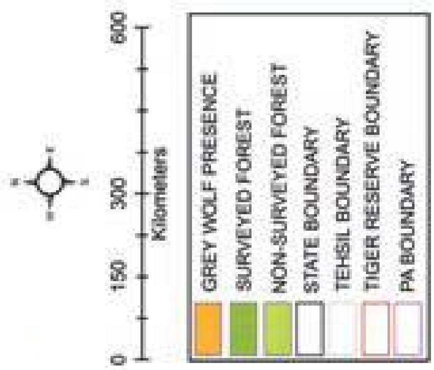


Figure 4.16: Distribution of Sloth bear (Dhole) in the Central Indian & Eastern Ghat Landscape.





Grey Wolf: Canis lupus *pallipes (WPA: Schedule I; IUCN: Least concern)*

Wolf presence was recorded in most of the forests of Madhya Pradesh, Maharashtra, Odisha and Chhattisgarh. In Andhra Pradesh its presence was recorded in northern portion but wolves were not recorded from parts of Nagarjunasagar-Srisailam and Gundla Brahmeswaram. Relatively more wolf signs were found at the periphery of the Tiger Reserves than within the reserves. Wolf presence in Ranthambore Tiger Reserve was only recorded from the human dominated part of Ranthambore National park and Keoladeo Wildlife Sanctuary. Wolf signs were also recorded from other arid landscape like Mukundra hills and Kuno Wildlife Sanctuary. Forest patches of central Maharashtra had continuous wolf occupancy and the agro–pastoral areas are also known to be inhabited by wolves. Continuous presence of wolf was also recorded from the forests of Northern Chhattisgarh and Eastern Maharashtra. The forested area occupied by the wolf in central Indian landscape was 89,304 km^2 comprising 25% of the sampled area (Fig. 4.17).

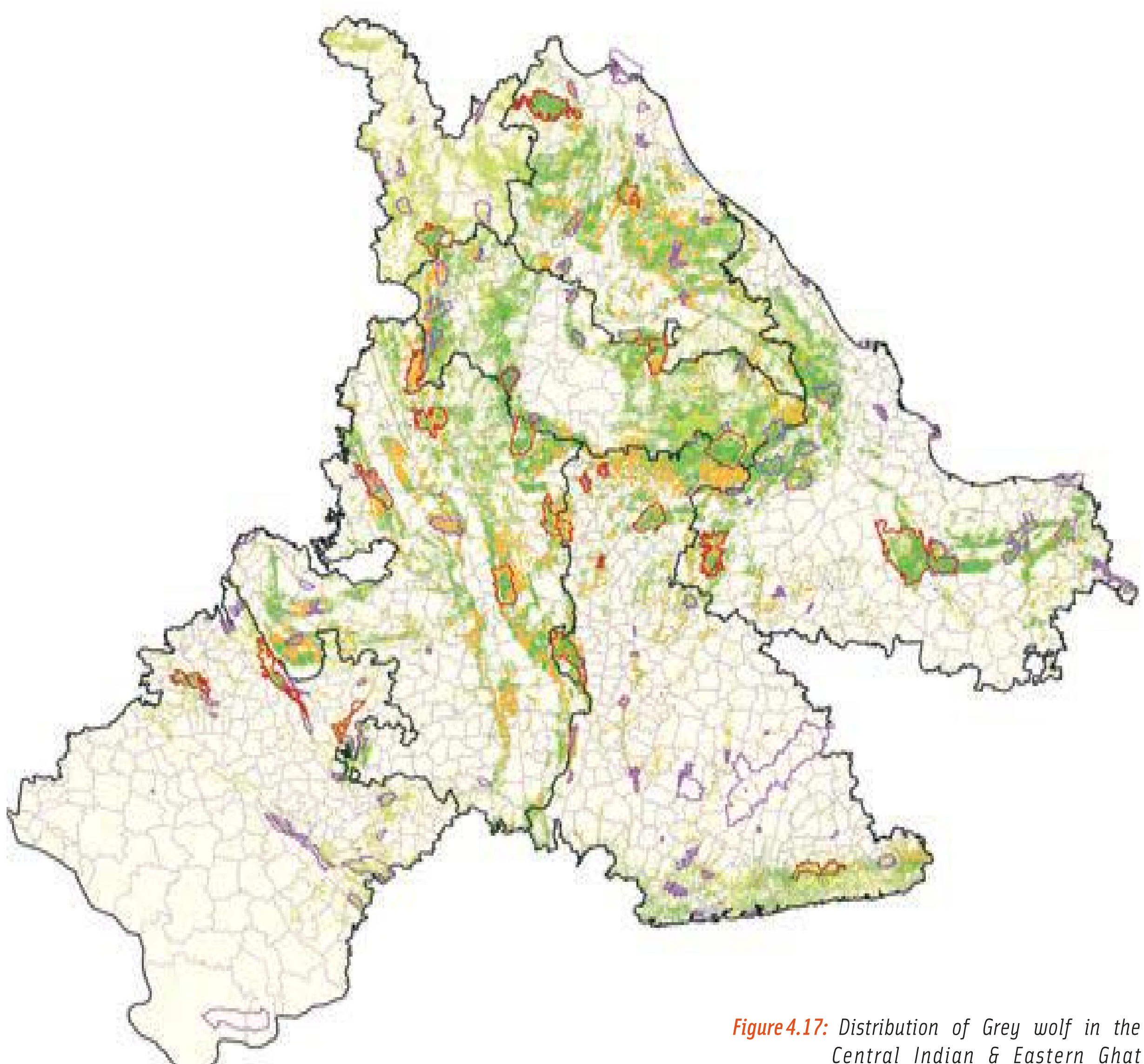


Figure 4.17: *Distribution of Grey wolf in the Central Indian & Eastern Ghat Landscape.*

Golden Jackal: Canis aureus *(WPA: Schedule II, IUCN: Least concern)*

Jackal signs were recorded from across all the forested areas of Madhya Pradesh, thus having the largest distribution amongst carnivores in this state. In the states of Andhra Pradesh and Maharashtra, jackal records were relatively less and largely outside of the protected areas. In Odisha, jackal was distributed in most of the forested areas. No photo-captures of jackal were obtained from Tadoba, Kawal and Nagarjunasagar Srisailam. Area occupied by golden jackal was 2,00,366 km^2 comprising 56% of the sampled area, making it the most wide ranging carnivore in this landscape (Fig. 4.18).

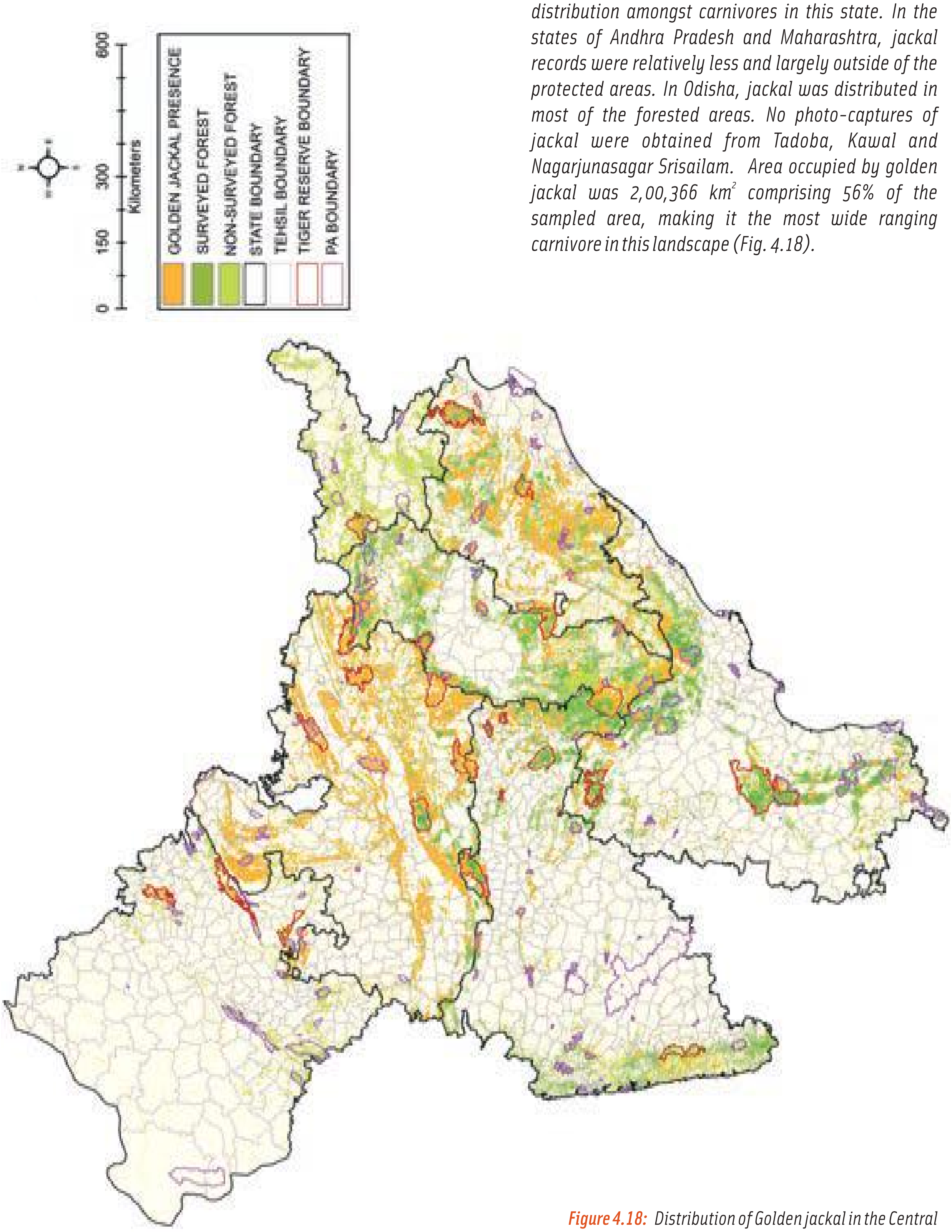
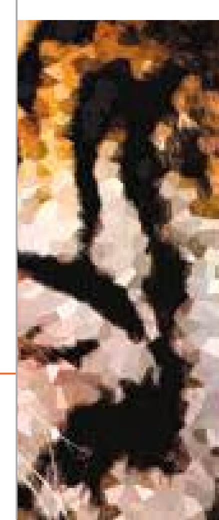


Figure 4.18: *Distribution of Golden jackal in the Central Indian & Eastern Ghat Landscape.*

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Western Ghats Landscape 05

Qamar Qureshi, Y. V. Jhala, R. Gopal, V. C. Mathur, S. Rajesh, P. S. Somasekhar and C. M. Sivakumar

This Landscape comprises the states of Goa, Karnataka, Kerala and Tamil Nadu. The total area sampled was 79,613 km^2. It is within this area the occupancies of various species is recorded. Major forest types of this landscape include Tropical Evergreen Forest, West Coast Semi Evergreen Forest, Moist Evergreen Forest, Slightly Moist Teak Forest, Moist Deciduous Forest, Dry Deciduous Scrub Forest, Dry Semi-Deciduous Forest and Grasslands (Champion and Seth 1968).

Tiger population has shown an increase while occupancy has remained stable within this landscape. (Table 2.1, Fig. 5.1). The landscape has recorded occupancy of tigers in 29,511 km^2 of forest (Fig 5.1). States of Karnataka, Kerala and Tamil Nadu have all registered an increase in tiger abundance. Western Ghats terrain provides excellent connectivity and tigers have spread over most of the landscape. The Sahyadri Tiger Reserve has over 7 tigers (based on scat DNA). The Sahyadri tiger population though a part of the Western Ghat Landscape is accounted for in the Central Indian Landscape in the state of Maharashtra. The Connectivity between populations are threatened by infrastructure development, plantations and industrialization and require ecologically sensitive developmental planning.

Figure 5.1: Changes in tiger distribution in the Western Ghats Landscape from 2006 to 2014.

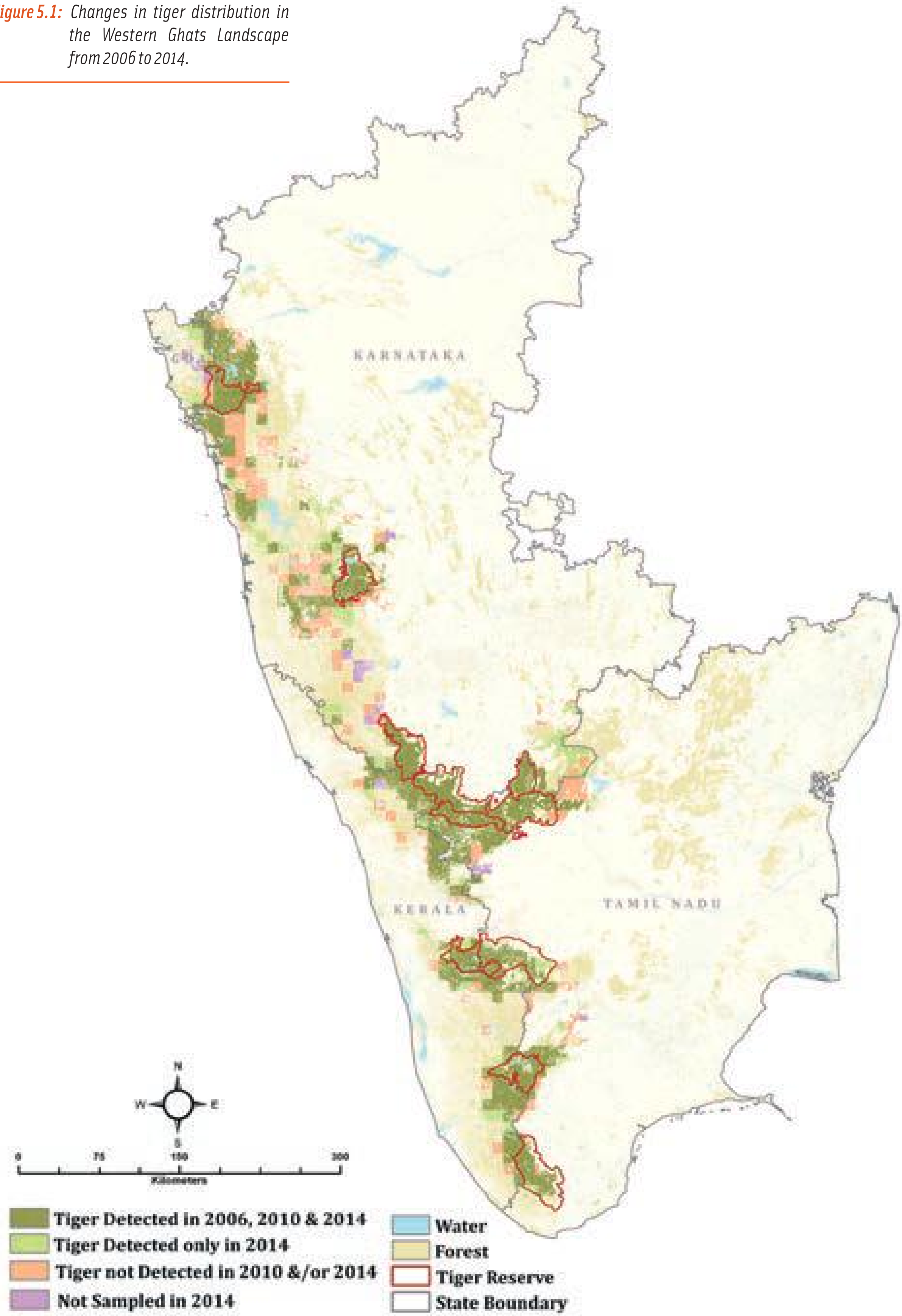


Table 5.1: *Principal components loadings after varimax rotation from Western Ghats Landscape. The cumulative variation explained by 6 components was 60%.*

Variables	PC-1-Protected-Canopied Forest	PC-2-Forest-Prey	PC-3-Human Disturbance	PC-4-Prey	PC-5-Rugged-high elevation terain	PC-6-Chital
Mean NDVI for Pre-monsoon	0.81	0.30				
Mean NDVI for Post-monsoon	0.78					
Core Area	0.72					
Canopy Cover	0.70					
Distance from Protected Areas	-0.58	-0.36				
Nightlights Area	-0.54				-0.35	
Encounter Rate of Gaur		0.69				
Encounter Rate of Elephant		0.61				
Encounter Rate of Sambar		0.61				
Pellet Count of Gaur		0.54		0.43		
Pellet Count of Elephant	0.33	0.47		0.32		
Encounter Rate of Barking Deer						
People Seen			0.86			
Livestock Seen			0.80			
Human Tail			0.78			
Pellet Count of Wild Pig				0.78		
Pellet Count of Barking Deer				0.69		
Pellet Count of Sambar	0.41	0.41		0.43		
Elevation					0.91	
Ruggedness	0.35	0.36			0.75	
Encounter Rate of Chital						0.80
Pellet Count of Chital				0.30		0.76
Encounter Rate of Wild Pig						

Six Principle Components that could be interpreted in ecological terms explained 60% of the variation from the Western Ghats Landscape (Table 5.2, 5.3). The best model had six Principle Components representing protection, prey abundance, remote-canopied forests, and terrain as covariates explaining tiger occupancy in the Western Ghat Landscape. Detection probability was best explained by intensity of tiger sign in the grid. The naive estimate of occupancy of 22% was improved to 27.49(SE 1.28) % by accounting for imperfect detection for each survey (probability = 0.36, SE 0.007). More importantly the occupancy model provided information on factors that likely influenced tiger occupancy and provided spatially explicit probability of tiger occupancy useful for conservation planning and understanding habitat connectivity and potential to support tigers.

Table 5.2: *Competing models tested and model selection using AIC for estimating tiger occupancy in Western Ghats to account for detection bias and influence of covariates.*

Model	AIC	Δ AIC	AIC wgt	No. of Parameter	-2Log (likelihood)
Ψ (PC1 + PC2 + PC3 + PC4 + PC5 + PC6), p(Tiger Sign)	5352.03	0	1.00E+00	9	2667.015
Ψ(PC1 + PC2 + PC3 + PC4 + PC6), p(Tiger Sign)	5387.04	35.01	2.50E-08	8	2685.522
Ψ (PC1 + PC2 + PC3 + PC6), p(Tiger Sign)	5389.79	37.76	6.30E-09	7	2687.893
Ψ (PC1 + PC3 + PC6), p(Tiger Sign)	5507.01	154.98	2.20E-34	6	2747.505
Ψ(PC1 + PC3), p(Tiger Sign)	5514.93	162.9	4.20E-36	5	2752.467
Ψ(PC1), p(Tiger Sign)	5525.08	173.05	2.60E-38	4	2758.539
Ψ(.),p(Tiger Sign)	5610.13	258.1	9.00E-57	3	2802.065
Ψ(.),p(.)	8153.53	2801.5	0.00E+00	2	4074.766

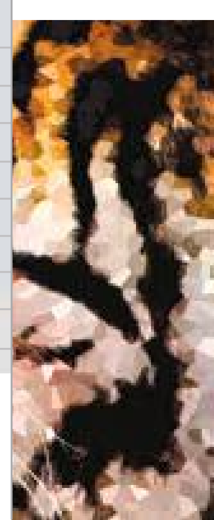
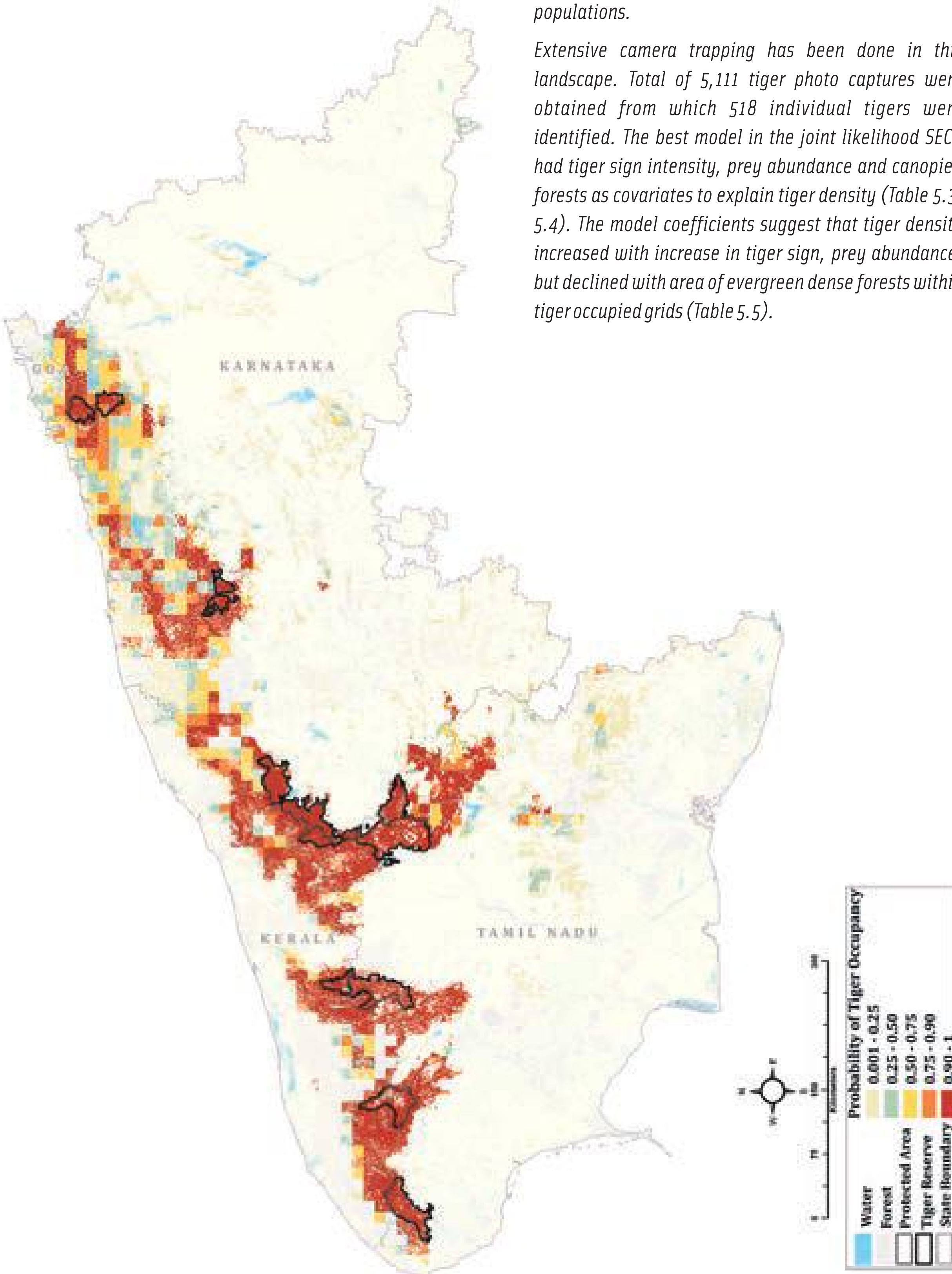


Figure 5.2: Tiger occupancy probability map in the Western Ghats obtained by accounting for detection bias and ecological covariates.



Tiger occupancy probability (Fig. 5.2) was high in the Western Ghat Landscape, suggesting conducive conditions for further expansion of tiger extent as well encouraging for dispersal movements between source populations.

Extensive camera trapping has been done in this landscape. Total of 5,111 tiger photo captures were obtained from which 518 individual tigers were identified. The best model in the joint likelihood SECR had tiger sign intensity, prey abundance and canopied forests as covariates to explain tiger density (Table 5.3, 5.4). The model coefficients suggest that tiger density increased with increase in tiger sign, prey abundance, but declined with area of evergreen dense forests within tiger occupied grids (Table 5.5).

Table 5.3: Model coefficients of best models explaining tiger occupancy in the Western Ghats Landscape.

	Variables	Estimate	Standard Error
A1	■ Constant	0.25	0.32
A2	■PC1	2.33	0.32
A3	■PC2	3.04	0.57
A4	■PC3	-1.08	0.29
A5	■PC4	0.64	0.26
A6	■PC5	1.17	0.27
A7	■PC6	0.89	0.24
B1	p1	-2.20	0.05
B2	p1.Tiger Signs	1.31	0.04

Table 5.4: Model selection for tiger density estimation with covariates in SECR for the Western Ghat Landscape.

model	Detection Function	No. Parameters	Log Likelihood	AIC	■AIC
D~tigps + preyER + ndvioct	Halfnormal	6	-7809.79	15631.57	0.00
D~tigps + preyER + preyDung + ndvimay + ndvioct + padist	Halfnormal	9	-7820.78	15659.55	27.98
D~tigps + preyER + preyDung + ndvimay + ndvioct	Halfnormal	8	-7822.16	15660.32	28.75
D~tigps + preyER + preyDung	Halfnormal	6	-7837.37	15686.74	55.17
D~tigps + preyER + ndvioct + hl	Halfnormal	7	-7861.59	15737.17	105.60
D~tigps + preyER + hl	Halfnormal	6	-7865.22	15742.44	110.87

tigps = Tiger sign index, PreyER= Wild prey Encounter rate, Prey Dung = Wild Prey Dung index, hl = Human disturbance index, ndvimay= NDVI Pre Monsoon , ndvioct= NDVI Post Monsoon

The world's largest tiger population is within this landscape residing within connected tiger reserves and protected areas along with adjoining reserve and protected forests constituted by the Nagarhole-Bandipur-Mudumalai-Wayanad-BRT-Satyamangalam complex spanning across the three states of Karnataka, Tamil Nadu and Kerala. This region has tiger presence in 10925 km^2 and holds about 585 tigers (Fig. 5.3). The other important populations are Parambikulam-Anamalai complex, Periyar-KMTR population and Bhadra-Kudremukh population. Goa now has a persistent tiger presence with about 3-5 tigers with a potential of becoming a home for breeding tigers. However, dispersion of tigers northwards has been slow as Anshi-Dandeli is a low tiger density area. This region of Northern Karnataka along with Goa holds potential for increasing tiger population in this landscape with targeted management inputs. Karnataka has done exemplary work in the relocation of villages from tiger reserves and declaration of new protected areas boarding Goa. Tamil Nadu and Kerala has shown significant increase in tiger population. Possibility of including protected forests of Goa and protected areas of Karnataka under the Tiger Reserves system will assist tiger recovery as well as serve to conserve the rich biodiversity of this biodiversity hotspot and enhance its value as a World Heritage Site. Potential to enhance tigers south of the Palghat gap exist in the Parambikulum-Anamalai complex as well as in Periyar. Management inputs have improved protection and prey populations seem to be responding, if these practices continue we are likely to see tiger populations improving in these landscapes by the next cycle of assessment. These regions could benefit from reduction of human pressures by using various schemes available particularly incentivized voluntary relocation from core tiger habitats.

Table 5.5: Model coefficients of best covariate model for estimating tiger density in Western Ghat Landscape

Parameter	beta	SE.beta
Density	-8.94	0.11
tigps	1.01	0.08
preyER	0.07	0.05
ndvioct	-0.15	0.06
g0	-3.43	0.03
Sigma	7.7	0.01

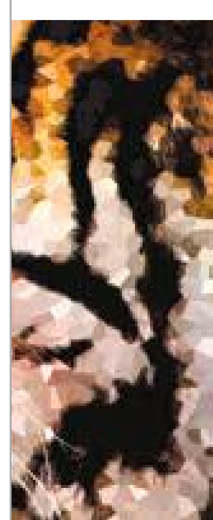
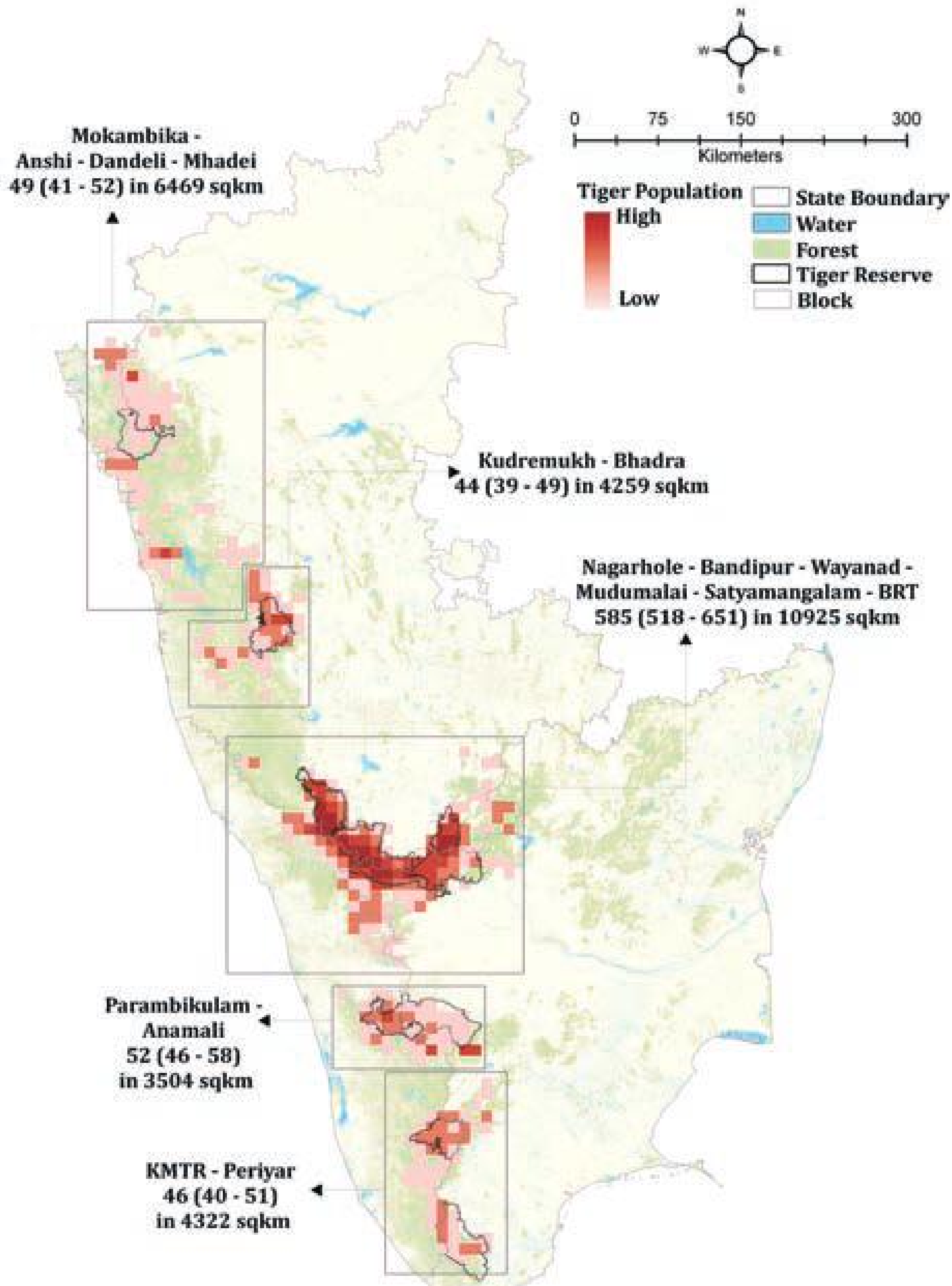


Figure 5.3: *Tiger density extent and population blocks within Western Ghats Landscape.*



Leopard: Panthera pardus (WPA: Schedule I; IUCN: Near threatened)

Leopard distribution in this landscape was 46,790 km^2 comprising 59% of the sampled area (Fig. 5.4). Major contiguous leopard occupied habitat blocks were (a) Anshi Dandeli-Goa-Radhanagri-Sahyadri, (b) Sharavathi Valley –Kudremukh – Bhadra, (c) Nagarhole – Mudumalai – Wayanad – Biligiri Ranganatha Temple –Cauvery Wildlife sanctuary, (d) Peechi – Vazhani – Parambikulam – Indira Gandhi Wildlife Sanctuary and (e) Periyar – Srivilliputhur – Kalakad Mundanthurai (Fig. 5.4). Signs of leopards were sparsely reported from the forested areas joining these blocks. However, leopard is known to occur even in human dominated areas, it is reported to use tea and coffee plantations and other agricultural areas as well which were not sampled during this exercise. Leopard presence was also reported from fragmented forest patches of central Karnataka and North Eastern Tamil Nadu. Leopard was reported from fragmented forests of Bengaluru urban and rural area, which is a major urban sprawl with high human densities. Human-leopard conflict is of concern but it is lower compared to the Himalayan states.

The leopard density in Western Ghats landscape was calculated from 12 camera trapped sites where a total of 4134 photo captures of leopard were obtained. From these captures a total of 668 individual leopard were identified. Leopard sign encounters, prey abundance, dense forest and elevation best explained leopard density in the Western Ghat Landscape (Table 5.6 & Table 5.7) . The total population of leopard within the sampled forest of Western Ghats landscape was estimated to be 2487 (SE range 1846-3129).

In an earlier study conducted at Mudumalai Tiger Reserve, 29 leopards in a sampling area of 107 km^2 were photo captured, with a spatially explicit density of 13.17 (SE=±3.15) leopards per 100 Km^2 (Kalle et al. 2011). While at Kalakad-Mundanthurai Tiger Reserve (KMTR), spatially explicit maximum likelihood estimate was 2.8 ± (SE=±2.0)leopards per 100 Km^2 (Ramesh et al. 2012).

Table 5.6: Covariate models and model selection using a joint likelihood framework (in SECR program R) for estimating leopard density in the Western Ghat Landscape.

Model	Detection Function	No. Parameters	Log Likelihood	AIC	AIC
D~leops + ndvioct + PreyER + elev	Halfnormal	7	-5291.87	10597.74	0
D~leops + ndvioct + PreyDung + elev + hl	Halfnormal	8	-5292.42	10600.84	3.1
D~leops + tigps + PreyDung + elev + hl + PreyER	Halfnormal	9	-5341.7	10701.39	103.65
D~leops + tigps	Halfnormal	5	-5351.01	10712.02	114.28
D~leops + tigps + PreyDung + rugg	Halfnormal	7	-5349.73	10713.45	115.71
D~leops + PreyDung + elev + hl + PreyER	Halfnormal	8	-5349.39	10714.79	117.05

leops= Leopard sign index, tigps = Tiger sign index, PreyER= Wild prey Encounter rate, Prey Dung = Wild Prey Dung index, hl = Human disturbance index, ndvioct= NDVI Post Monsoon, rugg = Ruggedness, elev= Elevation

Table 5.7: Coefficients for the best covariate model in SECR for estimating leopard density in the Western Ghats Landscape.

Parameter	beta	SE.beta
Density	-8.140	0.148
leops	0.300	0.043
ndvioct	0.290	0.120
preyER	0.131	0.051
elev	0.225	0.055
g0	-4.302	0.040
Sigma	7.725	0.018

Figure 5.4: Spatially explicit leopard density map obtained by joint likelihood covariate model in SECR for Western Ghats.

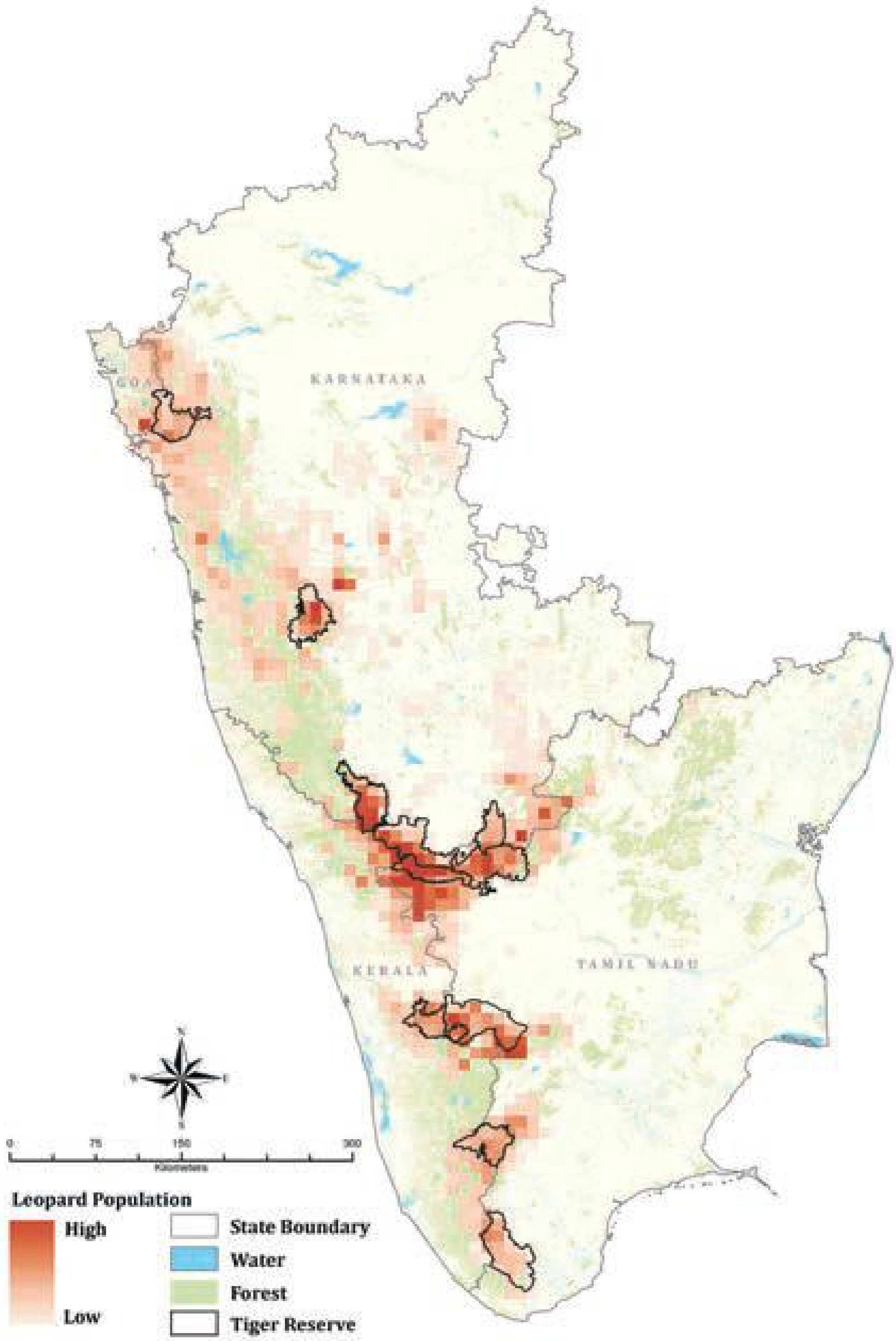
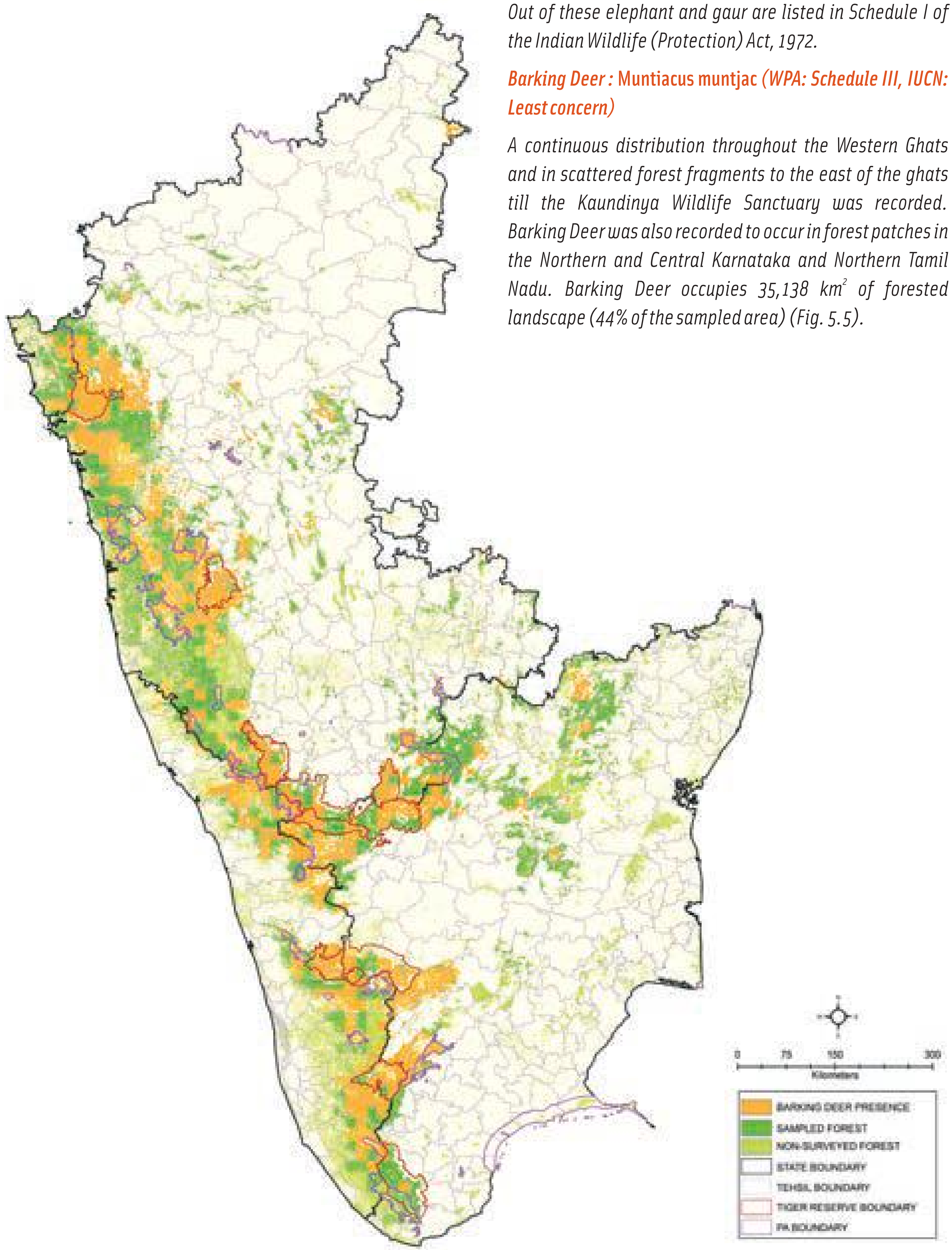


Figure 5.5: *Distribution of Barking deer in the Western Ghats Landscape.*



Occupancy of major prey species in Western Ghats Landscape

Major prey species of tigers found in this landscape are chital, sambar, gaur, elephant, barking deer and wild pig. Out of these elephant and gaur are listed in Schedule I of the Indian Wildlife (Protection) Act, 1972.

Barking Deer : Muntiacus muntjac ***(WPA: Schedule III, IUCN: Least concern)***

A continuous distribution throughout the Western Ghats and in scattered forest fragments to the east of the ghats till the Kaundinya Wildlife Sanctuary was recorded. Barking Deer was also recorded to occur in forest patches in the Northern and Central Karnataka and Northern Tamil Nadu. Barking Deer occupies 35,138 km² of forested landscape (44% of the sampled area) (Fig. 5.5).

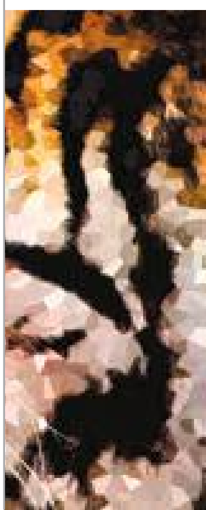
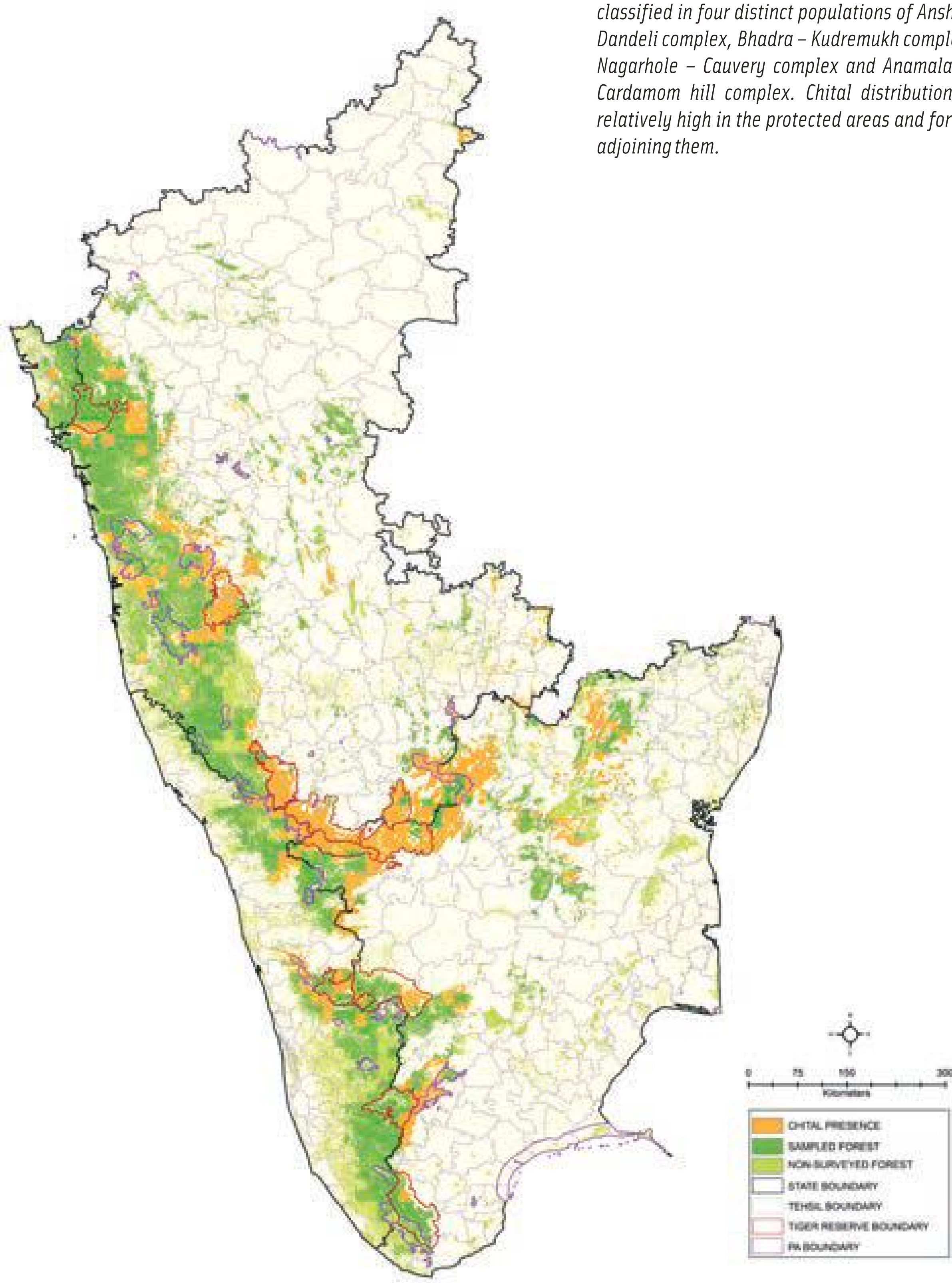


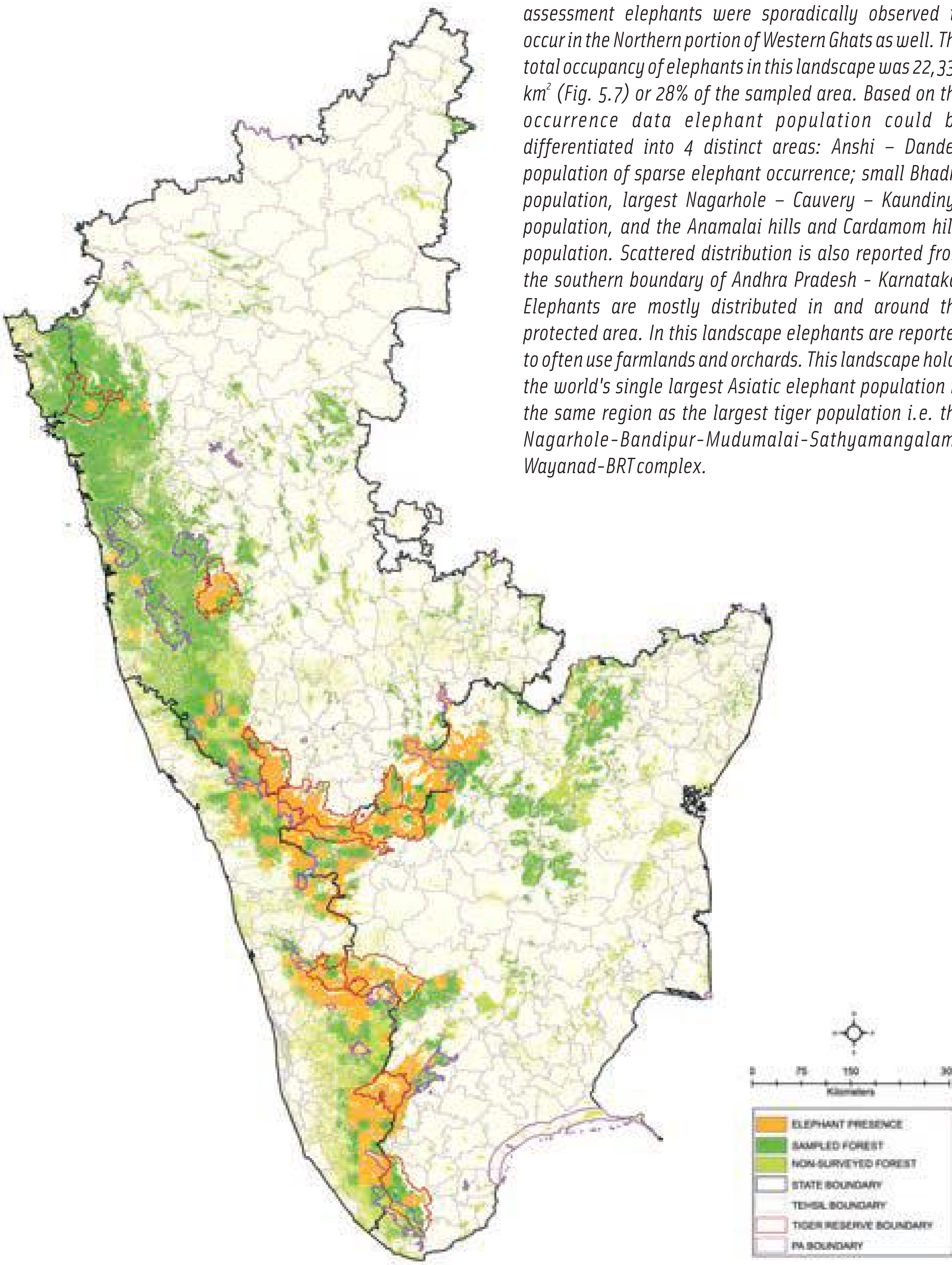
Figure 5.6: *Distribution of Chital in the Western Ghats Landscape.*



Chital: Axis axis *(WPA: Schedule III, IUCN: Least concern)*

Chital was recorded to occupy a total area of 24,901 km^2. of forested landscape (Fig. 5.6, (31% of the sampled area). The distribution could be classified in four distinct populations of Anshi – Dandeli complex, Bhadra – Kudremukh complex, Nagarhole – Cauvery complex and Anamalai – Cardamom hill complex. Chital distribution is relatively high in the protected areas and forest adjoining them.

Figure 5.7: *Distribution of Elephant in the Western Ghats Landscape.*



Elephant: Elephas maximus *(WPA: Schedule I, IUCN: Endangered)*

Elephants are one of the flagship species of this landscape and their distribution was earlier recorded mostly from the Southern Western Ghats. In the current assessment elephants were sporadically observed to occur in the Northern portion of Western Ghats as well. The total occupancy of elephants in this landscape was 22,330 km^2 (Fig. 5.7) or 28% of the sampled area. Based on the occurrence data elephant population could be differentiated into 4 distinct areas: Anshi – Dandeli population of sparse elephant occurrence; small Bhadra population, largest Nagarhole – Cauvery – Kaundinya population, and the Anamalai hills and Cardamom hills population. Scattered distribution is also reported from the southern boundary of Andhra Pradesh - Karnataka. Elephants are mostly distributed in and around the protected area. In this landscape elephants are reported to often use farmlands and orchards. This landscape holds the world's single largest Asiatic elephant population in the same region as the largest tiger population i.e. the Nagarhole-Bandipur-Mudumalai-Sathyamangalam-Wayanad-BRT complex.

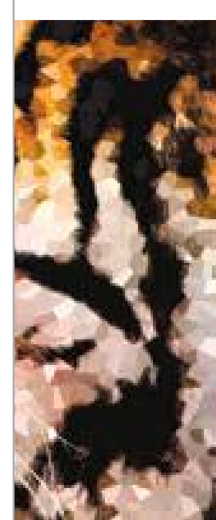
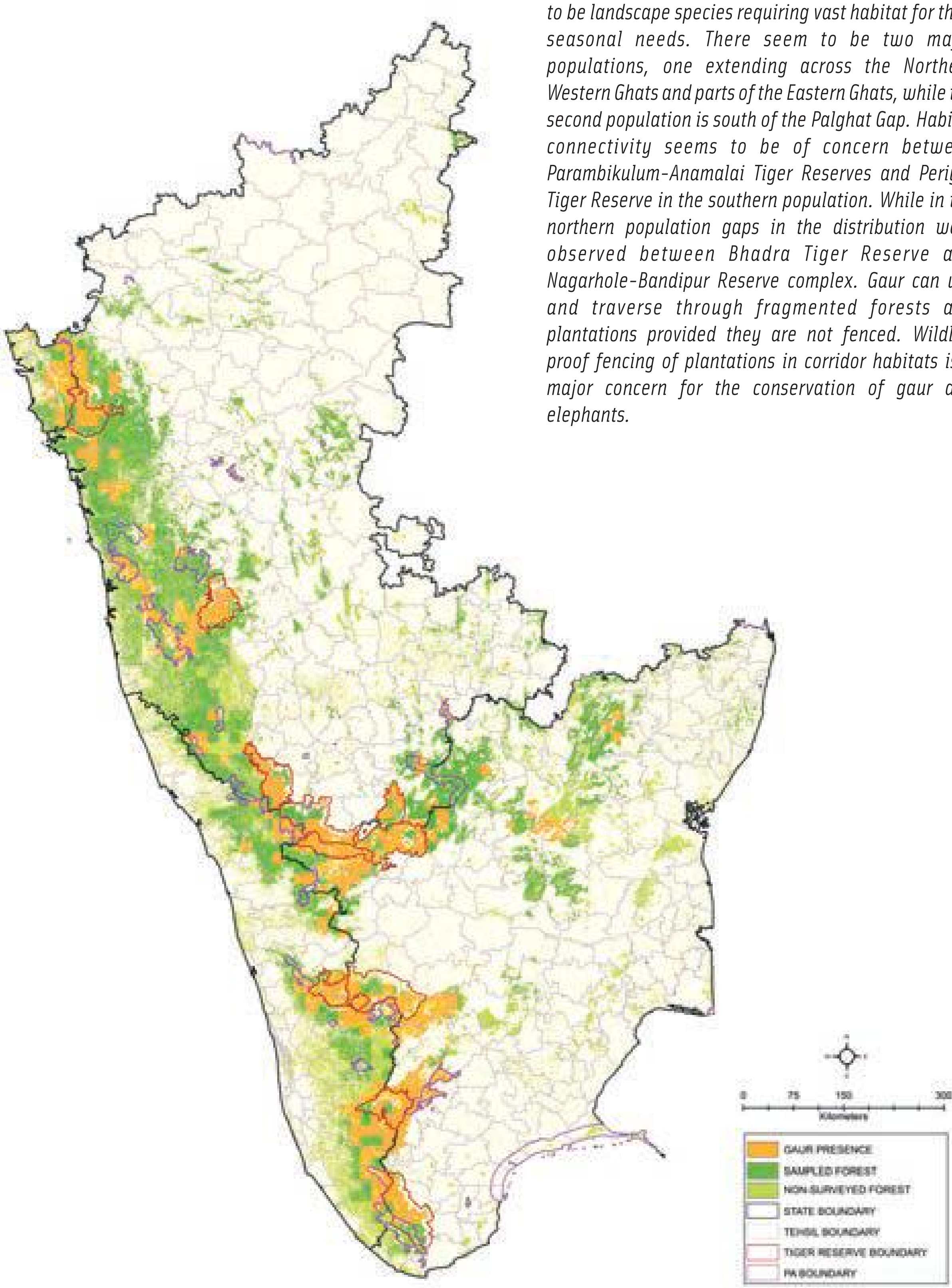


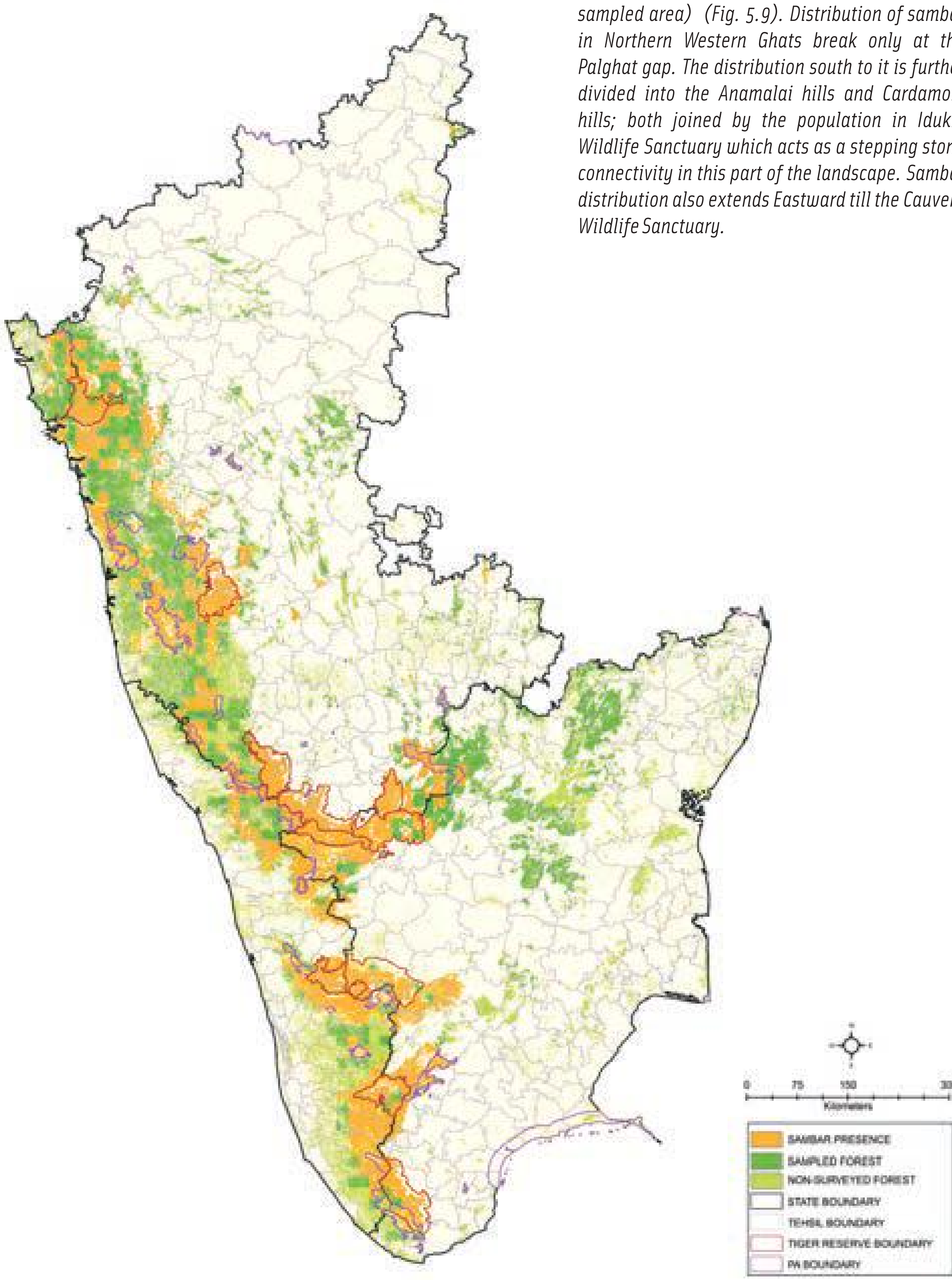
Figure 5.8: *Distribution of Gaur in the Western Ghats Landscape.*



Gaur : Bos gaurus *(WPA: Schedule I, IUCN: Vulnerable)*

Gaur was well distributed within the Western Ghat Landscape with an occupancy of 24,874 km^2 (31% of the sampled area) (Fig. 5.8) Gaur like elephant are known to be landscape species requiring vast habitat for their seasonal needs. There seem to be two major populations, one extending across the Northern Western Ghats and parts of the Eastern Ghats, while the second population is south of the Palghat Gap. Habitat connectivity seems to be of concern between Parambikulum-Anamalai Tiger Reserves and Periyar Tiger Reserve in the southern population. While in the northern population gaps in the distribution were observed between Bhadra Tiger Reserve and Nagarhole-Bandipur Reserve complex. Gaur can use and traverse through fragmented forests and plantations provided they are not fenced. Wildlife proof fencing of plantations in corridor habitats is a major concern for the conservation of gaur and elephants.

Figure 5.9: *Distribution of Sambar in the Western Ghats Landscape.*



Sambar: Rusa unicolor *(WPA: Schedule III, IUCN: Vulnerable)*

Sambar was recorded to occupy a total area of 37,596 km^2. of forested landscape (47% of the sampled area) (Fig. 5.9). Distribution of sambar in Northern Western Ghats break only at the Palghat gap. The distribution south to it is further divided into the Anamalai hills and Cardamom hills; both joined by the population in Idukki Wildlife Sanctuary which acts as a stepping stone connectivity in this part of the landscape. Sambar distribution also extends Eastward till the Cauvery Wildlife Sanctuary.

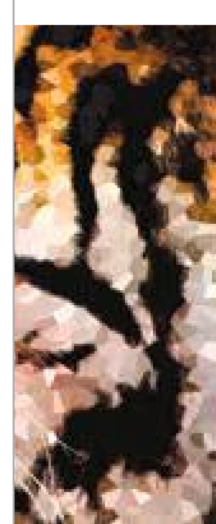
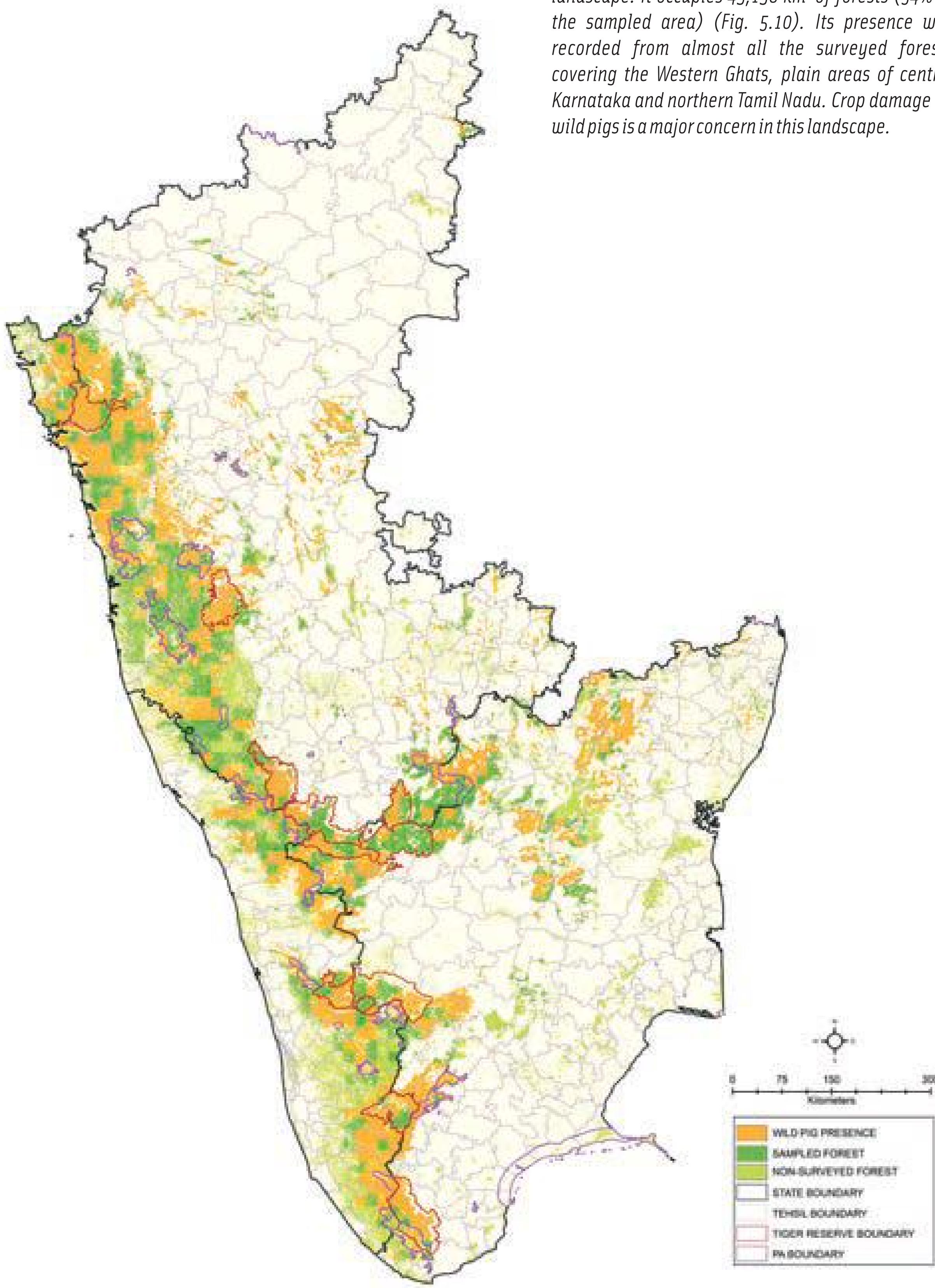


Figure 5.10: *Distribution of Wild pig in the Western Ghats Landscape.*



Wild pig: Sus scrofa *(WPA: Schedule III, IUCN: Least concern)*

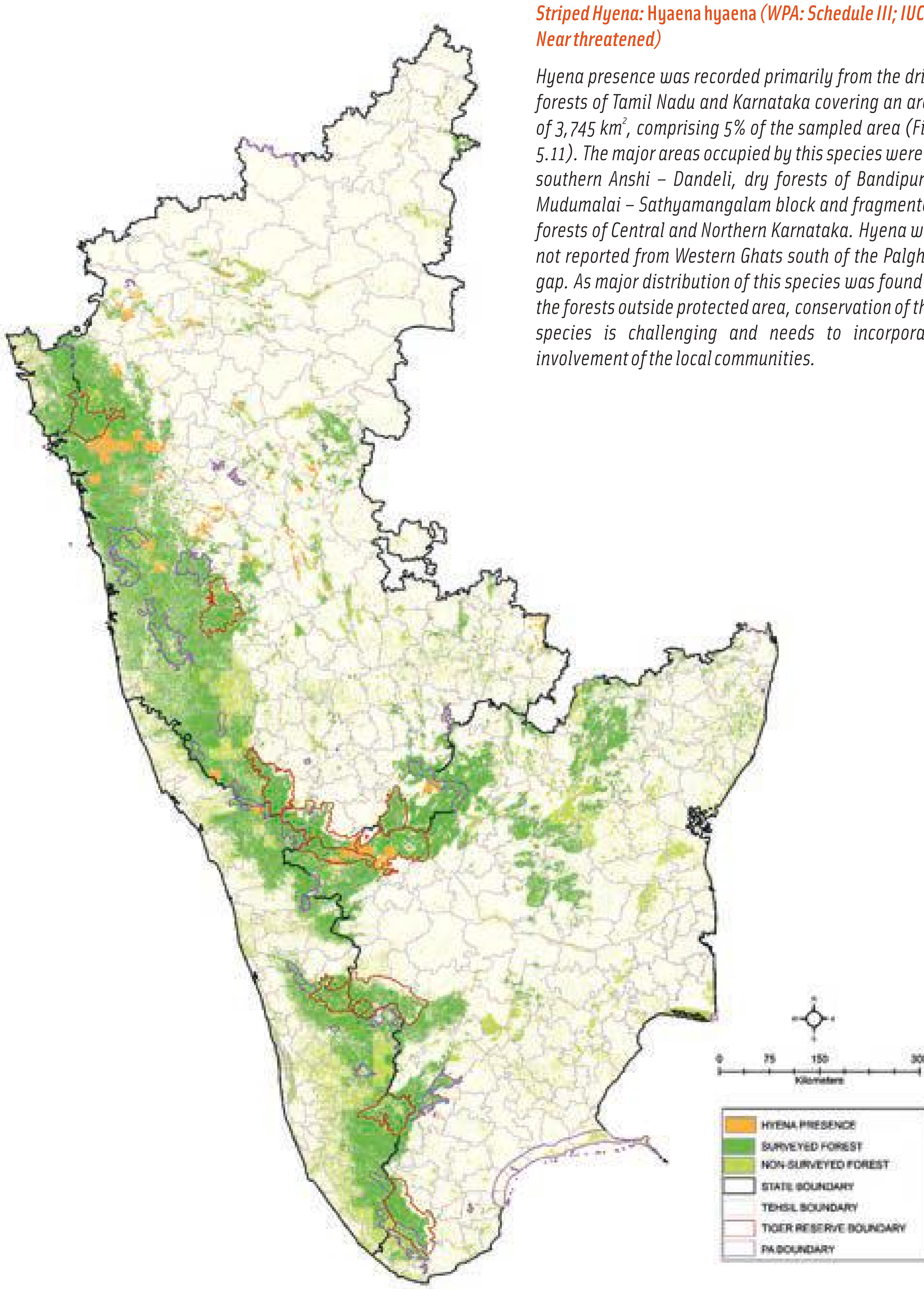
Wild pig is the most widely spread herbivore in this landscape. It occupies 43,138 km^2 of forests (54% of the sampled area) (Fig. 5.10). Its presence was recorded from almost all the surveyed forests covering the Western Ghats, plain areas of central Karnataka and northern Tamil Nadu. Crop damage by wild pigs is a major concern in this landscape.

Besides tigers and leopards, other major carnivores found in the Western Ghats were striped hyena, wild dog, wolf, sloth bear and jackal.

Striped Hyena: **Hyaena hyaena** ***(WPA: Schedule III; IUCN: Near threatened)***

Hyena presence was recorded primarily from the drier forests of Tamil Nadu and Karnataka covering an area of 3,745 km^2, comprising 5% of the sampled area (Fig. 5.11). The major areas occupied by this species were in southern Anshi – Dandeli, dry forests of Bandipur – Mudumalai – Sathyamangalam block and fragmented forests of Central and Northern Karnataka. Hyena was not reported from Western Ghats south of the Palghat gap. As major distribution of this species was found in the forests outside protected area, conservation of this species is challenging and needs to incorporate involvement of the local communities.

Figure 5.11: *Distribution of Hyena in the Western Ghats Landscape.*



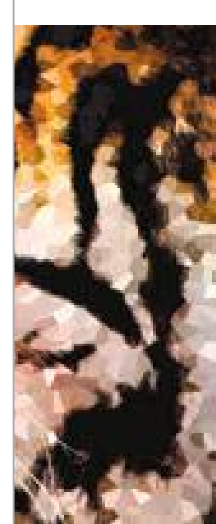
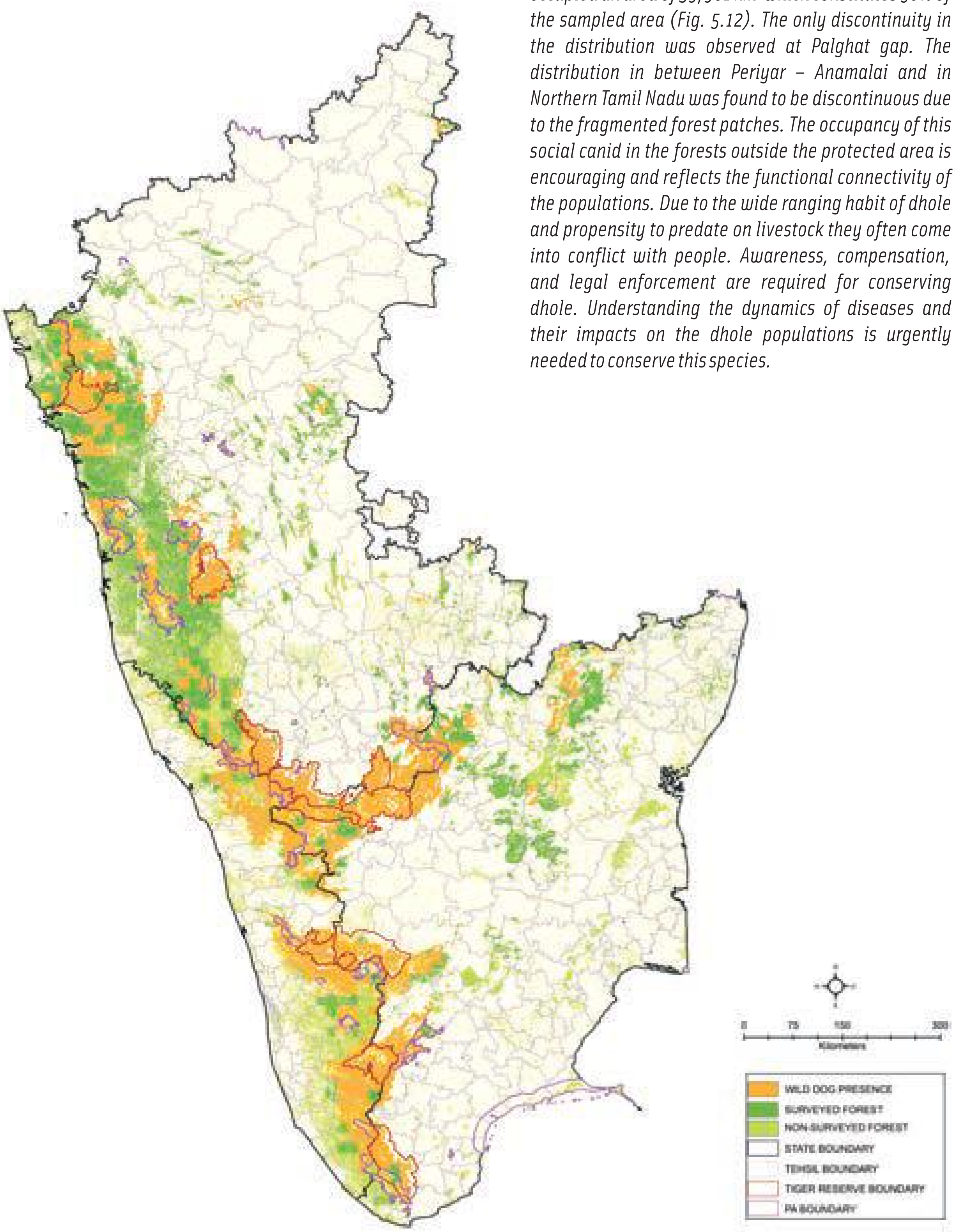


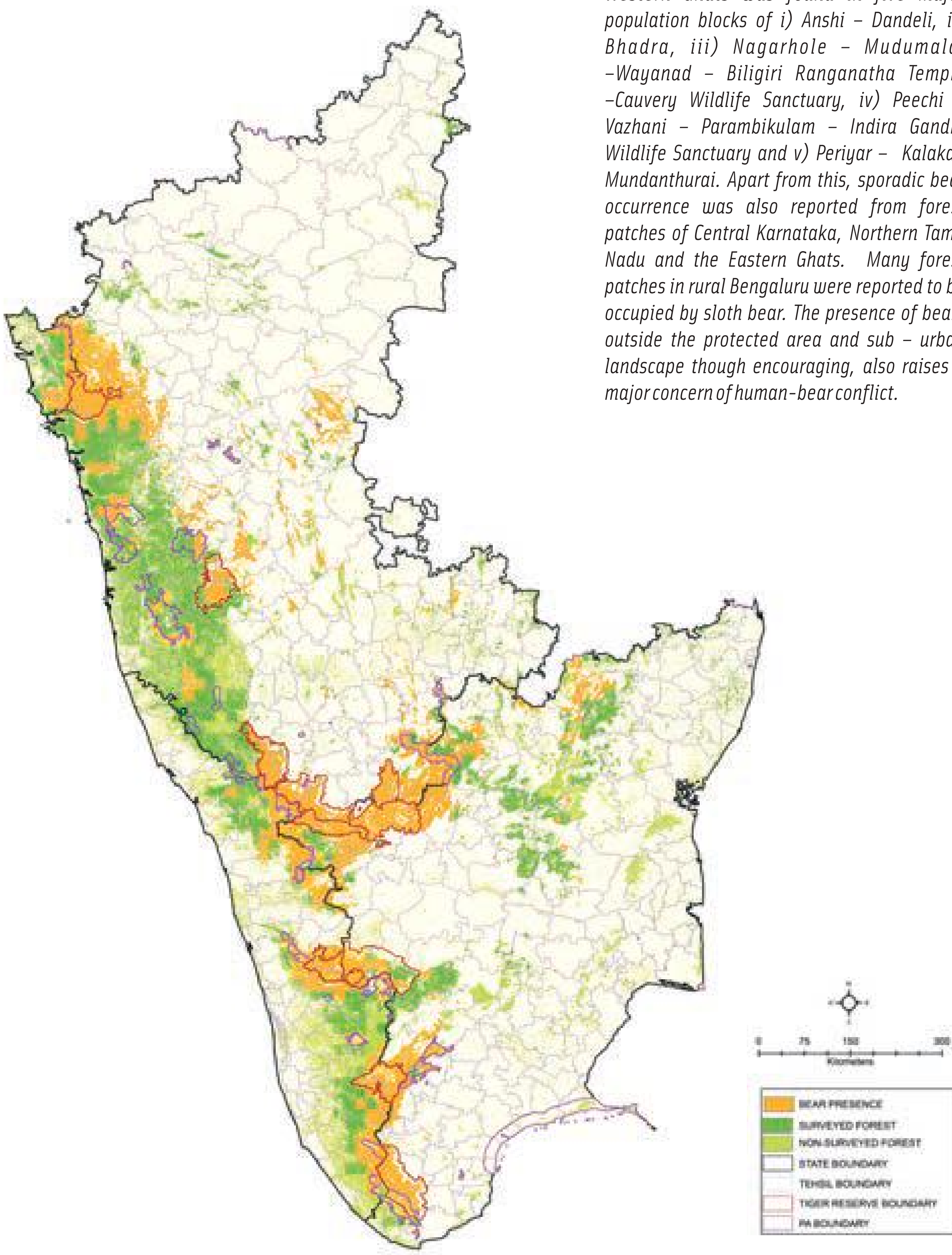
Figure 5.12: *Distribution of Wild dog (Dhole) in the Western Ghats Landscape.*



Wild dog (Dhole): Cuon alpines *(WPA: Schedule II; IUCN: Endangered)*

Dhole signs were recorded from most areas where leopard presence was also recorded, excluding the fragmented forests of Central Karnataka. Wild Dog occupied an area of 39,981 km^2 which constitutes 50% of the sampled area (Fig. 5.12). The only discontinuity in the distribution was observed at Palghat gap. The distribution in between Periyar – Anamalai and in Northern Tamil Nadu was found to be discontinuous due to the fragmented forest patches. The occupancy of this social canid in the forests outside the protected area is encouraging and reflects the functional connectivity of the populations. Due to the wide ranging habit of dhole and propensity to predate on livestock they often come into conflict with people. Awareness, compensation, and legal enforcement are required for conserving dhole. Understanding the dynamics of diseases and their impacts on the dhole populations is urgently needed to conserve this species.

Figure 5.13: Distribution of Sloth bear in the Western Ghats Landscape.



Sloth Bear: Melursus ursinus *(WPA: Schedule II; IUCN Vulnerable)*

Sloth bear signs were recorded from an area of 36,761 km² comprising 46% of the sampled area (Fig. 5.13). The distribution of Sloth bear in Western Ghats was found in five major population blocks of i) Anshi – Dandeli, ii) Bhadra, iii) Nagarhole – Mudumalai –Wayanad – Biligiri Ranganatha Temple –Cauvery Wildlife Sanctuary, iv) Peechi – Vazhani – Parambikulam – Indira Gandhi Wildlife Sanctuary and v) Periyar – Kalakad Mundanthurai. Apart from this, sporadic bear occurrence was also reported from forest patches of Central Karnataka, Northern Tamil Nadu and the Eastern Ghats. Many forest patches in rural Bengaluru were reported to be occupied by sloth bear. The presence of bears outside the protected area and sub – urban landscape though encouraging, also raises a major concern of human-bear conflict.

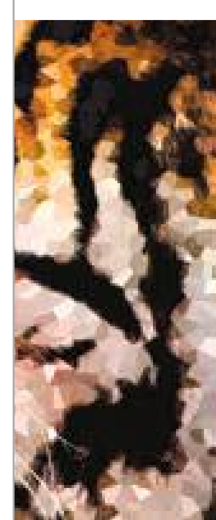
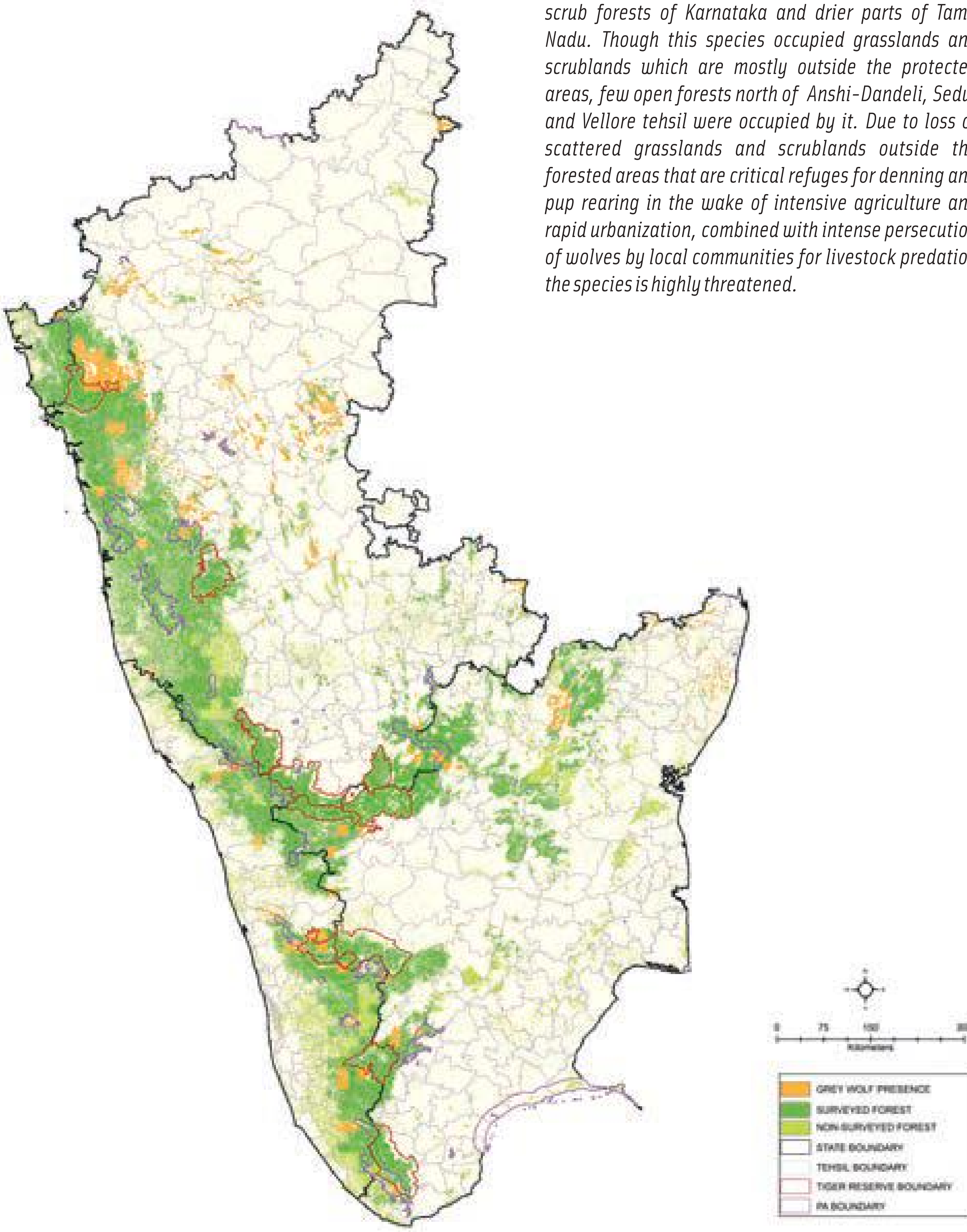


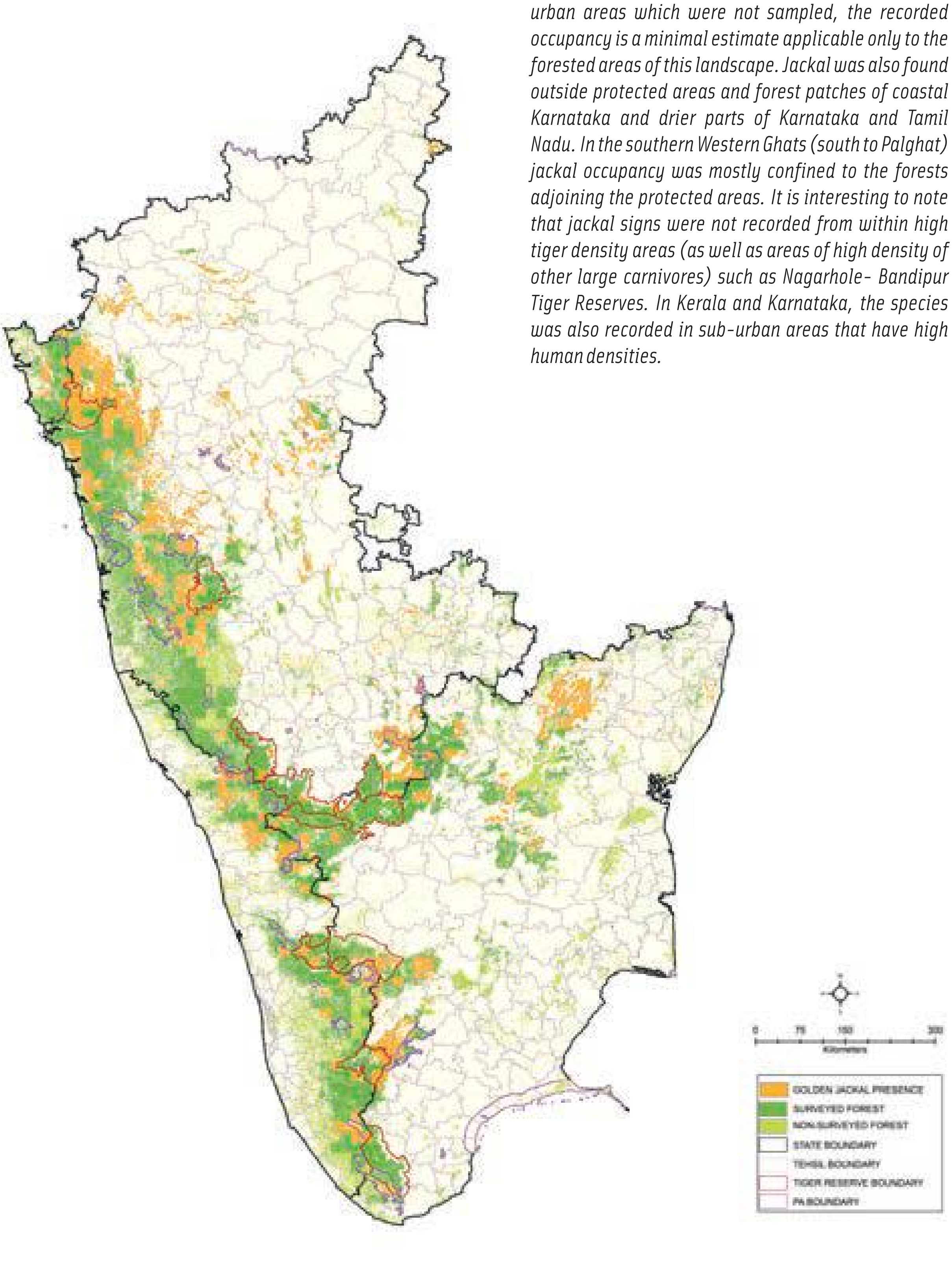
Figure 5.14: *Distribution of Grey wolf in the Western Ghats Landscape.*



Grey Wolf : Canis lupus pallipes *(WPA: Schedule I; IUCN: Least concern)*

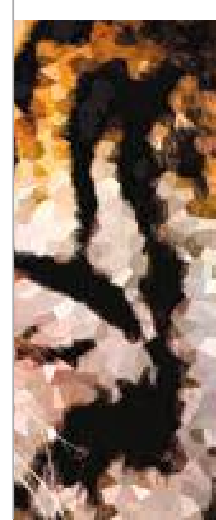
Wolves are known to prefer agro-pastoral and scrub forests and avoid thick canopied forests. Within the sampled forests the area occupied by wolves was 10,615 km^2 comprising 13% of the sampled area (Fig. 5.14). Wolf distribution was mainly recorded in flatter scrub forests of Karnataka and drier parts of Tamil Nadu. Though this species occupied grasslands and scrublands which are mostly outside the protected areas, few open forests north of Anshi-Dandeli, Sedur and Vellore tehsil were occupied by it. Due to loss of scattered grasslands and scrublands outside the forested areas that are critical refuges for denning and pup rearing in the wake of intensive agriculture and rapid urbanization, combined with intense persecution of wolves by local communities for livestock predation the species is highly threatened.

Figure 5.15: *Distribution of Golden jackal in the Western Ghats Landscape.*



Golden Jackal: Canis aureus *(WPA: Schedule II; IUCN: Least concern)*

Jackal distribution was contiguous in the northern Western Ghats. Jackal was recorded to occupy 26,985 km^2 constituting 34% of the sampled area (Fig. 5.15). Since jackals also occur in plantations, rural and semi-urban areas which were not sampled, the recorded occupancy is a minimal estimate applicable only to the forested areas of this landscape. Jackal was also found outside protected areas and forest patches of coastal Karnataka and drier parts of Karnataka and Tamil Nadu. In the southern Western Ghats (south to Palghat) jackal occupancy was mostly confined to the forests adjoining the protected areas. It is interesting to note that jackal signs were not recorded from within high tiger density areas (as well as areas of high density of other large carnivores) such as Nagarhole- Bandipur Tiger Reserves. In Kerala and Karnataka, the species was also recorded in sub-urban areas that have high human densities.

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North Eastern Hills and Brahmaputra Flood Plains 06

Qamar Qureshi, Y. V. Jhala, D. P. Bankhwal, R. Gopal, and B. S. Bonal

This landscape comprises of three zones; the Upper Bengal Dooars, the Brahmaputra flood plains and north-eastern hill region. Within this landscape tigers are reported to occur in the States of Assam, Arunachal Pradesh, Mizoram and northern part of West Bengal. However, the Phase-I survey was conducted only in limited areas and was primarily restricted to some protected areas. The total habitat surveyed in Phase-I was 21,017 km^2. It is within this surveyed forest area that occupancy of each species is reported. Major forest types include East Himalayan Moist Mixed Deciduous Forest, East Himalayan Mixed Coniferous Forest and Assam Alluvial plains Semi-Evergreen Forest (Champion and Seth 1968).

Within the limited areas that were surveyed in this landscape, tigers have shown a promising trend with the populations of Kaziranga showing contiguity with those of Paake and Nameri tiger reserves and more interestingly covering the major part of the Karbi Anglong (Fig. 6.1). Dibang valley and Namdapha were more extensively sampled compared to earlier surveys and show a persisting low density tiger population.

Total of 2,996 photo captures of 152 individual tigers were obtained from the limited areas camera trapped in this landscape. Tiger numbers have shown improvement in the State of Assam with Kaziranga having the maximum number of tigers numbering over a hundred tigers (Tables 2.1 & 2.2, Figs. 6.1 & 6.2). On the basis of genetic sampling minimum 5 tigers were recorded in Dibang valley and 4 tigers in Namdapha Tiger Reserve, based on this count within search area minimum density was estimated to be 0.77(SE 0.1) tiger/100 km^2. Extrapolating this density to tiger habitat estimated by MaxEnt gave a potential tiger population of about 17 in Namdapha and Dibang landscape block. Kaziranga landscape having 2,773 km^2 holds 163 tigers (Fig. 6.2) and is the most important conservation unit not only for tigers but also for greater one horned rhinoceros, barasingha, wild buffalo, elephant and Bengal florican. This area is connected with Karbi-Anglong in the south, Nameri in the north and Orang on its west. This area gets flooded every year by Brahmaputra and Karbi hills act as an important refuge. It is crucial to manage traffic on the highway passing through Kaziranga by using green infrastructure and modern technology so that infrastructure and urban sprawl do not form a barrier for this important movement of wildlife into Karbi Anglong. Namdapha has remained a low density area, while Dibang has recently recorded breeding females. Two tigers were identified in Buxa on the basis of scat based DNA and serious efforts to recover tigers in this landscape are required. These efforts should include improved protection, reduced human pressure and prey enhancement. The other important populations in this landscape are Pakke in Arunachal Pradesh, Nameri and Manas in Assam, all these populations are low density areas and have a potential for further growth but they need more resources for protection, reduction of human pressures and staff. Since tiger reserves in this landscape have high biodiversity values associated with unique habitats and closed canopy forests, care needs to be taken that management actions to increase tigers should not compromise these other habitats and their biodiversity values. Many of the habitats of the North East inherently have low carrying capacity for tigers, therefore besides reducing anthropogenic and associated pressures other management options like habitat alteration should be considered only after careful scientific consideration.

Figure 6.1: Changes in tiger distribution in the North Eastern hills & Brahmaputra Flood Plains since 2006 to 2014.

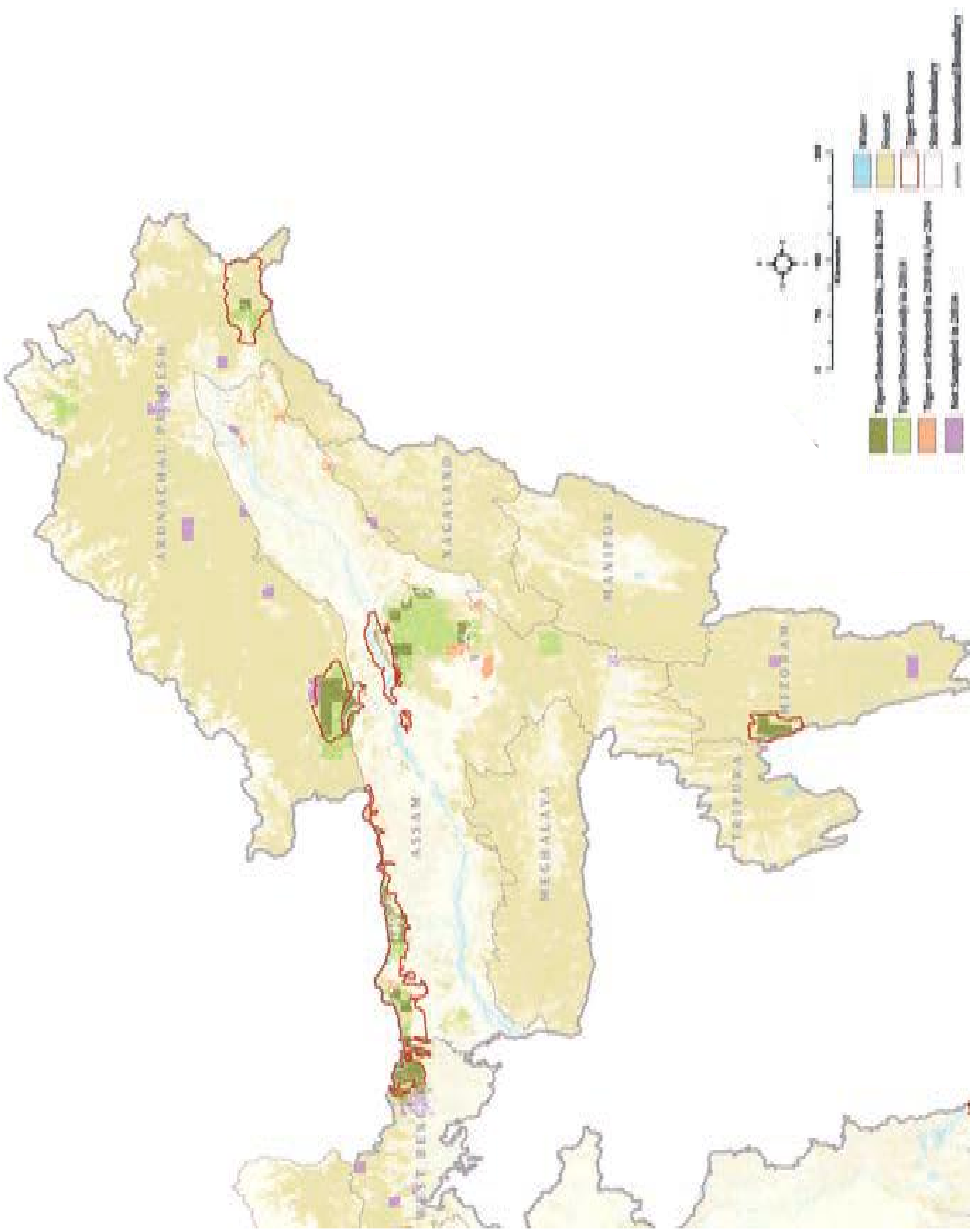
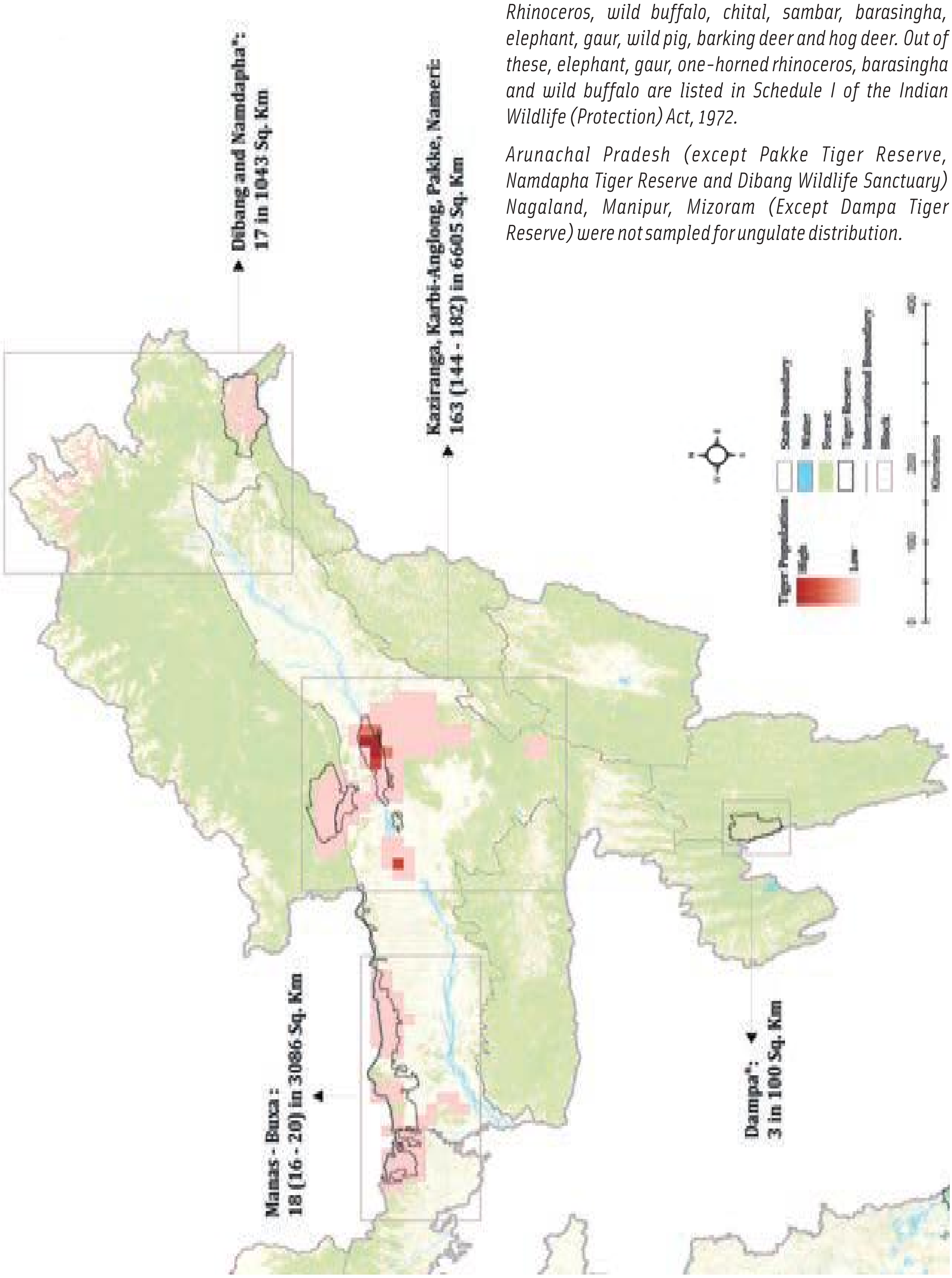


Figure. 6.2: Tiger density, extent and population blocks in the North Eastern Hills and Brahmaputra Flood Plains.



Distribution and occupancy of major prey species in North Eastern Hills and Brahmaputra Flood Plains

Major ungulates found in North eastern Hills and Brahmaputra Flood Plains are greater one-horned Rhinoceros, wild buffalo, chital, sambar, barasingha, elephant, gaur, wild pig, barking deer and hog deer. Out of these, elephant, gaur, one-horned rhinoceros, barasingha and wild buffalo are listed in Schedule I of the Indian Wildlife (Protection) Act, 1972.

Arunachal Pradesh (except Pakke Tiger Reserve, Namdapha Tiger Reserve and Dibang Wildlife Sanctuary) Nagaland, Manipur, Mizoram (Except Dampa Tiger Reserve) were not sampled for ungulate distribution.

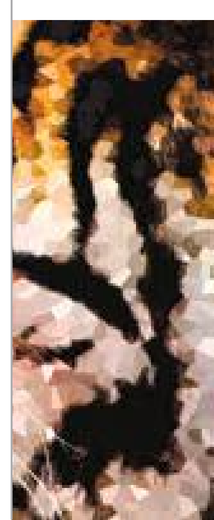
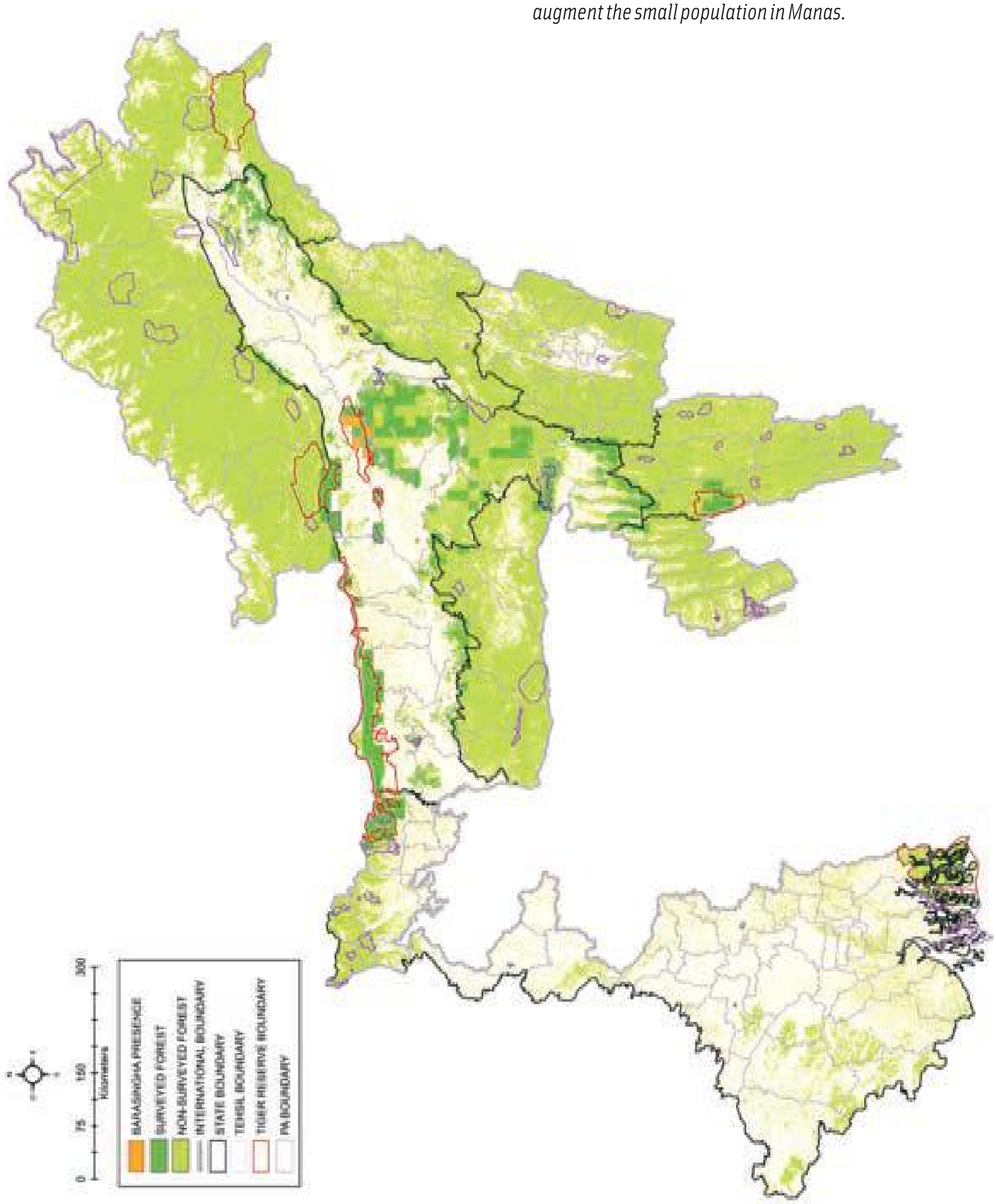


Figure 6.3: *Distribution of Barasingha in the North-Eastern Hills and Brahmaputra Flood Plains Landscape.*



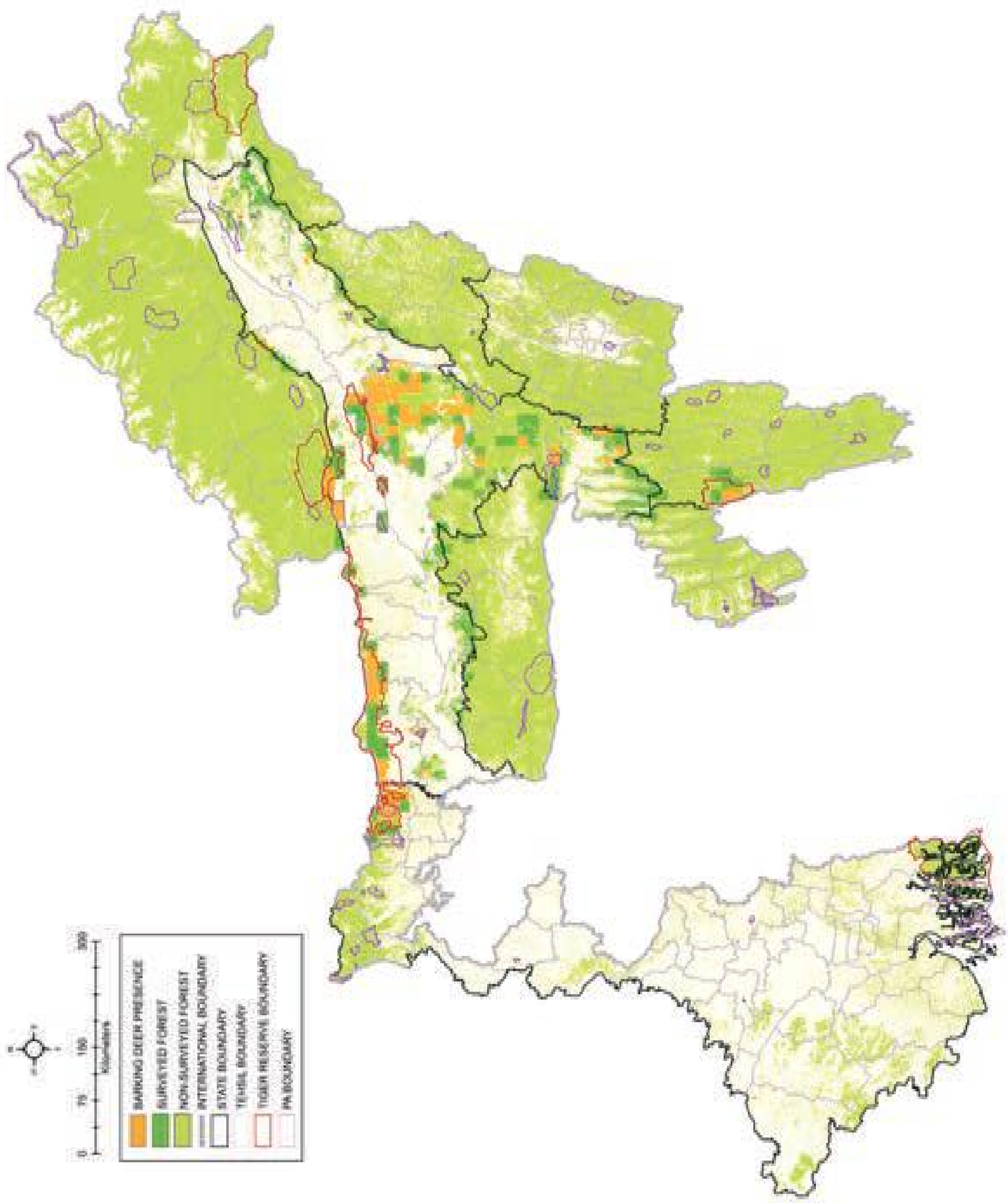
Barasingha: Rucervus duvaucelii ranjitsinhii *(WPA: Schedule I, IUCN: Vulnerable)*

Barasingha was reported from Kaziranga and Manas Tiger Reserves. In this area Barasingha mainly inhabit the flood plains and swamps around Brahmaputra River. Total occupancy was reported to be 271 km^2 (1.3% of the sampled area) (Fig. 6.3). Nineteen individuals have been moved to Manas Tiger Reserve from Kaziranga Tiger Reserve to augment the small population in Manas.

Figure 6.4: Distribution of Barking deer in the sampled forests of North-Eastern Hills and Brahmaputra Flood Plains Landscape.

Barking Deer: Muntiacus muntjac *(WPA: Schedule III, IUCN: Least concern)*

Barking deer are one of the prey species that are widely distributed outside protected areas and are also extensively hunted in this landscape. Barking deer were recorded to occupy 6,345 km² of the sampled forests (30% of the area) (Fig. 6.4).



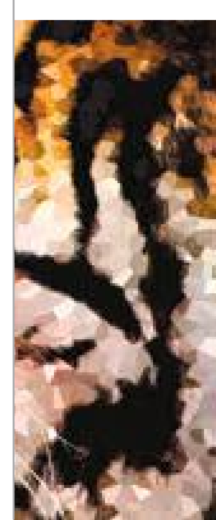
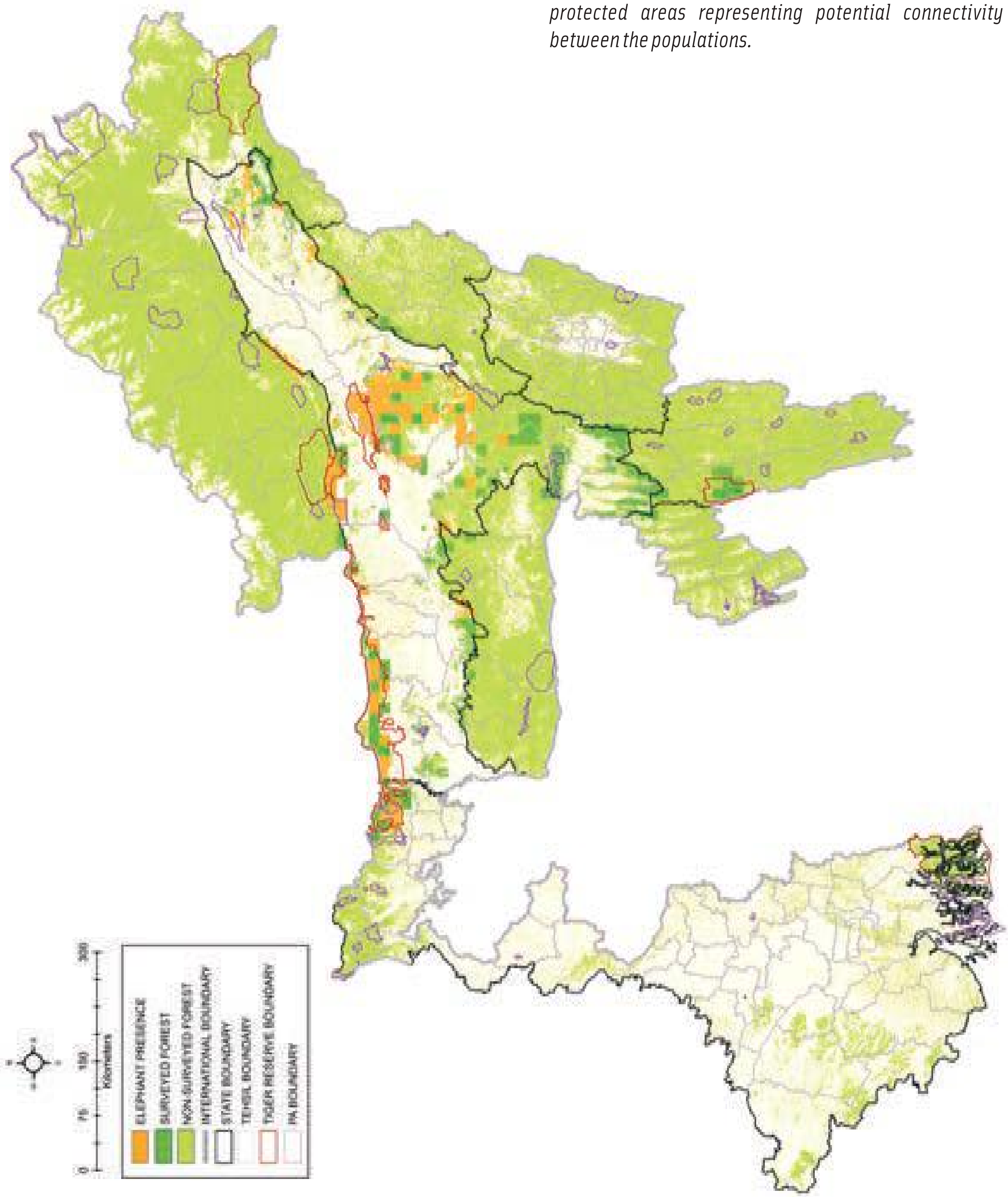


Figure 6.5: *Distribution of Elephant in the sampled forests of North-Eastern Hills and Brahmaputra Flood Plains Landscape.*



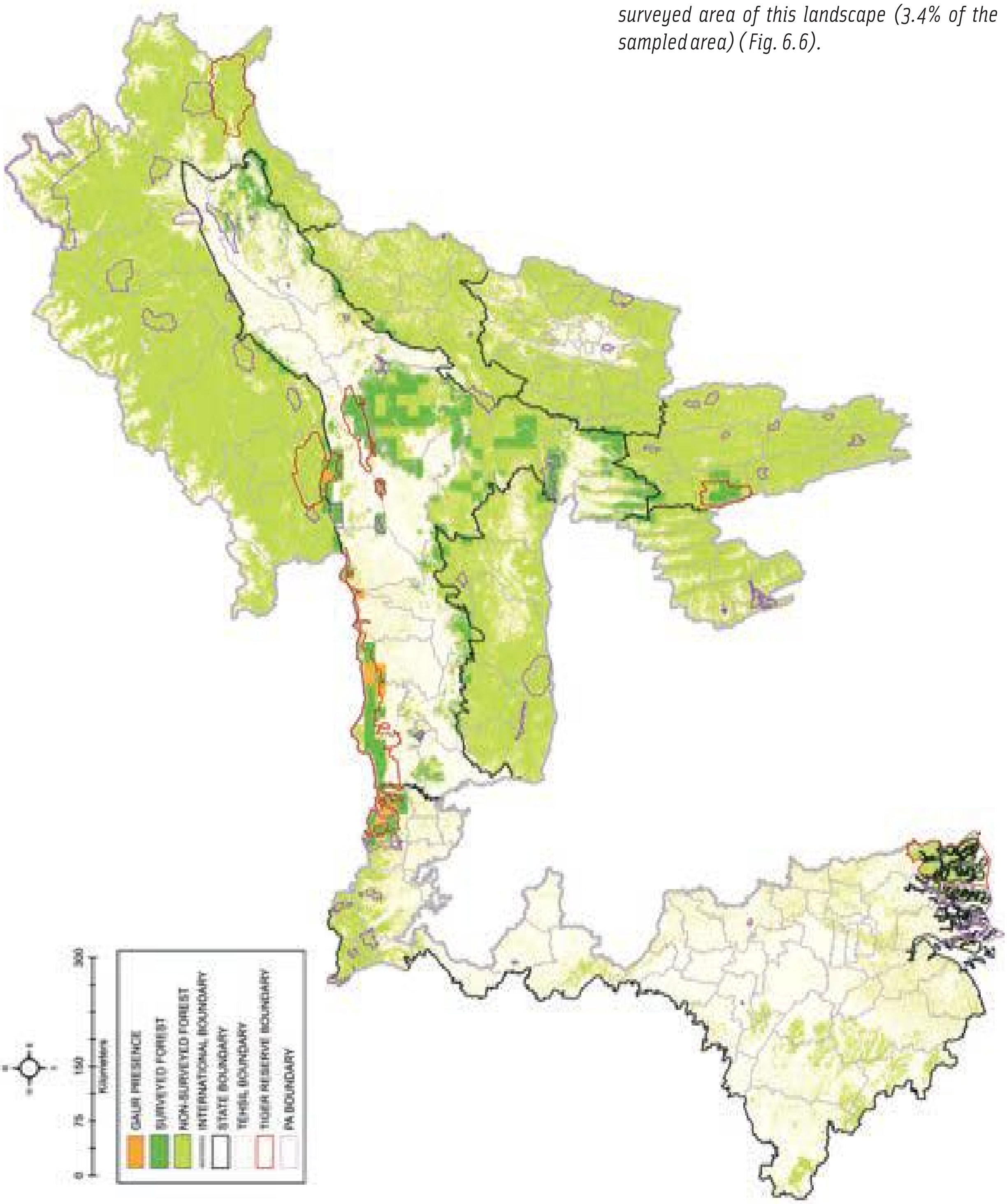
Elephant: **Elephas maximus** *(WPA: Schedule I, IUCN: Endangered)*

Elephant distribution is continuous along the junction of upper Brahmaputra plains and Himalayan foothills, Kaziranga Tiger Reserve, forested areas of Karbi Anglong, Assam - Nagaland boundary and Assam - Meghalaya boundary. The total occupancy was recorded to be 7,772 km^2 in the surveyed forest area (37% of the sampled area) (Fig. 6.5). Elephants are also present in the forest outside protected areas representing potential connectivity between the populations.

Figure 6.6: *Distribution of Gaur in the sampled forests of North-Eastern Hills and Brahmaputra Flood Plains Landscape.*

Gaur: Bos gaurus *(WPA: Schedule I, IUCN: Vulnerable)*

Gaur distribution was scattered along the junction of northern bank of Brahmaputra plains and the Himalayan foothills. The distribution was largely confined to the Manas Tiger Reserve, Nameri Tiger Reserve and forest patches adjoining in Assam. The total area occupied by this bovid was small, 724 km² in the surveyed area of this landscape (3.4% of the sampled area) (Fig. 6.6).



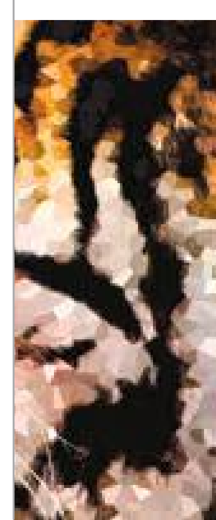
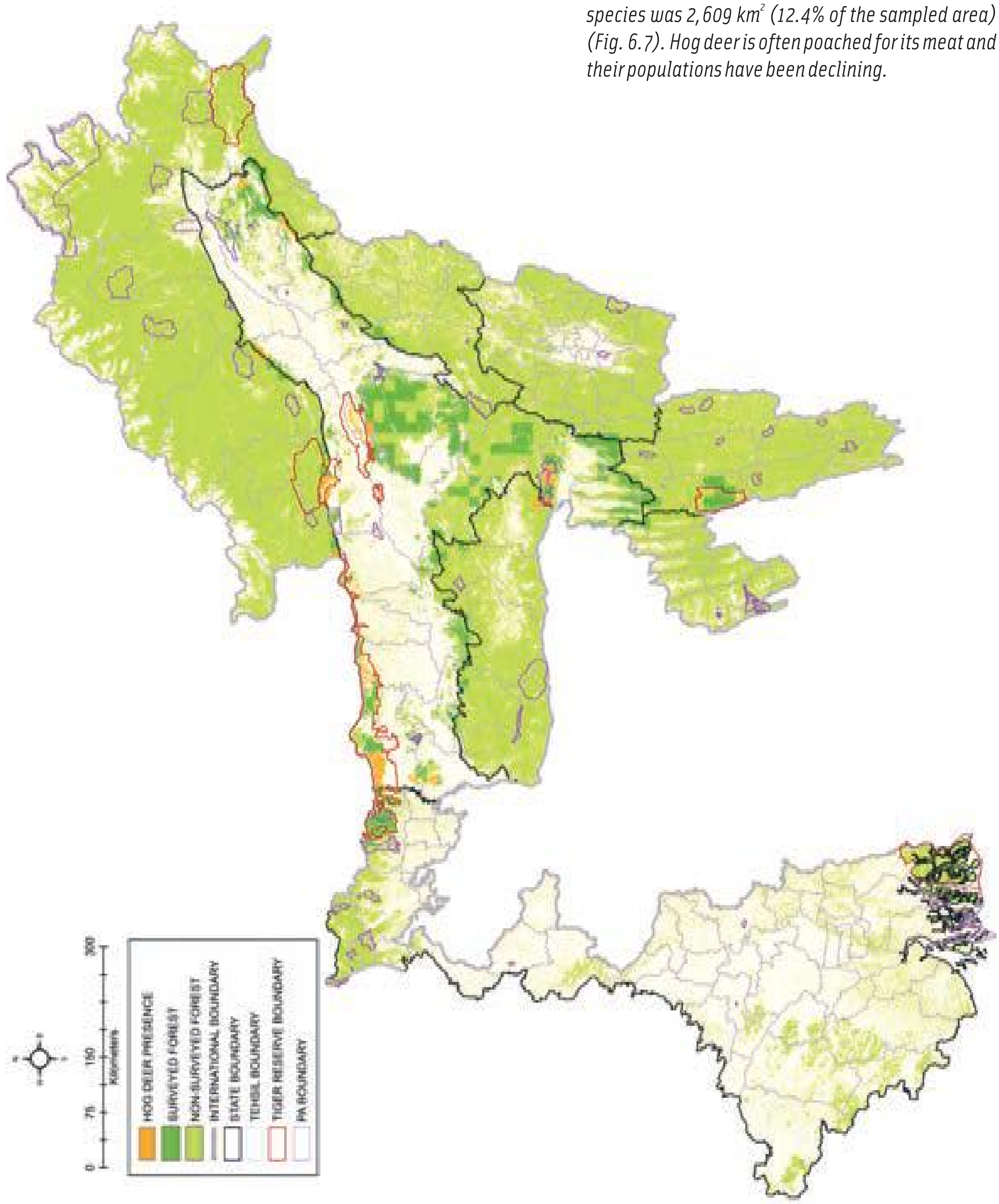


Figure 6.7: Distribution of Hog Deer in the sampled forests of North-Eastern Hills and Brahmaputra Flood Plains Landscape.

Hog Deer: Axis porcinus *(WPA: Schedule III, IUCN: Endangered)*

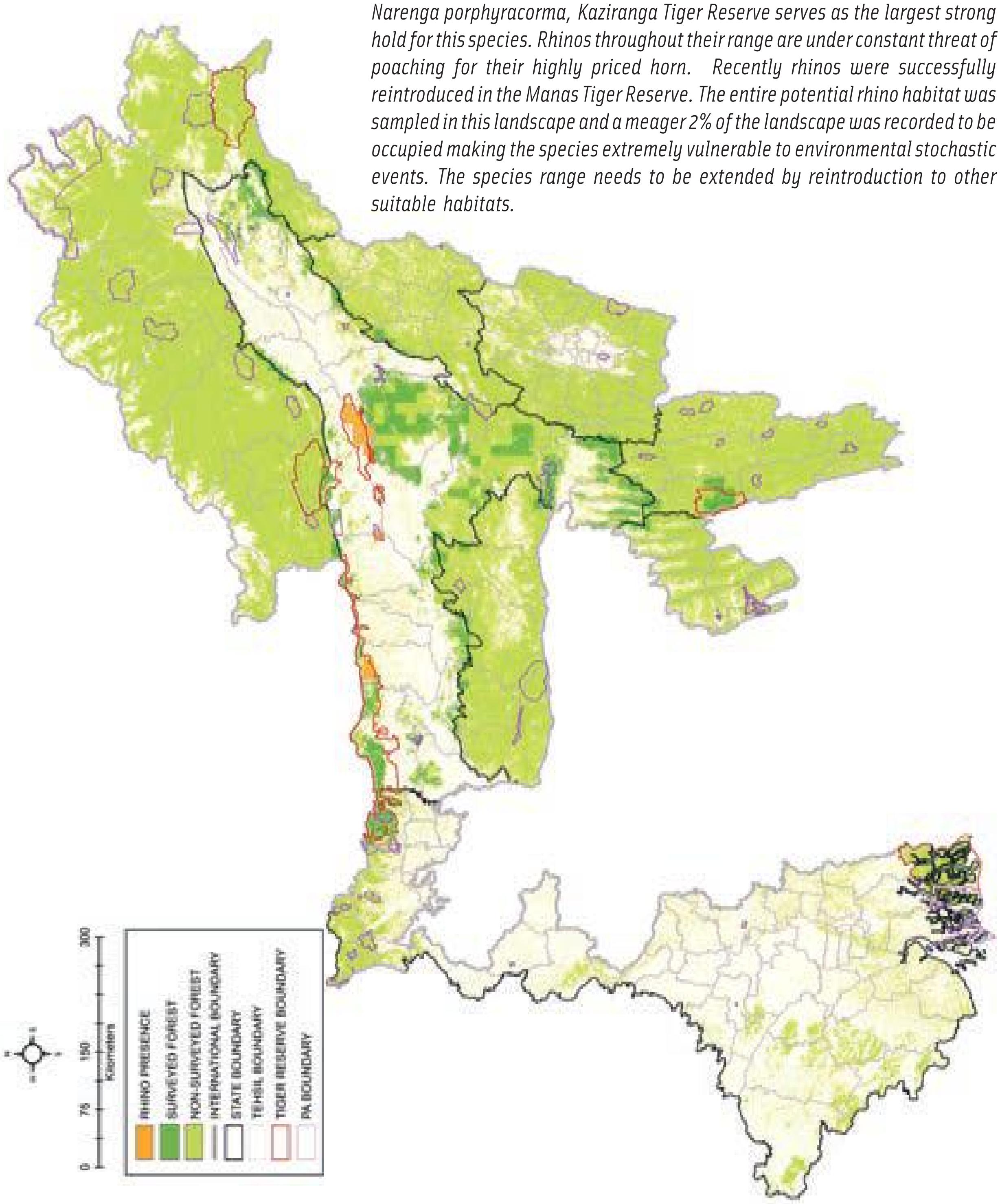
A continuous distribution of hog deer was recorded for along the Brahmaputra flood plains. In central Assam, hog deer was present in Kaziranga Tiger Reserve, Manas Tiger Reserver, Borail Wildlife Sanctuary, Burachapori Wildlife Sanctuary, Orang National Park, Eastern Boundary of Assam - Arunachal Pradesh. Total area occupied by this species was 2,609 km^2 (12.4% of the sampled area) (Fig. 6.7). Hog deer is often poached for its meat and their populations have been declining.



Greater One-horned Rhinoceros: Rhinoceros unicornis *(WPA: Schedule I, IUCN: Vulnerable)*

Rhinoceros is the flagship species of the flood plain habitat. Its presence was recorded in protected areas of Assam (Kaziranga, Orang, Pabitora, laokhowa - Burachapori and Manas) and West Bengal (Gorumara and Jaldapara). Total area occupied by rhinos was recorded to be 413 km^2 (2% of the sampled area) (Fig. 6.8). Rhino distribution was largely confined to Kaziranga Tiger Reserve, Manas Tiger Reserve Orang National Park and Pabitora. Owing to the tall alluvial grasslands along Brahmaputra River dominated by Saccharum spontaneum and Narenga porphyracorma, Kaziranga Tiger Reserve serves as the largest strong hold for this species. Rhinos throughout their range are under constant threat of poaching for their highly priced horn. Recently rhinos were successfully reintroduced in the Manas Tiger Reserve. The entire potential rhino habitat was sampled in this landscape and a meager 2% of the landscape was recorded to be occupied making the species extremely vulnerable to environmental stochastic events. The species range needs to be extended by reintroduction to other suitable habitats.

Figure 6.8: Distribution of Greater one-horned Rhinoceros in the North-Eastern Hills and Brahmaputra Flood Plains Landscape.



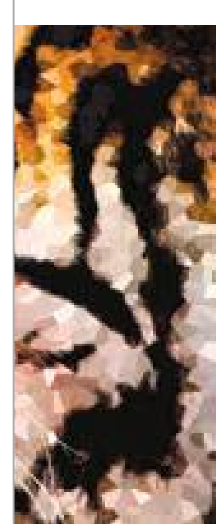
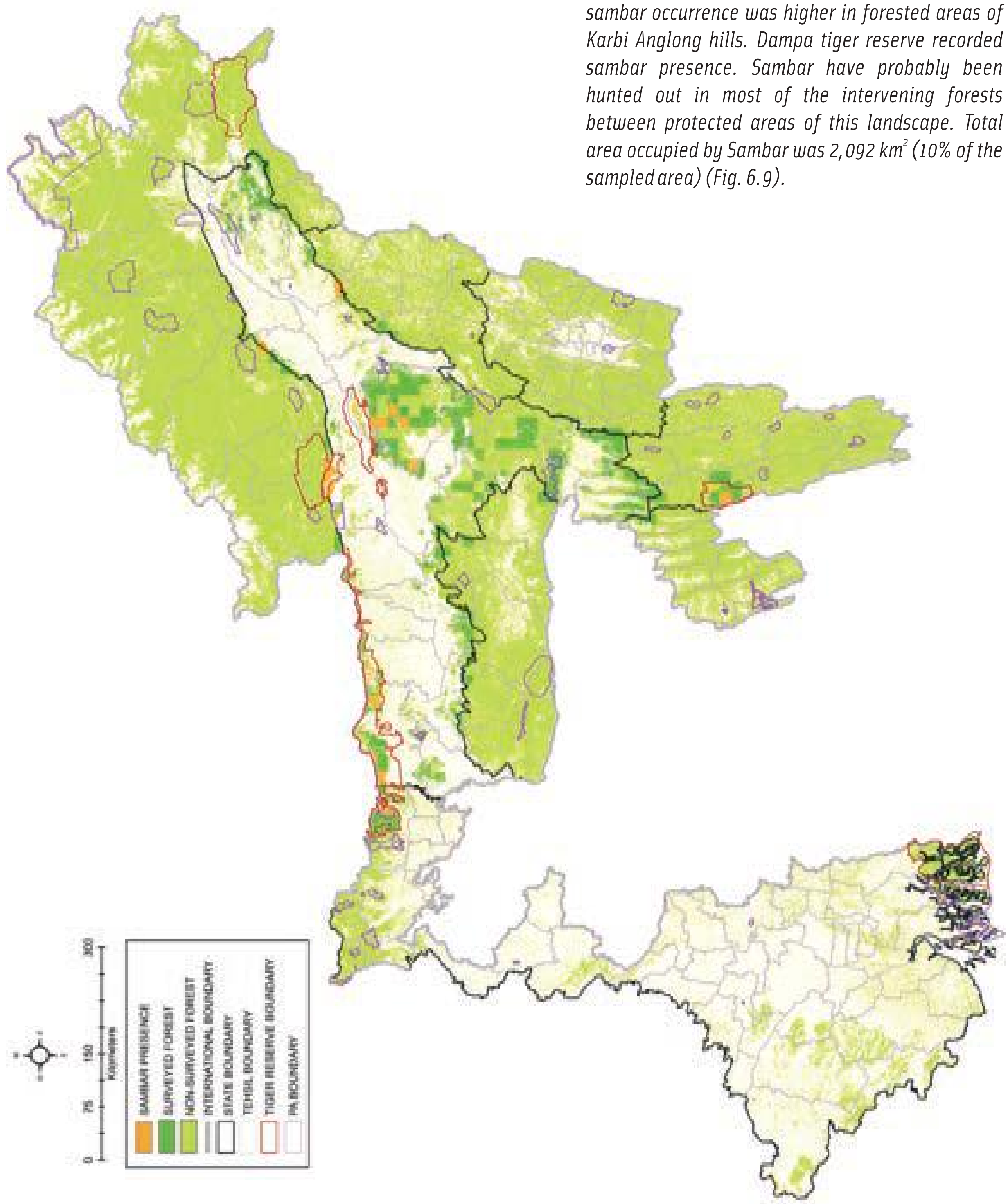


Figure 6.9: *Distribution of Sambar in the sampled forests of North-Eastern Hills and Brahmaputra Flood Plains Landscape.*



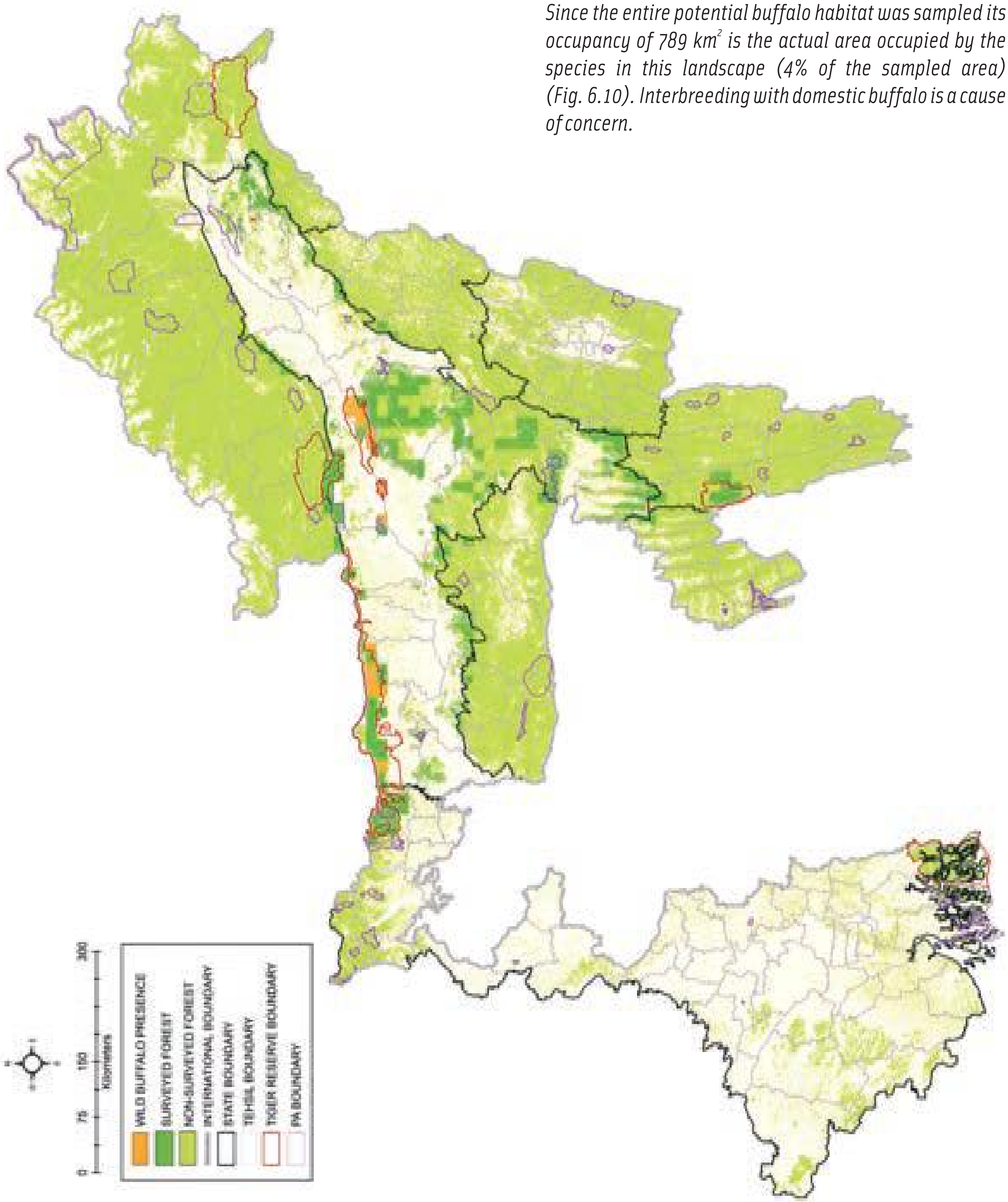
Sambar: **Rusa unicolor** ***(WPA: Schedule III, IUCN: Vulnerable)***

Sambar presence was recorded in protected areas in the forests along the Brahmaputra plains and in the Karbi Anglong hills. The protected areas were Manas Tiger Reserve, Sonai – Rupai Wildlife Sanctuary, Pakke Tiger Reserve, Nameri Tiger Reserve and in Lakhimpur tehsil of Assam. Its distribution was also sparcely recorded in the Kaziranga Tiger Reserve but sambar occurrence was higher in forested areas of Karbi Anglong hills. Dampa tiger reserve recorded sambar presence. Sambar have probably been hunted out in most of the intervening forests between protected areas of this landscape. Total area occupied by Sambar was 2,092 km² (10% of the sampled area) (Fig. 6.9).

Wild Buffalo: **Bubalua arnee** ***(WPA: Schedule I, IUCN: Endangered)***

In this landscape, wild buffalo is largely confined to the protected areas of Kaziranga Tiger Reserve, Manas Tiger Reserve, Orang National Park, Burachapori Wildlife Sanctuary and Bherjan-Borajan-Podumoni Wildlife Sanctuary. A distinct presence was also recorded on the border of Kampur - Nagaon tehsil of Assam. Wild buffalo was recorded to occur in swampy grasslands and marshes. Since the entire potential buffalo habitat was sampled its occupancy of 789 km^2 is the actual area occupied by the species in this landscape (4% of the sampled area) (Fig. 6.10). Interbreeding with domestic buffalo is a cause of concern.

Figure 6.10: *Distribution of Wild buffalo in North-Eastern Hills and Brahmaputra Flood Plains Landscape.*



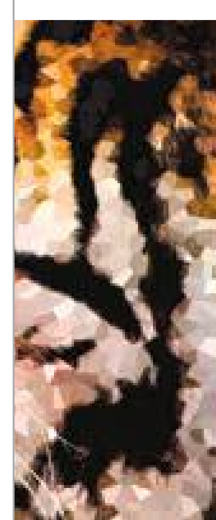
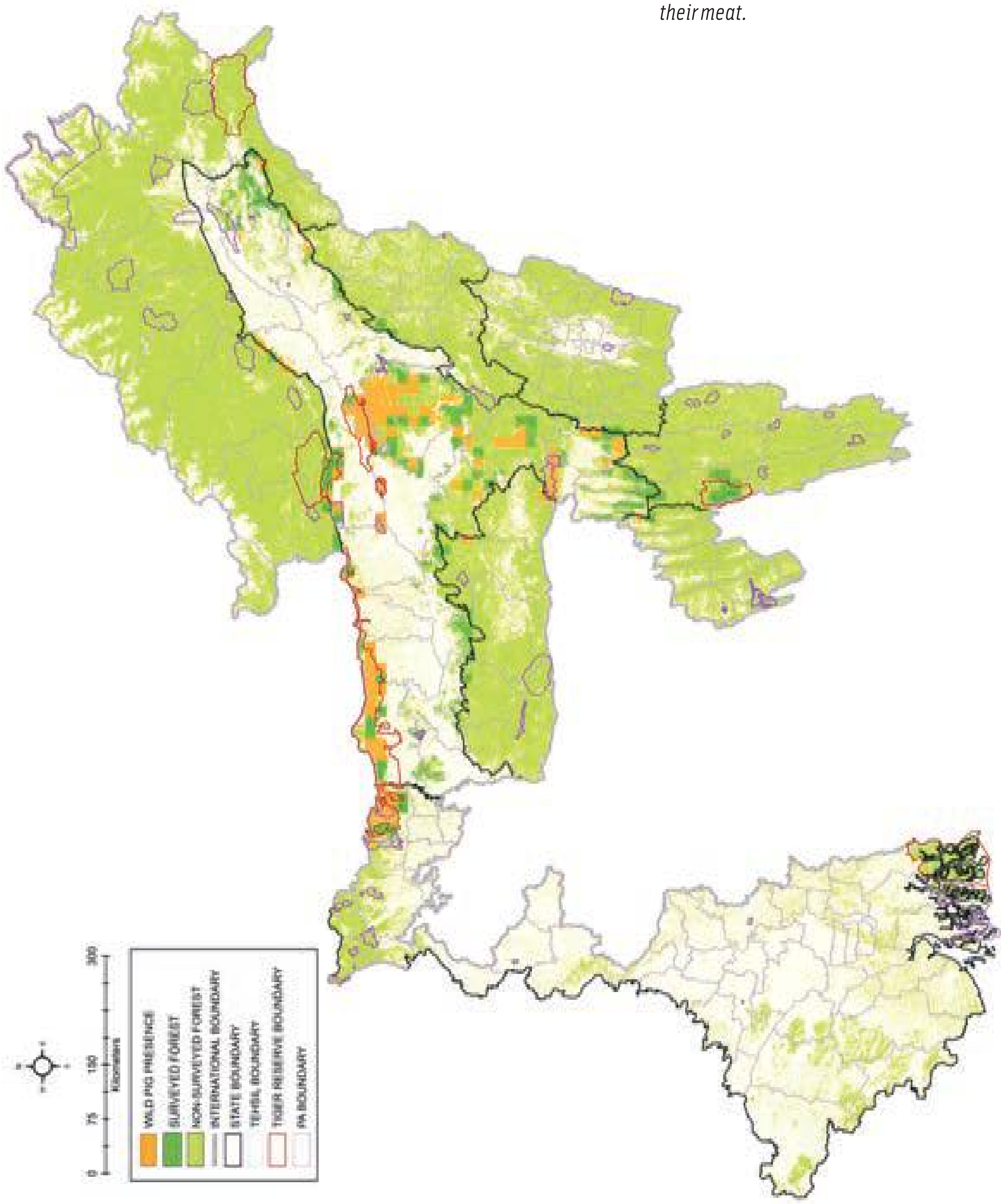


Figure 6.11: *Distribution of Wild pig in the sampled forests of North-Eastern Hills and Brahmaputra Flood Plains Landscape.*



Wild pig: Sus scrofa *(WPA: Schedule III, IUCN: Least concern)*

Wild pig occupancy was recorded 7,488 km^2 of forested landscape (36% of the sampled area) (Fig. 6.11). The distribution of wild pig was similar to barking deer, which covered most of the surveyed areas. Wild pigs are also reported to occur outside the protected area and are often hunted for their meat.

Other carnivore species whose distribution was partially recorded (Arunachal Pradesh, Mizoram, Nagaland, Manipur not sampled) in this landscape were leopard, wild dog, sloth bear and jackal.

Leopard : Panthera pardus *(WPA: Schedule I; IUCN: Near threatened)*

Leopard presence was contiguously recorded from the entire sampled part of the landscape. Leopard is believed to be present throughout the foothills of Arunachal Pradesh as well. Leopard distribution was continuous in Kaziranga and Karbi Anglong hills. It was also recorded in forested areas of Dampa. Leopard signs were also recorded from Dibru – Saikhowa National Park, Tinsukia, Dibrugarh, Diphu, and North Cachar forests. The area occupied by leopard within the sampled area of this landscape was 4,775 km² comprising 23% of the total sampled area (Fig. 6.12). Since covariate data were not systematically collected in Phase I survey of this landscape, modelling leopard density from camera trapped areas was not possible. In 5 of the camera trapped sites, 833 photo-captures of leopards were obtained, whereas there were no captures of leopard in Orang tiger reserve.

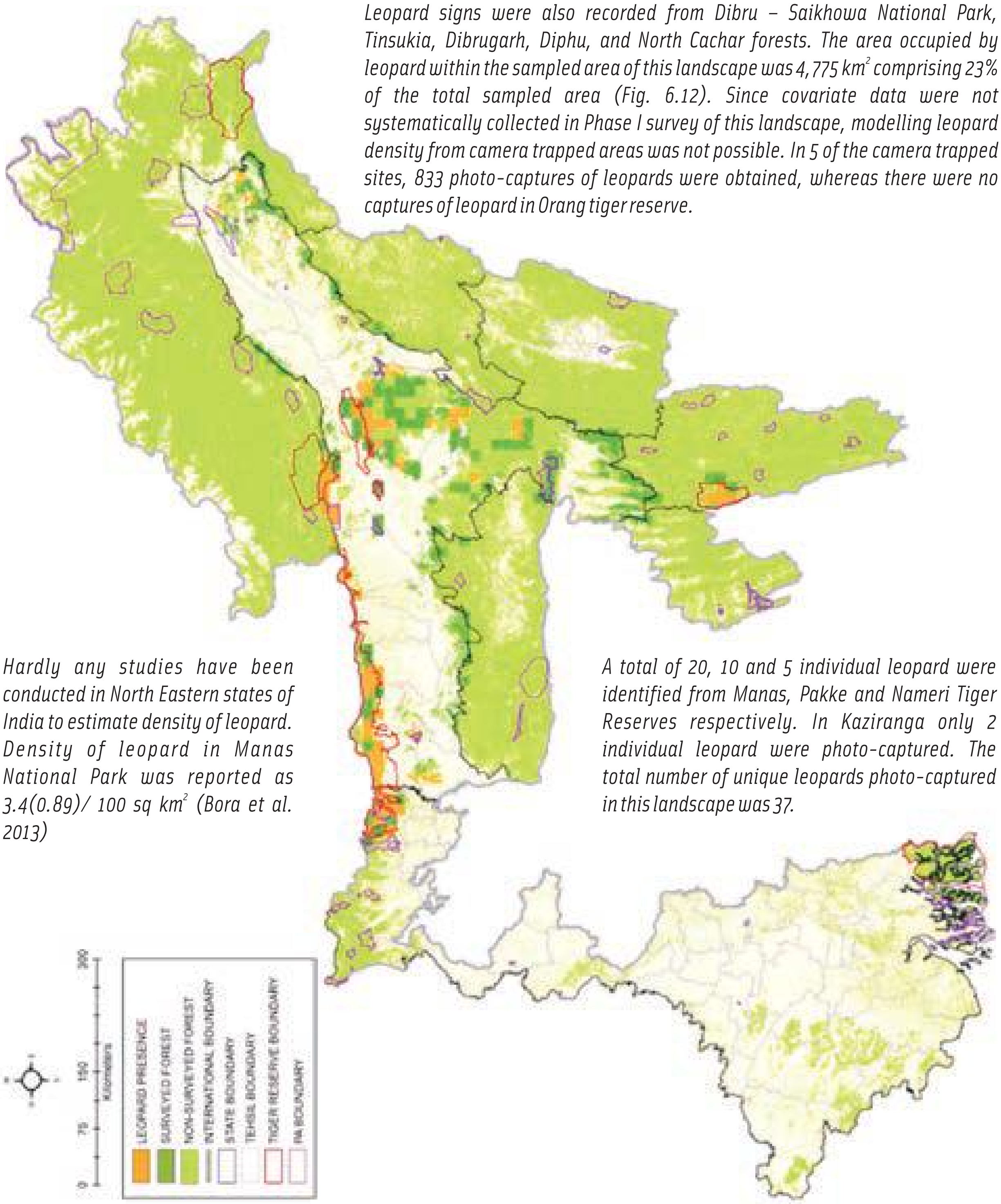


Figure 6.12: *Distribution of leopard in the sampled forests of North-Eastern Hills and Brahmaputra Flood Plains Landscape.*

Hardly any studies have been conducted in North Eastern states of India to estimate density of leopard. Density of leopard in Manas National Park was reported as 3.4(0.89)/ 100 sq km² (Bora et al. 2013)

A total of 20, 10 and 5 individual leopard were identified from Manas, Pakke and Nameri Tiger Reserves respectively. In Kaziranga only 2 individual leopard were photo-captured. The total number of unique leopards photo-captured in this landscape was 37.

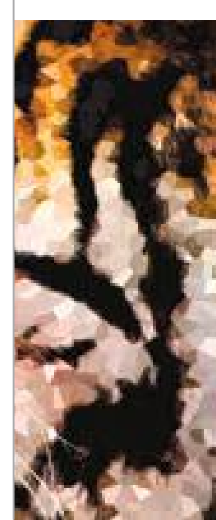
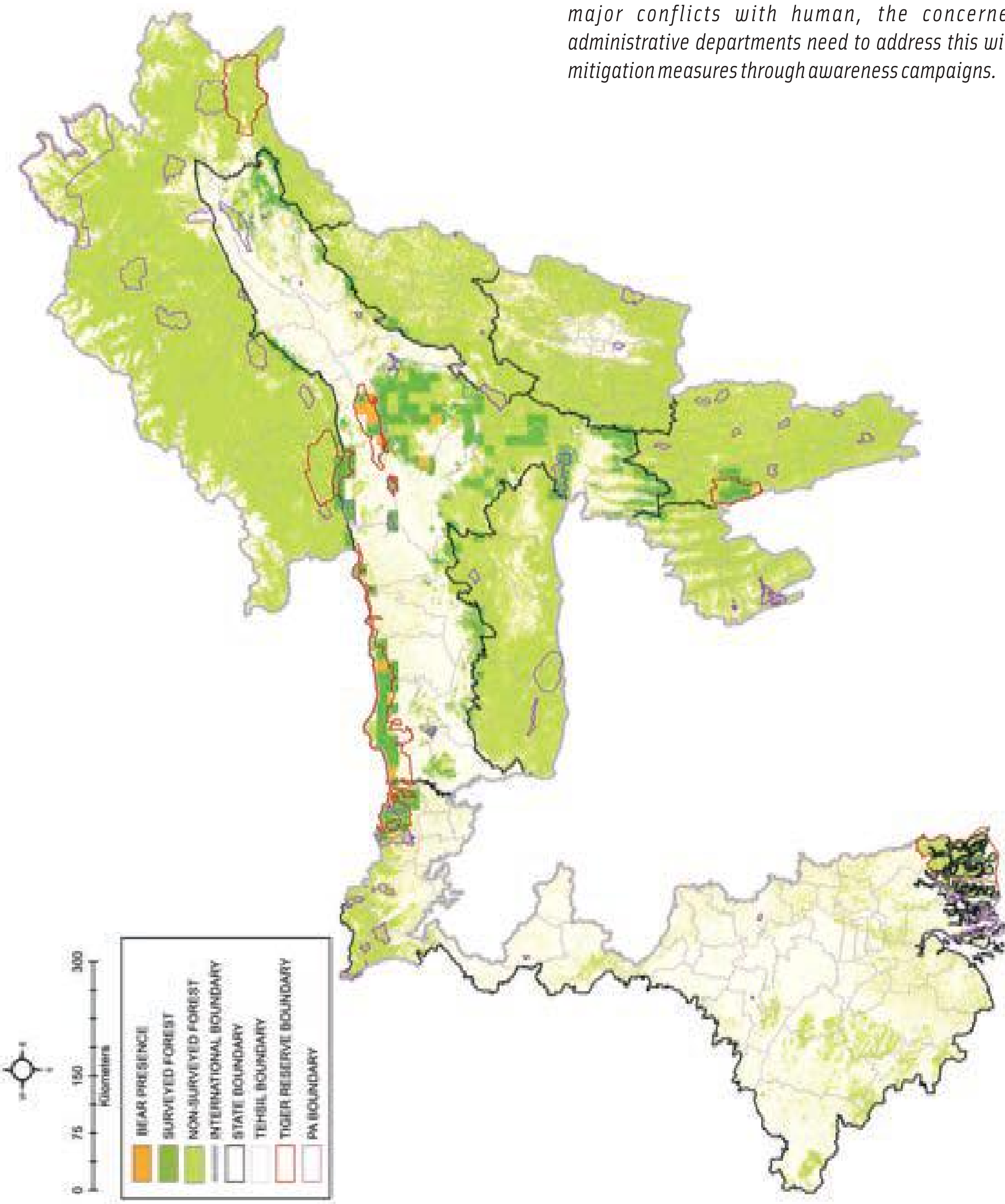


Figure 6.13: *Distribution of Bear in the sampled forests of North-Eastern Hills and Brahmaputra Flood Plains Landscape.*



Bear: Ursus thibetalus, Helarctos malayanus (*WPA: Schedule II; IUCN Vulnerable*)

Bear presence was recorded from Manas–Buxa, Kaziranga and Karbi Anglong hills. Besides these, bear presence was also detected in Diphu taluk of Assam. Bear distribution was found in 607 km^2 comprising 3% of the sampled area (3% of the sampled area) (Fig. 6.13). Sun Bear is also known to occur in the North Eastern hills and signs of sloth bear were not distinguishable from those of Sun bear. Bear in this landscape are known for major conflicts with human, the concerned administrative departments need to address this with mitigation measures through awareness campaigns.

Wild Dog (Dhole): Cuon alpinus *(WPA: Schedule II; IUCN: Endangered)*

Dhole sign was observed in Buxa, Manas, Nameri and Dampa. Its distribution was also detected in Borail Wildlife Sanctuary. This species is known to occur in the forest of this landscape outside the protected areas. Wild dog was found to occur in 652 km² representing 3% the sampled area of this landscape (Fig. 6.14).

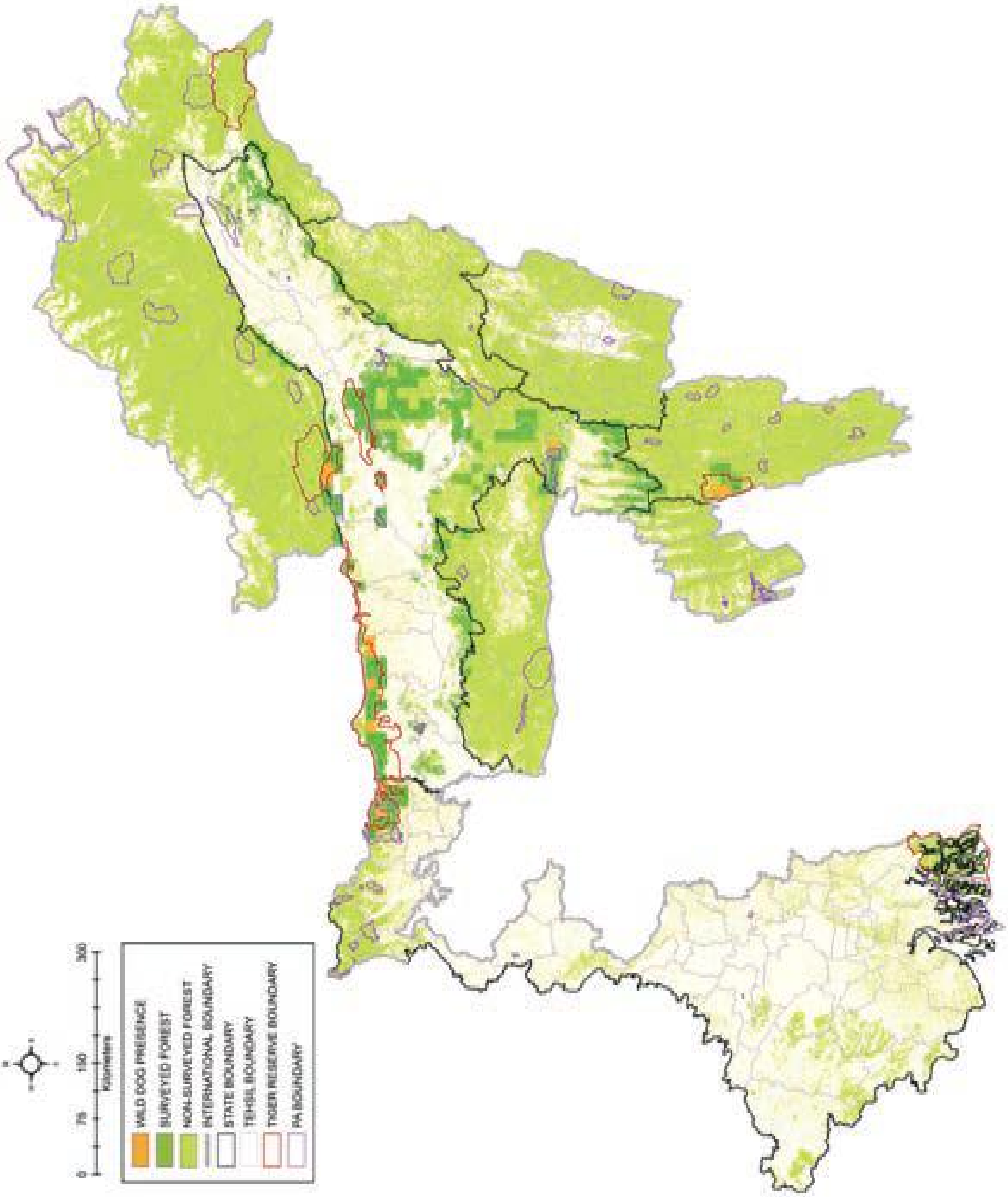


Figure 6.14: *Distribution of Wild dog (Dhole) in the sampled forests of North-Eastern Hills and Brahmaputra Flood Plains Landscape.*

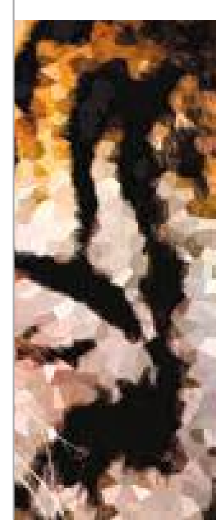
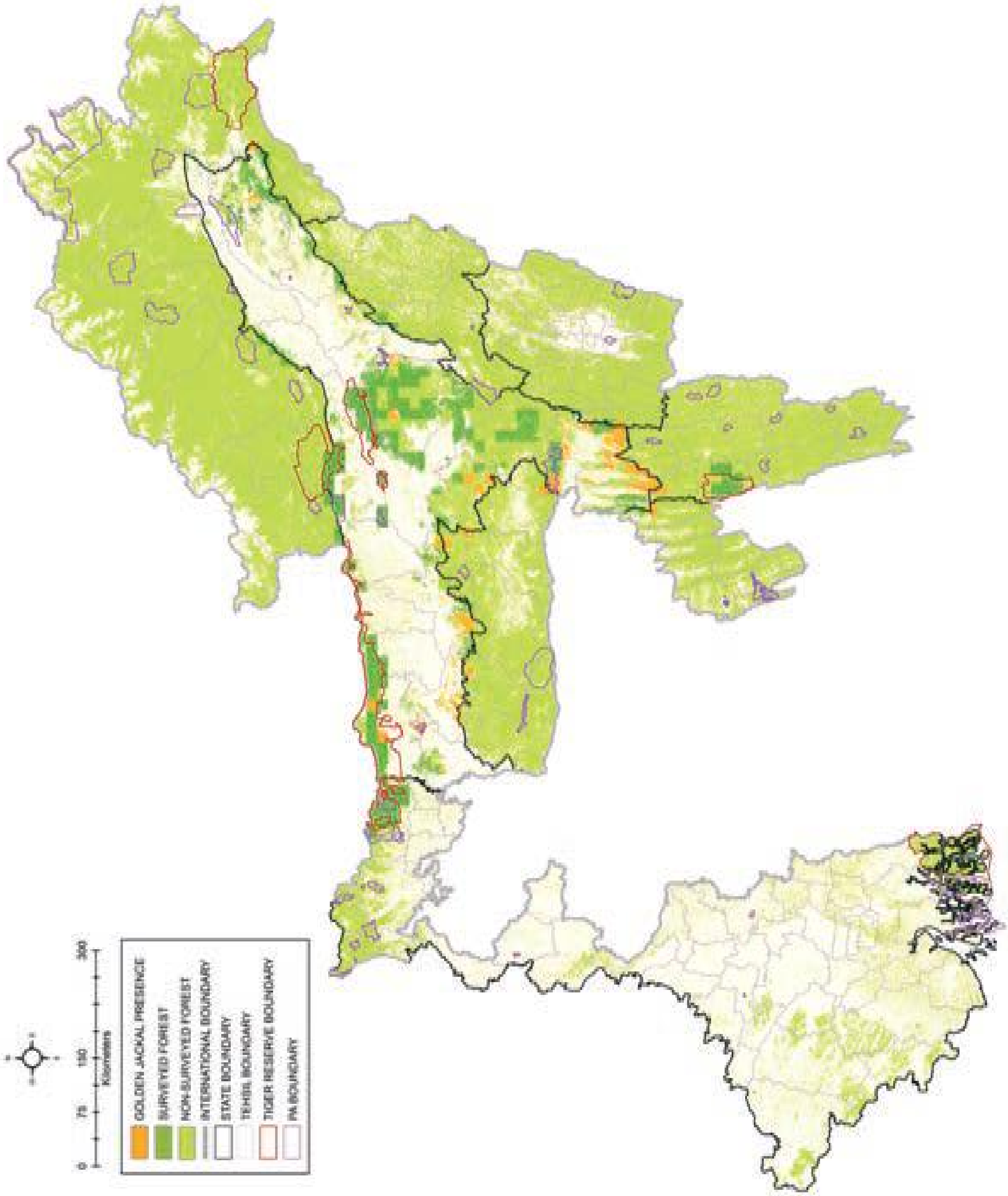


Figure 6.15: *Distribution of Golden jackal in the sampled forests of North-Eastern Hills and Brahmaputra Flood Plains Landscape.*

Golden Jackal : Canis aureus *(WPA: Schedule II; IUCN: Least concern)*

Jackals occurred mainly outside the protected areas and in the forested areas of Manas, Borail Wildlife Sanctuary and Chakraila Wildlife Sanctuary. Jackals were also found distributed in the forests of Tinsukia, Diphu, Silchar, Hamren, East Garo and West Khasi hills. Its distribution was found almost continuously in the forested areas of southern Assam. Jackal was found widely distributed covering an area of 4,454 km² or 21% of the total sampled area (Fig. 6.15).

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Sundarban Landscape 07

Y.V. Jhala, Qamar Qureshi, Manjari Roy, Dipanjan Naha, S. Dasgupta and S.P. Yadav

Sundarban is the world's largest mangrove forest located at the estuarine phase of Ganges and Brahmaputra river system spreading across Bangladesh and India. It is the only mangrove habitat where the tiger exists giving it the status of Level I Tiger Conservation Unit (TCU) (Wikramanayake et al. 1998). It is also one of the most important wetland globally (Junk et al. 2006) and is recognised as a World Heritage Site. The Indian Sundarbans spreads across an area of 4267 km^2 of mangrove forests. It is situated within 21°40'04"N and 22°09'21"N latitude, and 88°01'56"E and 89°06'01"E longitude, under the jurisdiction of the two 24 Parganas districts (South and North) of West Bengal. Sundarbans has been declared as 'Sundarban Biosphere Reserve' which includes the core areas (declared as national park), the buffer zone and the wildlife sanctuary of the tiger reserve along with protected mangrove tracts in the South 24-Parganas.

The Sundarban forests is classified under the sub-group 4B tidal swamp forests with subdivisions of mangrove type (4B/TS1 and 4B/TS2), salt water type mixed forest (4B/TS4), brackish type (4B/TS4) and palm swamp type (4B/E1) (Champion & Seth 1968). Major tree species include Piara Baen (Avicennia alba), Kala Baen (A. marina), Harguja (Acanthus ilicifolius), Khalsi (Aegiceras carniculatum), Kankra (Bruguiera sexangula), Goran (Ceriops decandra), Genwa (Exocoecaria agallocha), Golpata (Nypa fruticans), Hental (Phoenix paludosa), Gorjan (Rhizophora apiculata), Keora (Sonneratia apetala), Dhundul (Xylocarpus granatum) and Pashur (Xylocarpus mekongensis).

Besides the tiger, Sundarban is also home to fishing cat, leopard cat, and large Indian civet. Spotted deer, wild pig, and Rhesus macaque form the major prey species of the tiger. Different species of otters, bats, rats, dolphins, reptiles and turtles are also found here. The Reserve supports about 200 species of birds, 110 species of molluscs, 64 species of crabs and 50 species of fish (Working Plan of Sundarban Tiger Reserve).

Sundarban tigers differ morphologically from the mainland tigers (Barlow 2009) and also are one of the divergent groups amongst Bengal tigers (Singh et al 2015). Severe habitat loss has lead to lack of connecting corridors between Sundarban and the Indian peninsula, making this population geographically isolated. The logistic constraints imposed by the tidal forests coupled with the man-eating reputation of Sundarban tigers have lead to a dearth of rigorous scientific studies on their population dynamics, behaviour and conservation status. This in turn has impeded the assessment of any management success. Wildlife Institute of India had conducted a pilot study in 2010 (Jhala et al. 2011) on estimation of tiger population using camera traps in Sundarban which laid the groundwork for future similar studies. Over the years we have been able to demonstrate that the traditional camera trap-based mark-recapture exercise is possible provided it is tailored to the local conditions, such as usage of lures and ensuring geographic closure of the sampled area by channels wider than 1 km as tigers have shown an avoidance for the same (Roy et al. 2015 In Press & Naha et al. 2015 In Review).

Camera trap surveys were carried out in five ranges of Sundarban Biosphere Reserve by World Wide Fund for Nature-India (WWF) and Wildlife Institute of India (WII) (Fig. 7.1). WWF conducted camera trapping in Basirhat Range in 2013 and in Ramganga Range and National Park East Range in 2014, while WII did the same in National Park West Range and Sajnekhali Wildlife Sanctuary Range in 2014 from a total of 2,220 tigers photo captures, 62 unique tigers were identified using software Extract -Compare (Hiby et al 2009) .

Figure 7.1: Camera trap coverage across Sundarban Landscape

With almost a total coverage of Sundarban by camera traps we estimated the tiger population of entire Sundarban Biosphere Reserve using spatially explicit capture recapture with joint distribution of covariates in a likelihood framework in package SECR program R. The estimated tiger population was 76 tigers with a standard error range of 62 to 96 tigers (excluding cubs) (Fig. 7.2).

Our estimate of 76 tigers (62 to 96) in 2014 when compared with the estimate of 2010 (70 tiger, (64-90)), shows that the population has been stable for the past few years. However, in 2010, sampling was limited to West Range while in 2014, the entire tiger reserve as well as parts of the 24 Parganas (South) Forest Division were camera trapped, providing an even more reliable estimate.

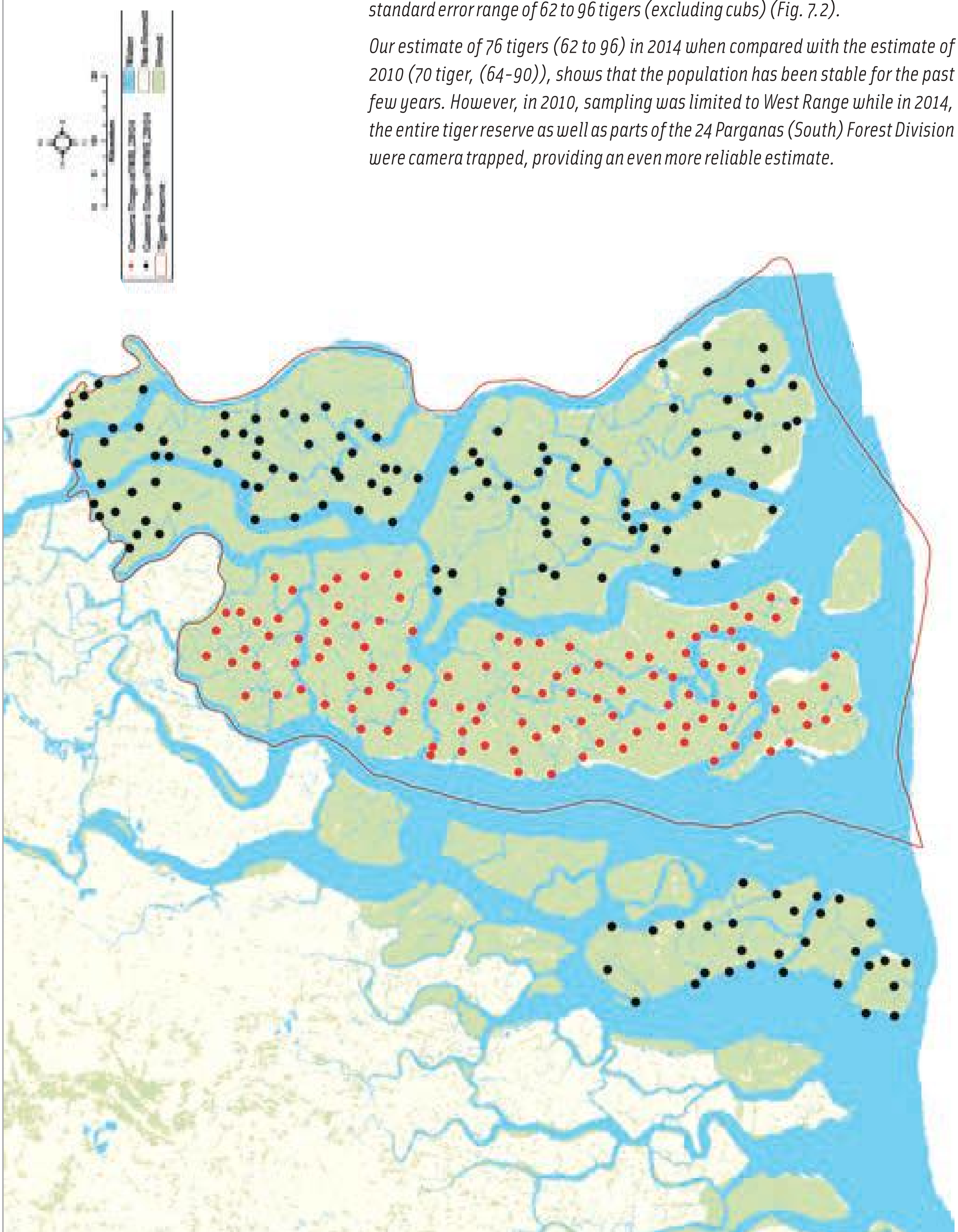
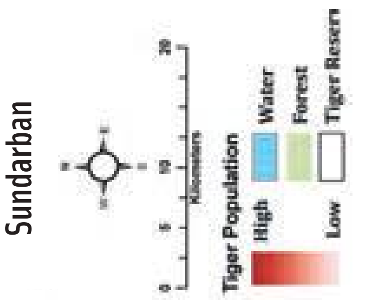
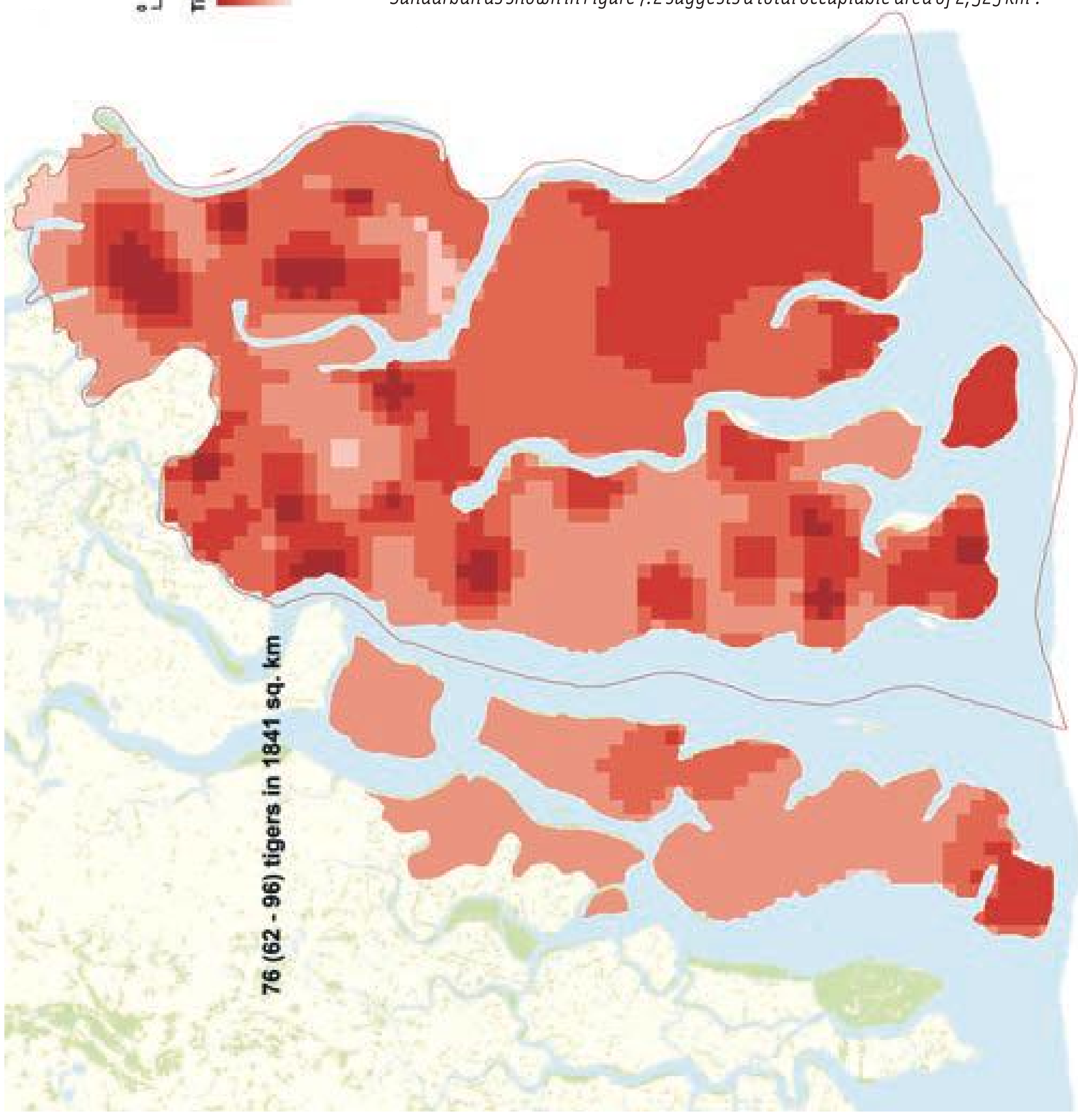


Figure 7.2: Spatially explicit tiger density gradient of the Sundarban Landscape.





Tiger density was comparatively low in the 24 Parganas and in the National Park West Range. The tiger density ranged between 1.6 to 4.8 tigers per 100 km².

The West Bengal Forest Department conducted khal surveys across the Sundarban Landscape following the guidelines of the field guide specific to Sundarban (Jhala et al. 2014). During khal survey, direct sightings and signs of tiger, fishing cat, otter, estuarine crocodile, monitor lizard, wild pig, spotted deer, rhesus macaque and lesser adjutant stork were recorded while information on human disturbance along with vegetation covariates after every 15 minutes, were collected. Geographic coordinates (GPS) along with type of mangrove, slope of the bank and width of the upper and lower bank were noted for each sighting/sign encountered (Fig. 7.3). In a dynamic system like Sundarban, defining land and water areas is challenging due to varying effect of tides. We therefore removed permanent large water channels wider then 1 km and considered the remaining as area usable by wildlife. Habitat mask of Sundarban as shown in Figure 7.2 suggests a total occupiable area of 2,325 km².

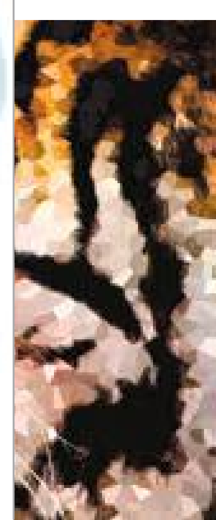


Figure 7.3: Phase I sampling across the Sundarban depicting effort invested in khal surveys, 2014.

The tiger population in the Indian Sundarban though lower than earlier estimates, is still large by global standards and forms one of the ten single largest tiger populations in India. Since the Bangladesh and Indian Sundarban tigers form a single population these should be considered as a single entity of conservation management. Thus the Sundarban tiger population is amongst the top 5 largest tiger populations in the world and of great conservation significance due to their size, unique adaptations and genetic constitution.

Perhaps the biggest threat to this landscape is the rising sea level due to climate change. Loucks et al. 2010 predicted that in the next 50-90 years assuming a 28cm rise in the sea level, 96% of Bangladesh Sundarban would get submerged, reducing the breeding tiger individuals to less than 20. Thus, to preserve this unique landscape, we need to take action at local scale (control of poaching) global scale (limiting carbon emissions) and regional scale (cross-country cooperation between India and Bangladesh).

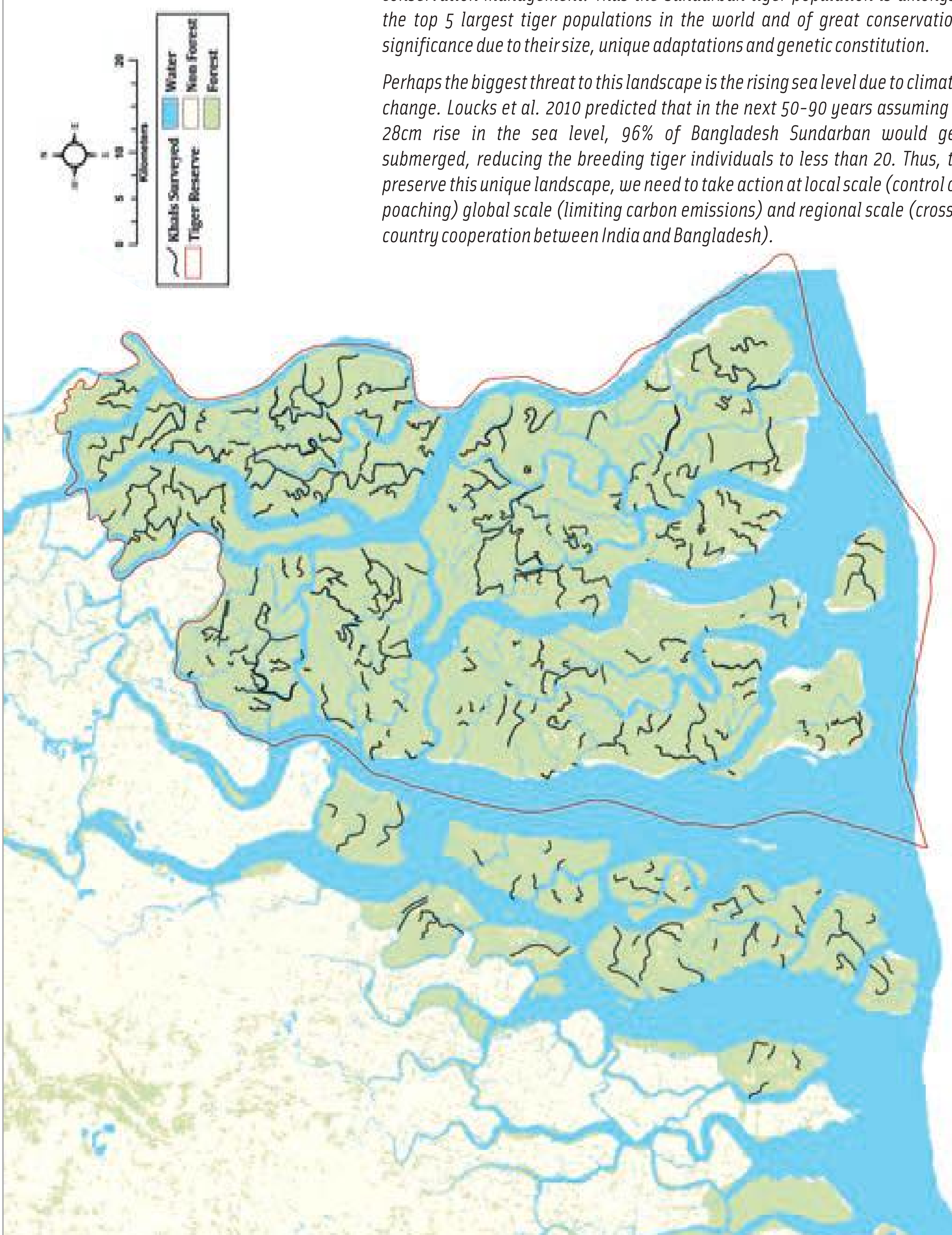
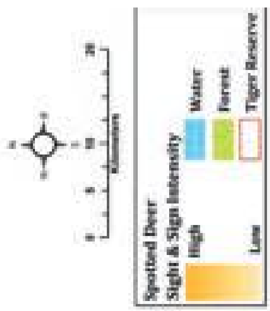


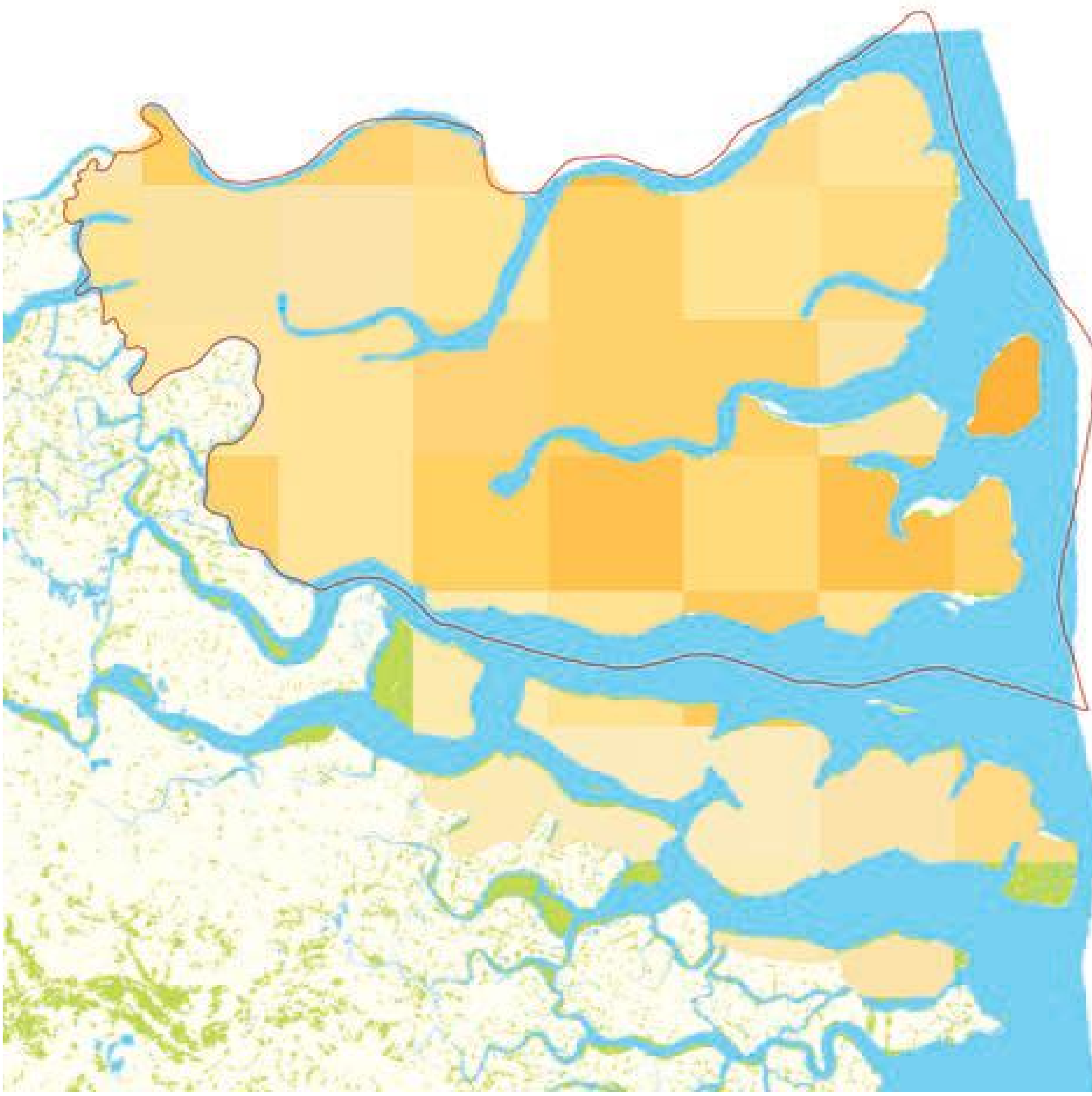
Figure 7.4: Spotted deer (Chital) sighting and sign encounter rates across Sundarban Landscape.

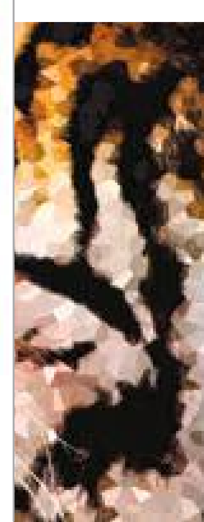


Sundarban presents a challenge for law enforcement; the tiger reserve management has taken stringent measures to combat poaching by establishing and managing remote anti-poaching camps. However, this vigil needs to be stepped up and maintained as it is relatively easy for poachers to go undetected in the Sundarban once they enter inland into remote areas. With high demand of tiger body parts internationally and the proximity of the Sundarban to the International border the reserve will always remain vulnerable to poachers and the management needs to keep up with innovation and use of technology.

Lastly, large water channels which are used as a conduit for commercial boat traffic inside the Sundarban landscape can become potential barriers to dispersal of tiger individuals between Sundarban Islands and lead to genetic isolation. Developmental activities within and near Sundarban promote such boat traffic and threaten the biodiversity values of this unique biome further, through effluents and pollution. Appropriate mitigation of these needs to be planned and implemented.

Spotted deer were observed to occur in 98% of the area. Relative spotted deer densities were observed to be high in West Range of the National Park and were relatively low in the 24 Parganas and buffer zone (Basirhat Range) (Fig. 7.4).





Wild pig relative abundance was low across the Sundarban. But their occurrence was widespread covering 96% of the area. Interestingly more pigs were encountered in 24 Parganas outside of the tiger reserve (Fig. 7.5).

Figure 7.5: Wild pig sighting and sign encounter rates across Sundarban Landscape

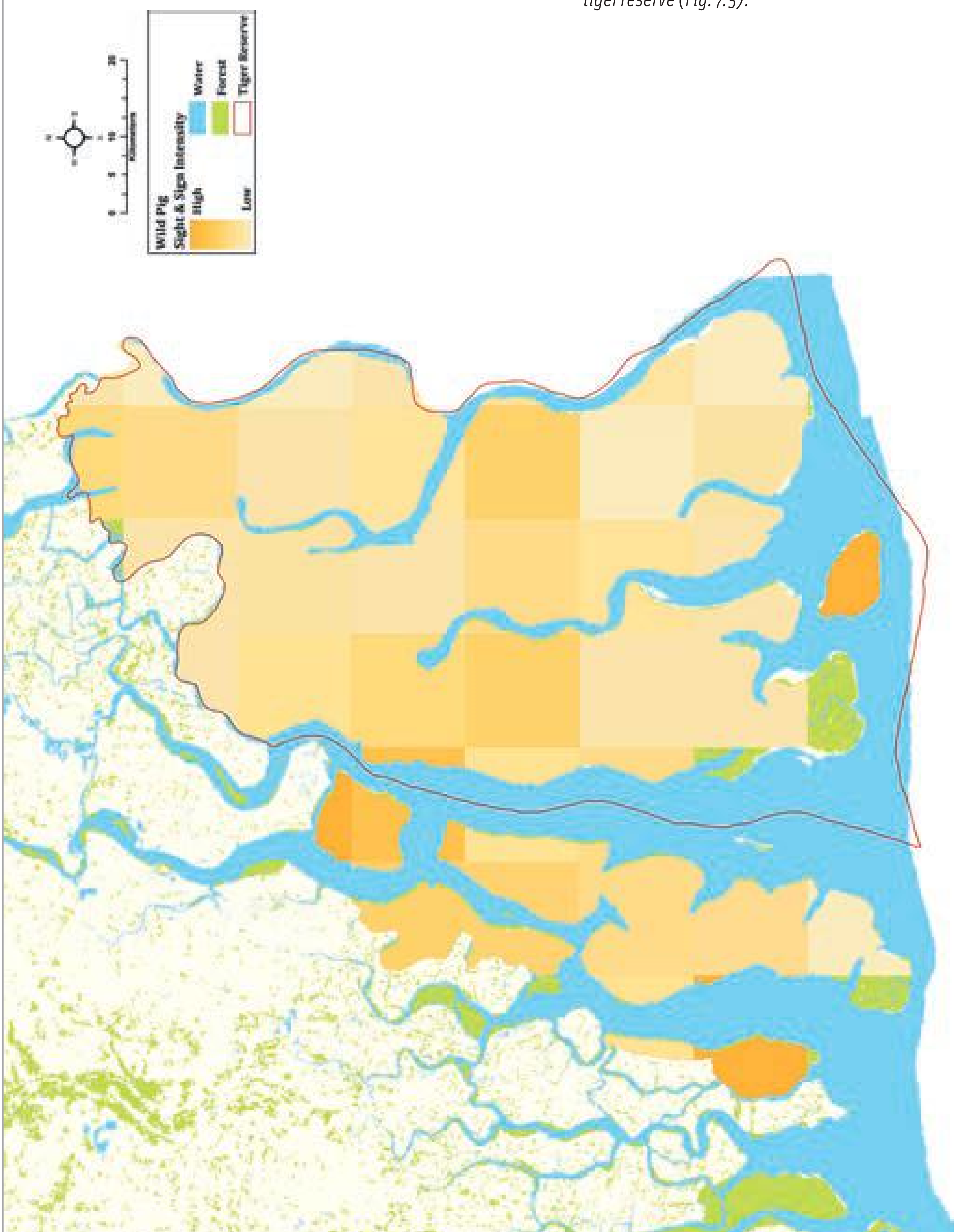


Figure 7.6: Rhesus macaque sighting and sign encounter rates across Sundarban Landscape

Rhesus macaque was distributed in 75% of the area. They had highest encounters in the National Park East range (Fig. 7.6).

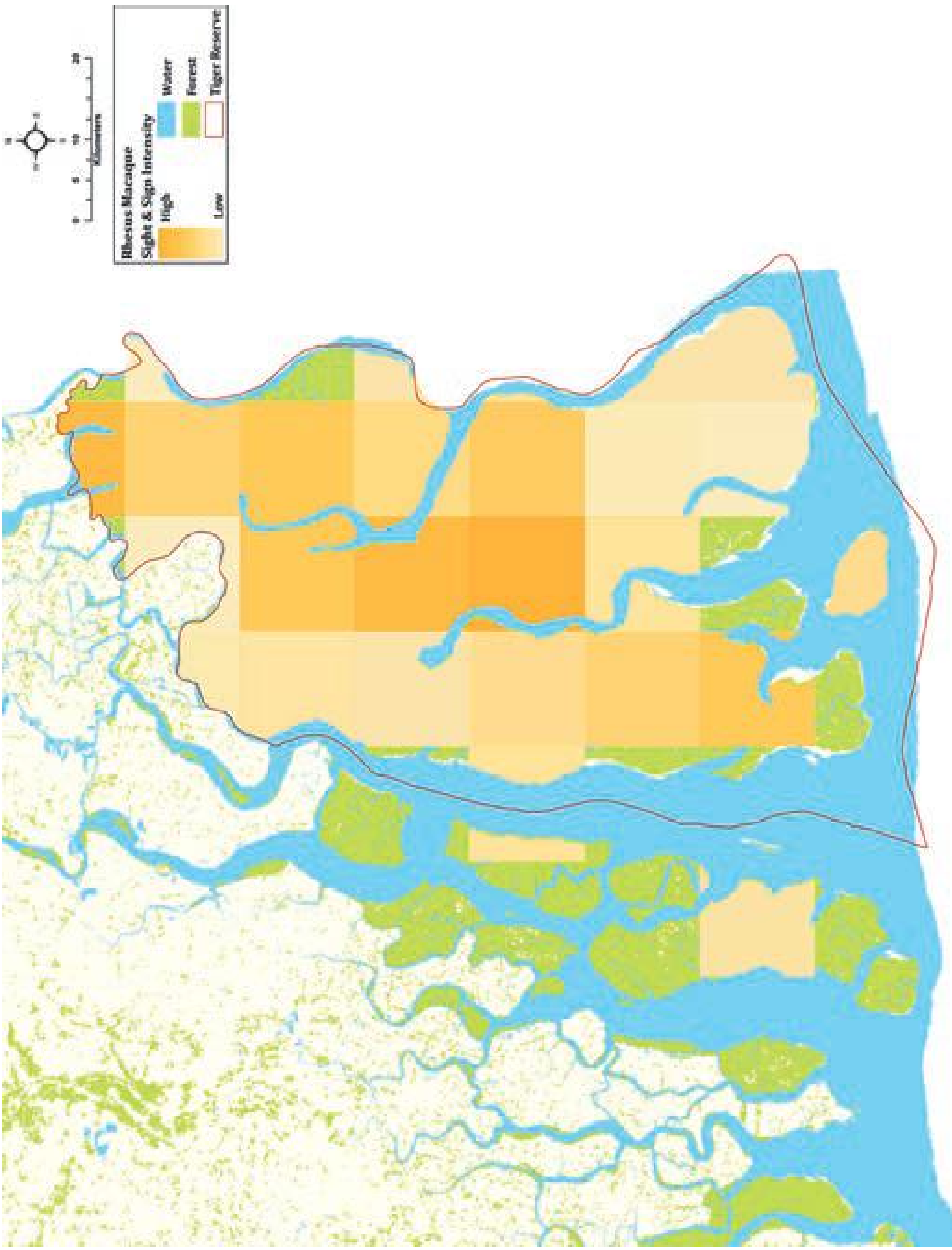


Figure 7.7: Lesser adjutant stork sighting and sign encounter rates across Sundarban Landscape

Lesser Adjutant stork was encountered across 46% of the Sundarban (Fig. 7.7) with higher relative abundance in the southern part of the National Park East range.

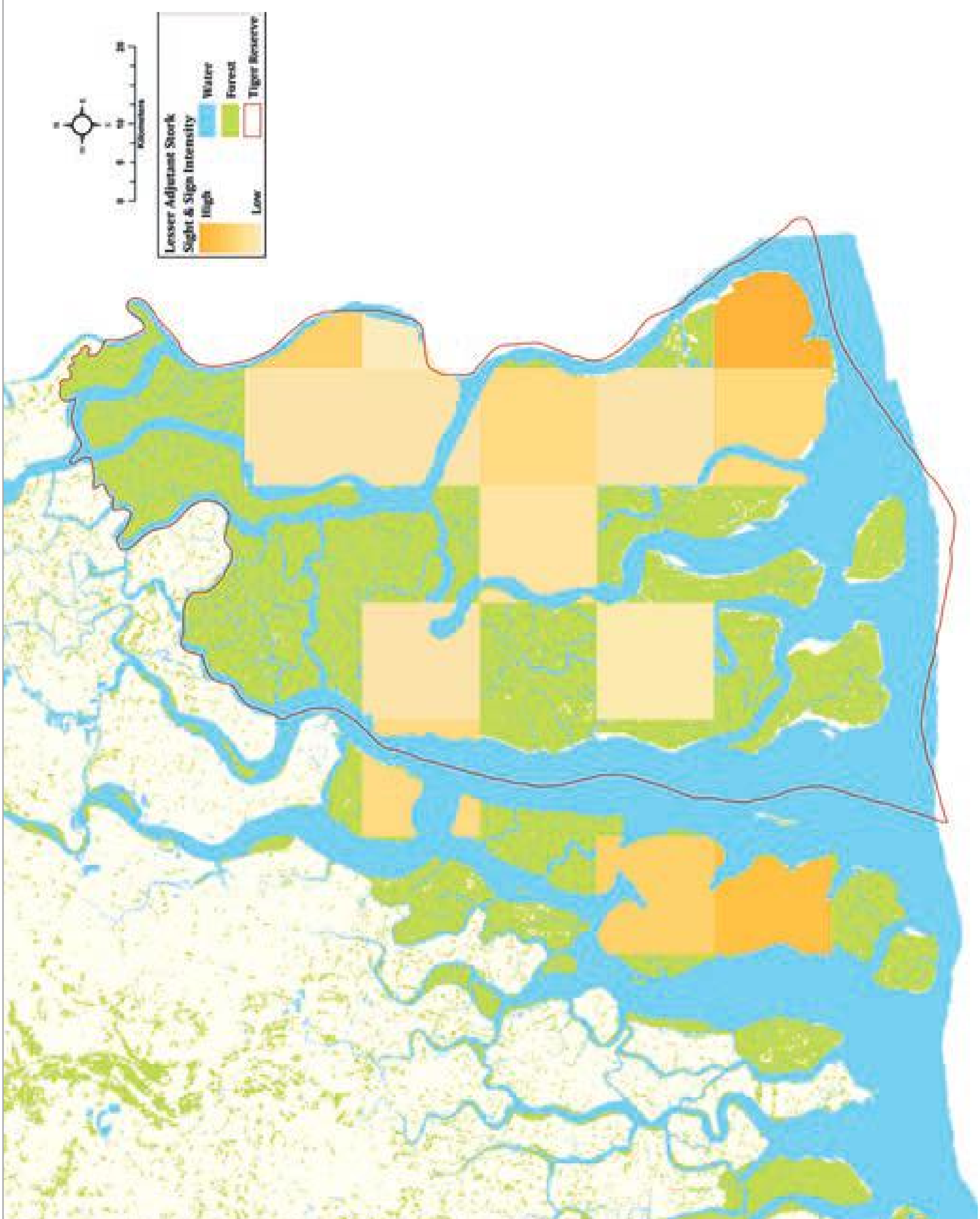


Figure 7.8: *Monitor lizard sighting and sign encounter rates across Sundarban Landscape*

Monitor lizard distribution was recorded in 60% of the area and was higher within the core area of the tiger reserve compared to the buffer zone (Fig. 7.8).

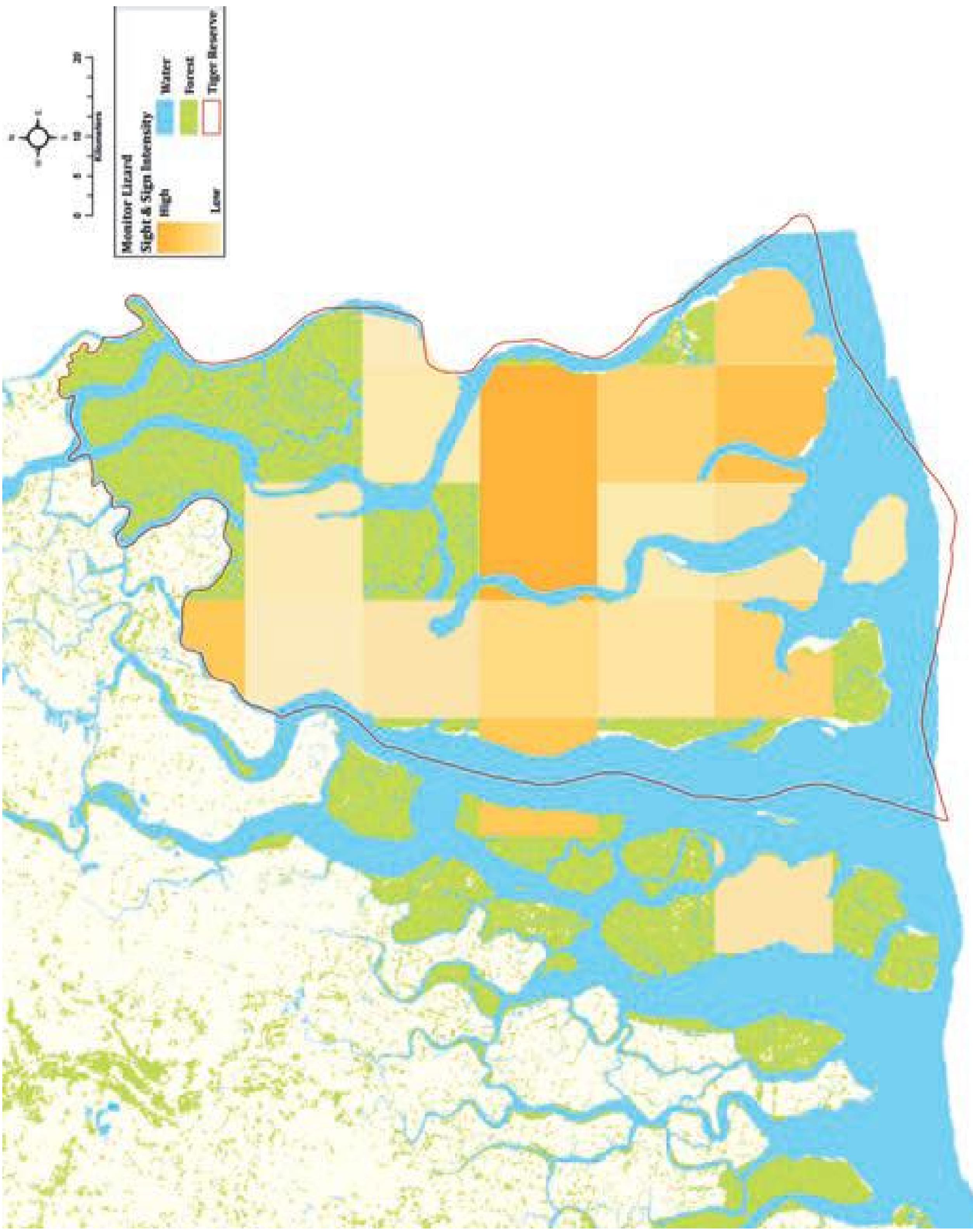


Figure 7.9: Otter sighting and sign encounter rates across Sundarban Landscape

Otters were more evenly distributed across the tiger reserve (Figure 7.9) with area coverage of 67%. Otters were observed to have a higher relative abundance in the southern part of National Park East Range.

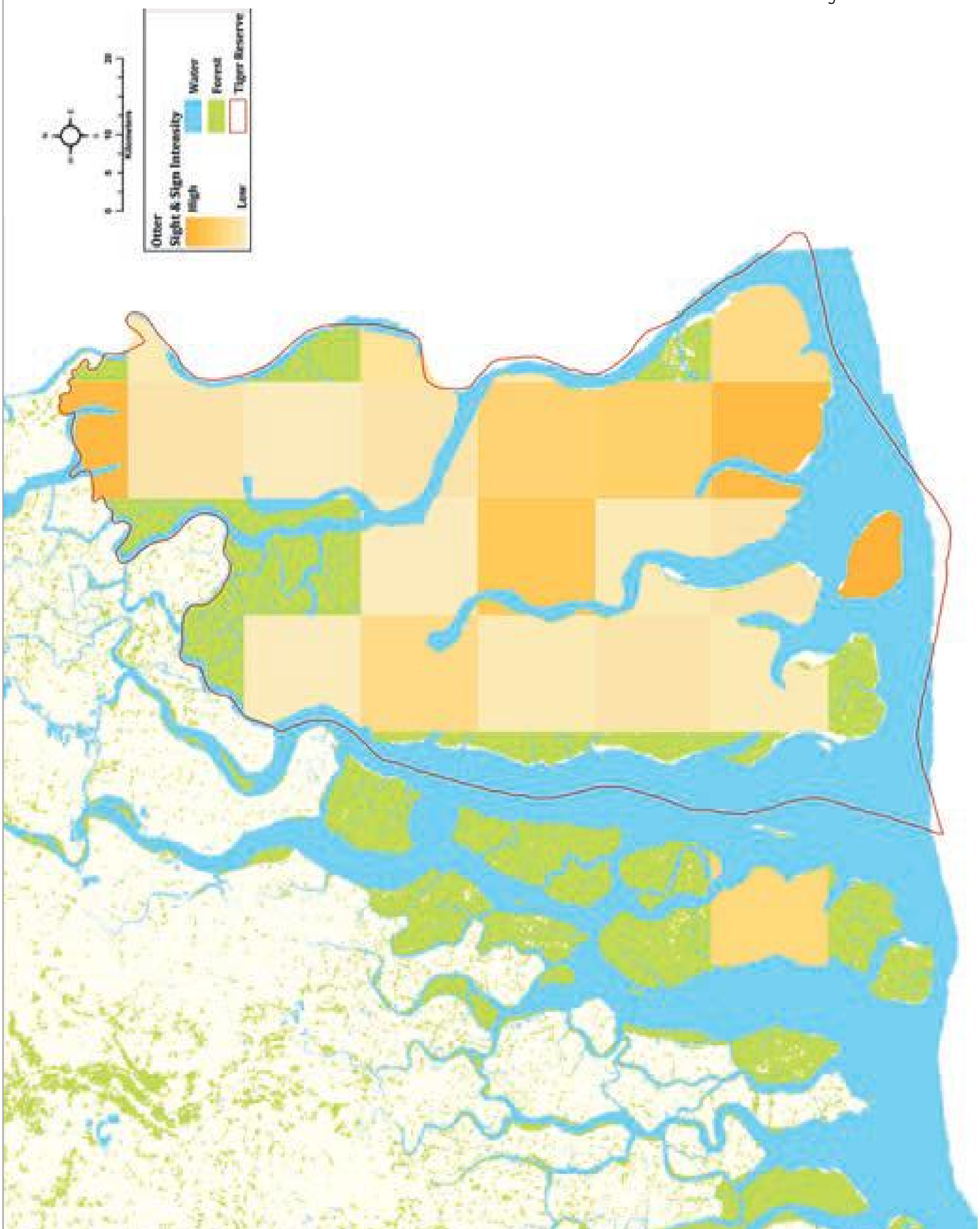
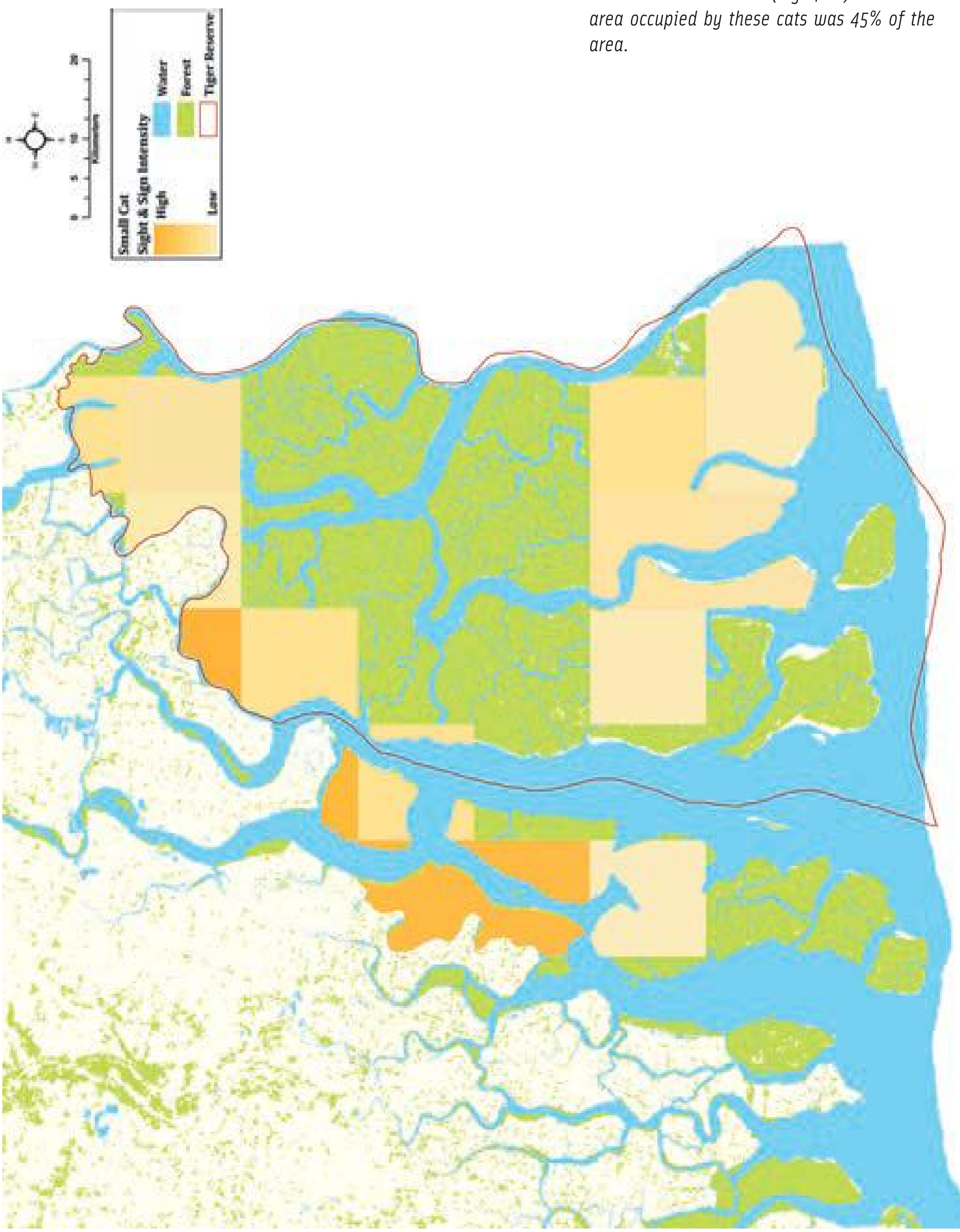


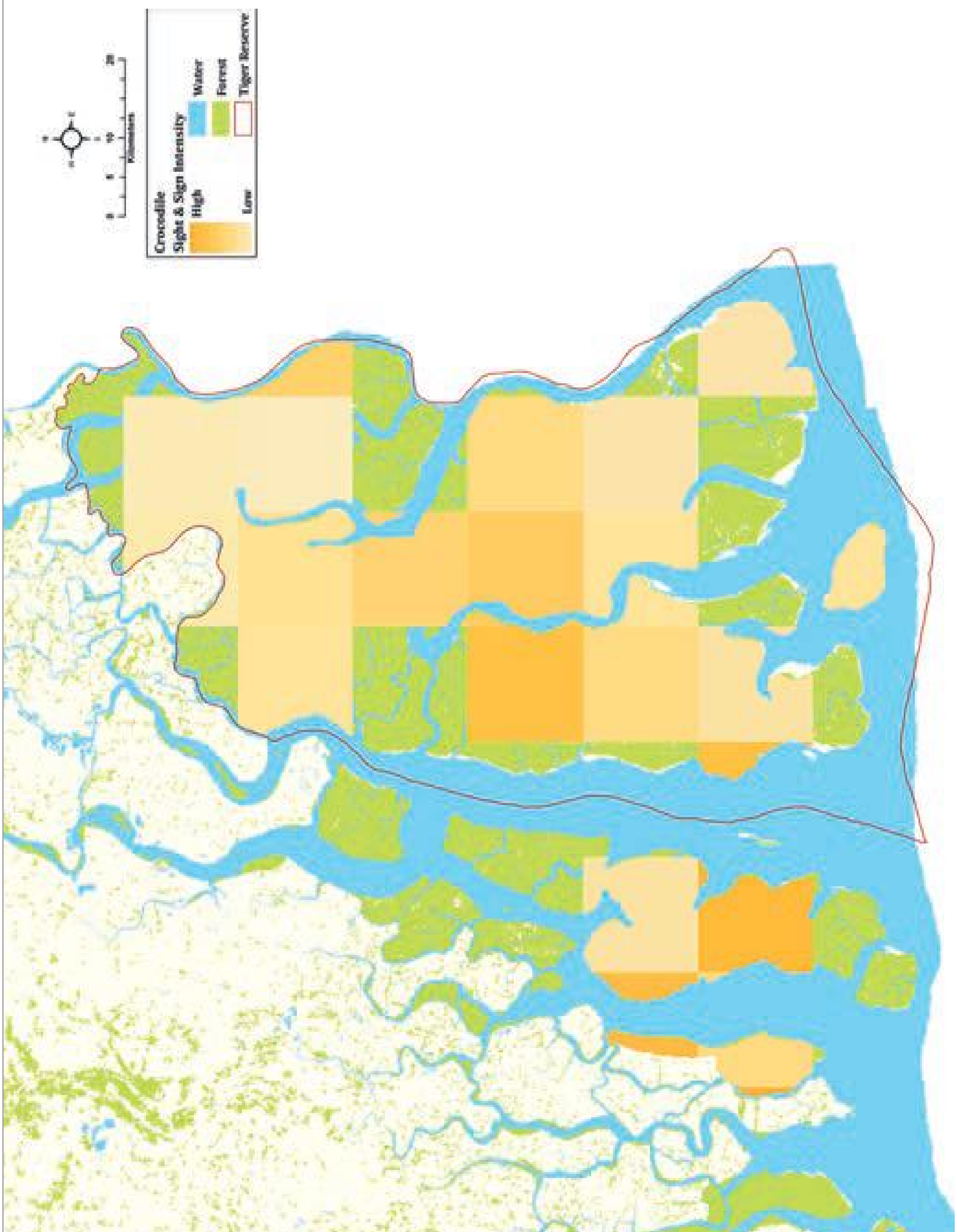
Figure 7.10: *Small Cats (Fishing cat / leopard cat) sighting and sign encounter rates across Sundarban Landscape*



It was difficult to differentiate between signs of fishing cat and leopard cat in the field therefore their signs were combined for analysis. The smaller cats were seen to be distributed more on the edges of Sundarban towards the mainland (Fig. 7.10). The total area occupied by these cats was 45% of the area.

Figure 7.11: *Crocodile sighting and sign encounter rates across Sundarban Landscape*

Estuarine crocodiles were observed in 65% of the area and were observed to use inland water channels more than large open water channels (Fig. 7.11).



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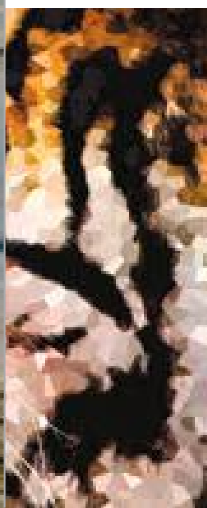


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Non-invasive Genetic Sampling to Assess Minimum Tiger Numbers and Genetic Structure

08

Vishnupriya Kolipakam, Shweta Singh, Sonu Yadav, Pranay Amruth Maroju, Bhawna Pant, Jegatheesh TR, Anurag Kushwaha, Q Qureshi & YV Jhala.

India harbours over 70% of the estimated global population of the world's wild tigers. Currently about ~2200 tigers exist in the wild in India, many of these as small fragmented populations. For the long-term survival of these wild tiger, it is important to ensure habitat connectivity between populations to facilitate geneflow. Quantifying geneflow in tiger populations is also crucial to our understanding of how ancestry, dispersal and isolation operate at landscape scales in maintaining metapopulations. Non-invasive genetic sampling permits large scale data collection from elusive species like tigers to address the above questions. Some tiger populations could not be assessed by camera trap based capture – mark recapture due to logistic constraints like insurgency or extremely low density. In such areas, we used non-invasive techniques to estimate the minimum number of individuals. Apart from this, scats were collected opportunistically in each landscape, across India. This gave us information on geneflow between populations, evolutionarily significant populations, and genetically distinct sub-clusters within the country. The above information assists in making management decisions on re-introductions, supplementations and translocation of individuals. Finally, this highlights how understanding the genetic structure of tigers in India would inform us sufficiently to focus conservation efforts most effectively.

Methodology:

Fecal samples of carnivores (scats) were collected opportunistically from field between December 2013 - December 2014 from the distribution range of the tiger. Information on GPS location and condition of scat was recorded. Scats were collected from field in plastic zip pouches containing silica, later aliquoted and kept in -20 °C freezer in 2ml screw cap vials/double bagged zip pouches with silica gel. Genomic DNA was extracted from samples using the guanidinium thiocyanate method (Boom et al, 1990). Following extraction, DNA samples were first screened for species identification using a tiger specific cytochrome-b marker (Bhagavatula and Singh, 2006) that amplifies a 162 base pair fragment. Tiger positive samples were confirmed after samples were run along with a positive and negative control. A panel of eleven highly polymorphic microsatellites developed from domestic cats (Menotti-Raymond et al, 1999) and tigers (Bhagavatula and Singh, 2006; Williamson et al, 2002) were used to identify individuals (Table 8.1). Extraction and PCR procedures were spatially separated and negative controls were included in all extraction and PCR procedures to monitor contamination. As DNA extracted from faecal samples are generally degraded and prone to error during scoring, we followed a multi-tube approach, where each PCR was repeated atleast three times for microsatellite analysis and we accepted an allele score only if it amplified in a minimum of three replicates. Scoring of alleles were performed using Geneious V.7.1.3 (Kearse et al, 2012). Further, to test the reliability of individual identification, *we calculated cumulative probability of identity (PID) (Waits et al, 2001) of our marker panel using GIMLET (Valière, 2002), which is indicative of the power of the selected markers to differentiate between individuals in a population. After accounting for scoring errors and the power of our markers, individuals in each population were identified using CERVUS 2.0 (Marshall et al, 1998).*

Following individual identification, minimum tiger numbers were estimated for each sampled site. For the genetic structure analysis, populations were apriori divided into landscape-scale ecologically and biogeographically meaningful clusters and subclusters:

1. *North-East - Dibang, Namdapha, Dampa, Kaziranga, Manas & Buxa*
2. *Terai Arc – Valmiki, Dudhwa, Corbett & Rajaji*
3. *Western India - Sariska & Ranthambore*
4. *Central India – Odisha, Bandhavgarh, Guru Ghasidas, Palamau, Sanjay Dubri, Tipeshwar, Indravati, Umred, Udanti-Sitanadi, Kanha, Achanakmar & Pench*
5. *Sunderban*
6. *Western Ghats - Sahyadri, Anshi-Dandeli, Goa, Bhadra, Biligiriranga Swamy Temple, Bandipur, Mudumalai, Anamalai, Periyar & Kalakkad Mundanthurai*

Population level summary statistics were computed using Arlequin by quantifying the mean number of alleles and observed heterozygosity (H_{obs}) to understand the genetic diversity. We used the Bayesian individual clustering approach in STRUCTURE 2.3.4 (Pritchard et al, 2000) to detect population structure by assigning sampled individuals into a number of clusters (K) based on the multilocus genotype data. We analyzed our data in STRUCTURE by using the admixed model and correlated allele frequencies option, and carried out ten independent simulations at each (K= 1 to 20), with a burn-in length of one million Monte Carlo Markov Chain (MCMC) steps and data collection phase of ten million MCMC iterations. These run times were sufficient to ensure convergence of the Markov chains. The true K or most likely number of population clusters in the dataset was inferred from (i) the ad hoc parameter of log-likelihood change in probability of individual assignments to K clusters (Ln P(K)), and (ii) the second order rate of change in the likelihood of K values (delta K). Both these values were computed from the STRUCTURE output using the program STRUCTURE HARVESTER v0.6.91 (Earl, 2012)

Results:

Out of 1147 number of scats from which DNA extraction was attempted, 718 succesfully amplified with either tiger or leopard specific primers and resulted in 341 tiger positive scats. Of the eleven loci used for genotyping, locus FCA954 recorded the maximum number of alleles at 22, while locus FCA424 had the minimum number of alleles (Number of alleles =11) . From the 341 tiger positive samples, we were able to identify 187 unique individual tigers and used 158 individual tigers for further population genetic analysis (Table 8.2 , 8.3).

Table 8.1: Details of the loci used in the analyses for individual identification and estimation of genetic structure. Given are the Probability of Identity (PID) values (cumulative), Polymorphic information content (PIC), the total number of alleles for each loci across all the

Sno	Loci	PID-Cummulative	PIC	Total Number of alleles	H_{exp}	H_{obs}
1	FCA304	2.50E-02	0.870	19	0.88	0.9
2	6HDZ700	1.48E-03	0.787	16	0.81	0.85
3	F85	9.44E-03	0.776	13	0.86	0.42
4	F53	4.53E-06	0.813	12	0.87	0.66
5	FCA441	3.26E-07	0.761	13	0.79	0.54
6	F124	4.57E-09	0.906	20	0.92	0.44
7	FCA424	2.15E-10	0.814	11	0.83	0.42
8	E7	6.87E-12	0.854	15	0.87	0.73
9	FCA954	8.93E-14	0.909	22	0.91	0.65
10	E6	1.43E-15	0.899	16	0.92	0.52
11	F96	1.43E-17	0.921	19	0.93	0.53

a) Minimum number of individual tigers

It was heartening to find evidence of tiger presence in Namdapha-Dibang, Dampa , Indravati and Goa (Table 8.2). The result of finding a minimum number of 7 tigers in Sahyadri was also encouraging.

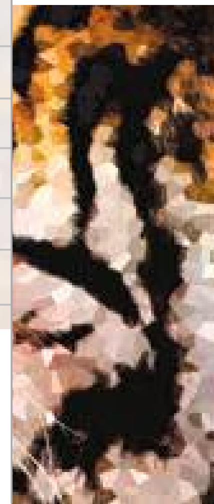
Table 8.2 : Details of scats used for genetic analysis to estimate minimum number of tigers from PAs where camera trapping was not possible. The table depicts the number of scats used, the number of scats positively identified as tigers, and the number of unique individual tigers.

Landscape	Protected Area	No. of scats used for genetic analysis	No. of Tiger positive Scat	Unique Individual Tigers
North-East	Namdapha	87	9	4
	Dibang	28	18	5
	Dampa	30	3	3
	Buxa	22	3	2
Central India	Indravati	17	6	4
	Palamau	21	6	3
	Udanti sitanadi	6	2	2
	Umred	2	1	1
	Tipeshwar	27	16	9
	Guru Ghasidas	20	7	5
	Sanjay Dubri	9	5	3
	Sahyadri	66	7	7
Western Ghats	Goa	34	3	3

b) Summary statistics of Landscape scale population clusters

*Table 8.3: **Summary statistics of each landscape cluster estimated from 11 microsatellite loci.***

Landscape	Number of Individuals	Mean number of alleles	Observed Heterozygosity	Expected Heterozygoisty
North-East	27	8.46	0.68	0.80
Terai Arc	26	7.64	0.65	0.78
Western India	11	5.36	0.77	0.71
Centra India	48	11.82	0.67	0.86
Sunderbans	3	2.82	0.79	0.65
Western Ghats	43	10.36	0.66	0.85
Total	**158**	**7.74**	**0.62**	**0.79**



C) Analysis of population genetic structure

Calculation of delta K from the STRUCTURE output at the country scale indicated that K=3 (Fig. 8.1) best describes the level of subdivision in our samples. The output indicated that the tiger population of the North-east represented a distinct genetic cluster from the rest of India (Fig. 8.1). When higher number of K was tested to investigate levels of population subdivision, we found evidence of further population clustering within landscapes. (Fig. 8.2 & 8.3).

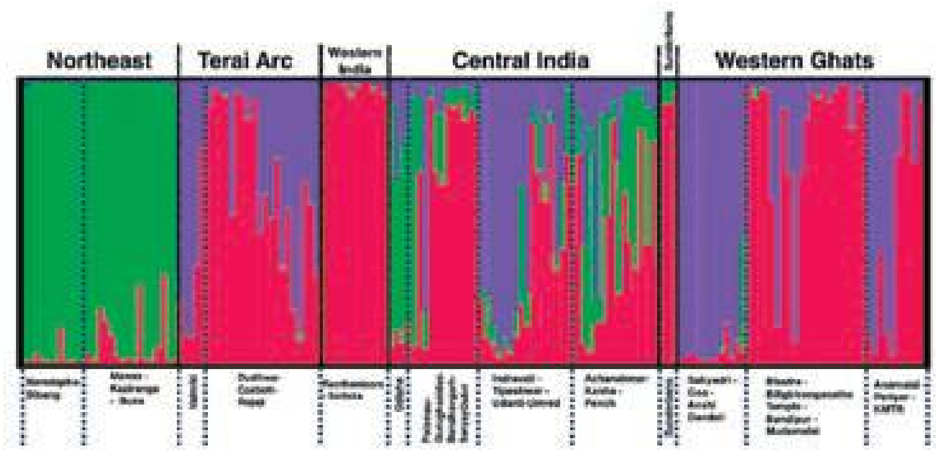


Figure 8.1: Individual assignment probabilities of tiger populations across the country analyzed using the model-based program STRUCTURE. Population structure at K=3

Structure analysis revealed mainly two large population clusters in the country, the North-eastern population and the rest of India (ROI). Further sub-structuring is present within the ROI, which delineates large landscape level clusters and gives an insight into the connectivity and gene-flow within these clusters.

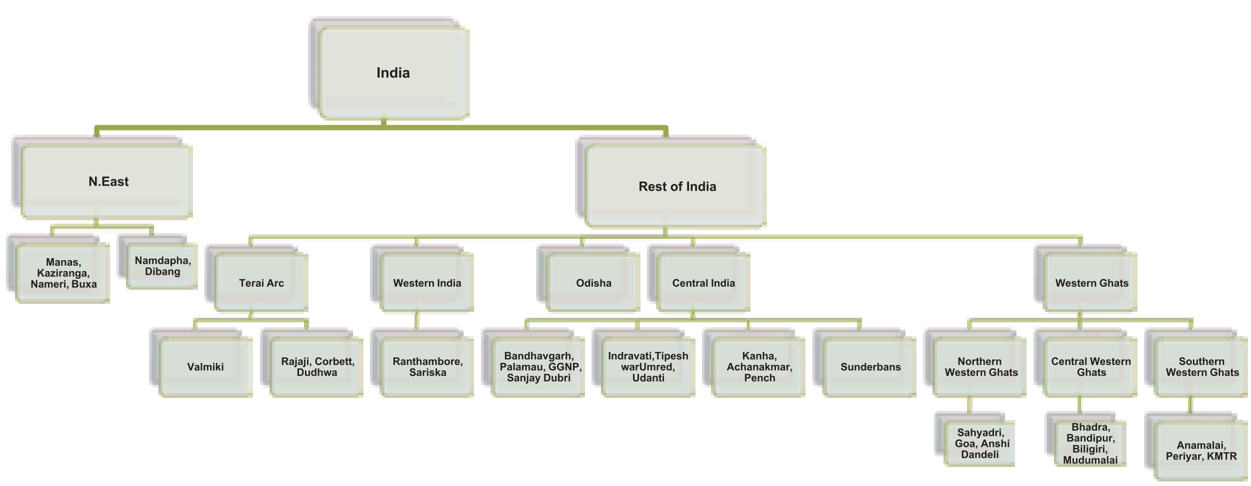


Figure 8.2: Dendrogram representing the different genetically coherent population level sub-clusters evident from the structure analysis of 158 tigers at eleven microsatellites

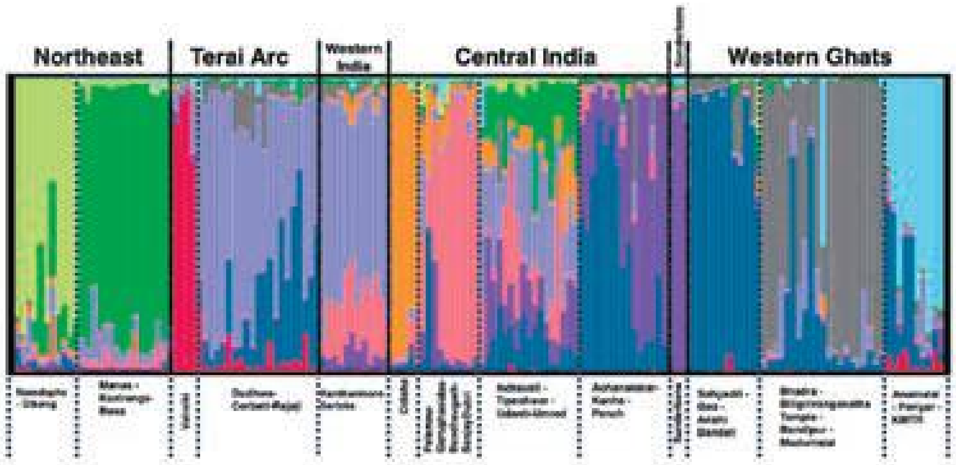


Figure 8.3: Individual assignment probabilities of tiger populations across the country analyzed using the model-based program STRUCTURE. Population structure at K=10

In the North-east, Dibang and Namdapha formed one population cluster, while Manas, Kaziranga, Nameri and Buxa formed a second cluster within the large Northeastern cluster (Fig. 8.3). Valmiki seperated out as a distinct cluster from the rest of Terai arc. The western Indian landscape of Ranthambore and Sariska seem to share their genepool with both the Terai Arc and Central Indian Cluster -I (Bandhavgarh – GGNP- Palamau). Tigers from Odisha (Simlipal) stand out as a unique cluster sharing some genetic makeup with Palamau and Central India tigers from Indravati & Udanti. Northern Western Ghats populations of Sahyadri-Goa-Anshi Dandeli, seem to be contiguous, sharing genes across the three populations and seem more aligned with the Central Indian cluster, with some gene-flow with the popualtions in Central Western Ghats.

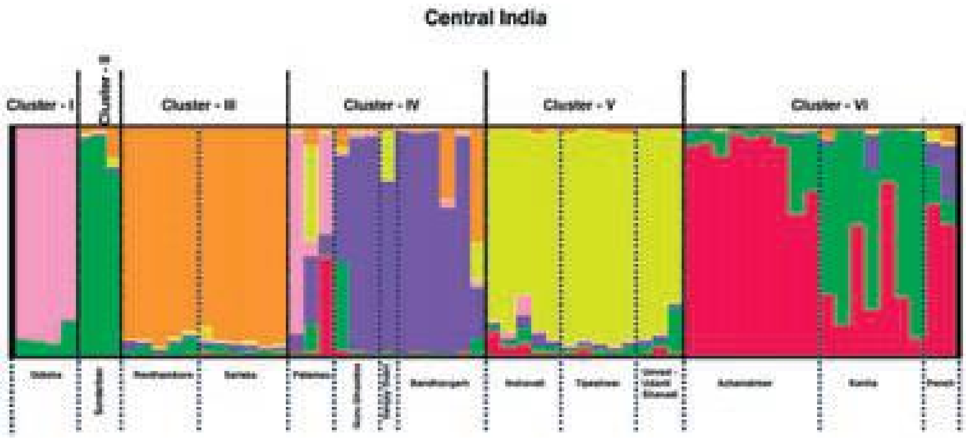
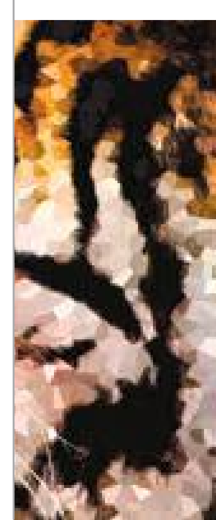


Figure 8.4: Individual assignment probabilities of tiger populations from Central India, Sunderbans and Western India analyzed using the model-based program STRUCTURE. Population structure at K=6

When the central Indian landscape alone, along with Sunderbans and the western Indian populations of Sariska and Ranthambore were tested for genetic partitioning (Fig. 8.4), the westrn Indian population separates out as a distinct cluster. Odisha represents a unique and fast declining gene-pool. The observed heterozygosity (0.45) was significantly lower than the expected heterozygosity (0.75), which indicates an inbred population, probably due to declining population size. It shows admixture with the population of Palamau (Jharkhand). However, more samples are required to confirm these findings. There seem to be three major population clusters in Central India –a) Bandhavgarh-GGNP-Palamau and b) Achanakmar – Kanha _ Pench, with the third population cluster being identified as c) Indravati – Tipeshwar – Udanti & Umred. Previous studies have elucidated the lack of connectivity between Bandhavgarh and Achanakmar-Kanha protected areas.



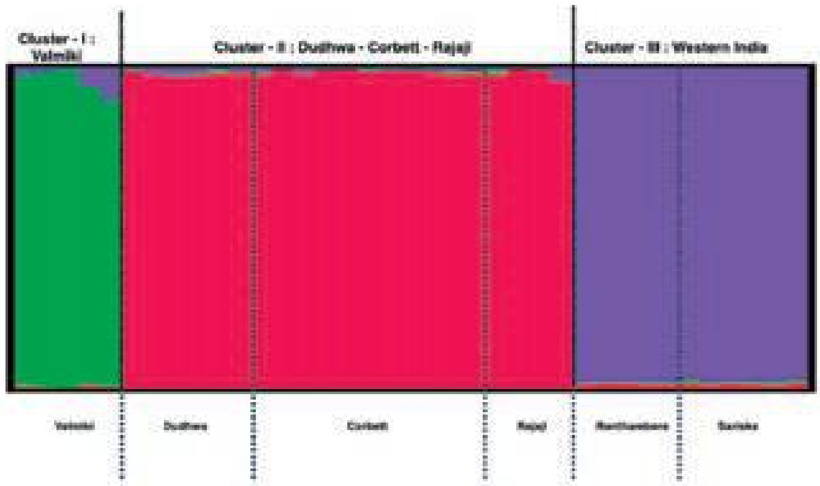


Figure 8.5: Individual assignment probabilities of tiger populations from Terai Arc and Western India analyzed using the model-based program STRUCTURE. Population structure at K=3

In a similar manner to the central Indian landscape analysis, when Terai Arc was investigated for the inherent population structure (Fig. 8.5), Valmiki stood out as a genetically distinct population, from the rest of the Terai Arc populations. It does not seem to have connectivity with Dudhwa, Corbett or Rajaji. The genepool of the tigers from Nepal need to be examined to understand if genetic connectivity is contiguous from Chitwan-Parsa population across shivaliks and Mahabharat hill ranges into Bardia. Terai arc also needs to be extensively sampled (especially the areas surrounding Valmiki and intervening areas of Dudhwa and Valmiki) to understand if there exists any connection between the extant populations in the Terai Arc. Here too, the western Indian populations of Ranthambore and Sariska represent a distinct cluster from that of the Terai Arc.

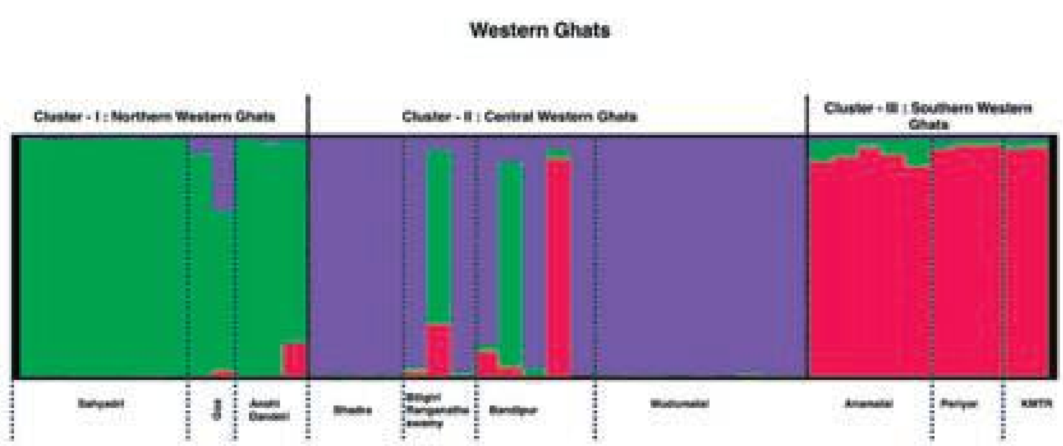


Figure 8.6 : Individual assignment probabilities of tiger populations from Western Ghats analyzed using the model-based program STRUCTURE. Population structure at K=3

There appears to be three distinct clusters in the Western Ghats landscape (Fig. 8.6). As mentioned above, the nothern Western Ghats population shares its affinity to a greater extent with the central Indian population than the central Western Ghat populations. The Southern Western Ghat populations also seem to be genetically distinct from that of the Central Western Ghats. The palghat gap appears to be a barrier to gene flow of tiger popualtions of the Central (Bhadra, Biligiriranga Swamy, Bandipur and Mudumalai) and Southern Western ghats (Anamalai, Periyar and KMTR).

Discussion

The overall genetic analysis of tigers in India, revealed information regarding landscape level population clusters and populations that need conservation attention. The model-based assignment probability analyses will help managers in making informed conservation decisions. The identified population clusters are suggestive of shared ancestry, geneflow and admixture. Till further research suggests better management strategies, we recommend that reintroductions, supplementations and translocation of tigers adhere to within sub-clusters that have been indicated.

Tigers from Odisha need immediate conservation attention as they are genetically unique and rapidly declining. The difference between the observed and expected heterozygosity is significantly different with a wide margin. This represents a population under isolation and/or decline. At this stage it seems that the population in Odisha is distinct from that of the rest of Central India, but shares some affinity with tigers from Palamau. These two populations could be looked at for supplementation and translocation. However, further samples are needed to confirm these findings.

We also observed a unique cluster of Valmiki in the Eastern Terai, both in the country wide and landscape level analyses. This could potentially be an artefact of sampling and small sample size (n=4). Further investigation with samples of tigers from Chitwan, Nepal, the adjoining areas of Valmiki and east of Dudhwa, are required to resolve the status of this population. However, as of now, it appears that the diversity that we see in the tigers of Rajaji, Dudhwa and Corbett do not encompass the genetic make up of the tigers in Valmiki, and it would be prudent to not mix the gene-pool of these tigers , if any conservation action is to be taken.

The western Indian population, though in the country wide analysis indicates a mixed ancestry from Terai and Central India, when tested with each of the mentioned landscapes, it separates out as a unique cluster. This indicates that these populations might be genetically closer to the population from Terai Arc and Central India, but when viewed at a population level, these tigers are distinct. This requires further investigation to determine if this population cluster is indeed formed due to the isolation and drift. If this were the case then it could possibly be highly inbred. If ecological studies suggest inbreeding depression, then appropriate measures to introduce genetic diversity from near-ancestral tiger populations could be considered.

Sunderban did not cluster as unique, but grouped with Central Indian tigers. This could possibly be indicative of recent colonization events or recent shared ancestry and geneflow with Central India until recent times and this is also corroborated by evidence from a recent study on Sunderban (Singh et al, 2015). However, there is also very little evidence of admixture and the cluster is homogenous, indicating no gene-flow from any other population. A coalescent analysis of population demographic history is needed in order to understand the processes (drift, founder effect, ancestral/contemporary geneflow) that have led to the current status. It is also important from a managerial perspective to treat this as a separate unit from the rest of India, as the number of samples we have analysed is comparatively low given the population size of tigers. With the effect we see, it would also be prudent to investigate the genetic make up of tigers in the Bangladesh Sunderban to get a complete picture of the genetic status of the population.

The Northern-Western Ghat tigers shared genetic material with Central Indian tigers, and this is in consonance with current and recent past tiger distribution pattern. Melghat tiger population was connected to Western ghats through Jabua and Nashik into Gujarat sulpaneshwar and Dhulia forests. Thus this region would be an admixture of genetic material from Western Ghats and Central India as observed. It was interesting to note that Palghat Gap formed a barrier to gene flow between Central and Southern Western Ghat populations, suggesting that this region was occupied by intense human activity from ancient times.

The tiger populations in the North-east represent a unique cluster when compared to the tigers from the rest of India. At the highest level of clustering, these tigers separate out as a distinct lineage from the rest of the tiger populations in the country. A plausible reason for this apart from isolation could also be the lineage of these tigers might differ from that of the rest of India. An interesting further step would be to investigate the admixture of genetic material between these populations and the indochinese tiger population (Panthera tigris corbetti) which borders the northeastern states. For managerial purposes, the two sub clusters of a) Manas-Kaziranga-Buxa and b) Namdapha-Dibang should be kept distinct.

The above dataset though small by genetic analysis standards forms the largest and most representative tiger dataset analysed together till data for tigers in India. The recommendations provided herein may change with more data, better laboratory and analytical approaches in the future. However, till that time they serve to provide managers and policy makers with a guide to conserve tigers within India.

Individual Site Results 09

Shivalik Hills & Gangetic Plains Landscape

Rajaji Tiger Reserve (Uttarakhand)

Bivash Pandav, Prerna Sharma, Shikha Bisht, Sudip Banerjee, Aisho Sharma Adhikarimayum, Rohan B. Bhagat, Syed Abrar, Urvashi Sharma, Parabita Basu, Y. V. Jhala and Qamar Qureshi.
Wildlife Institute of India

Named after the first Governor General of Independent India, Rajaji National Park (RNP) was formally granted the status of Tiger Reserve in April, 2015. G. Rajaji Tiger Reserve (RTR) is the second tiger reserve in the State of Uttarakhand after Corbett Tiger Reserve. RTR now encompasses the erstwhile RNP (with an area of 820 km^2), and the three ranges of Shyampur (Haridwar Forest Division), Kotdwar & Laldhang (Landowne Forest Division), and measures about 1,150 km^2. RTR is spread over the districts of Haridwar, Dehradun and Pauri Garhwal. The Rajaji Tiger Reserve includes three wildlife sanctuaries: Rajaji, Chilla & Motichur, which were merged in 1983.

Vegetation: Rajaji Tiger Reserve has a broadleaved deciduous forests, riverine vegetation, scrubland, grasslands and pine forests. The forest communities mainly consist of Rohini (Malollotus philippinensis), Amaltas (Cassia fistula), Shisham (Dalbergia sissoo), Sal (Shorea robusta), Palash (Butea monosperma), Arjun (Terminalia arjuna), Khair (Acacia catechu), Baans (Dendrocalamus strictus), Semul (Bombax ceiba), Sandan (Ougeinia oojeinensis), Chamaror (Ehretia laevis), Amla (Emblica officinalis), Kachnar (Bauhienia variegata), Ber (Ziziphus mauritiana), Chilla (Casearia tomentosa), Bel (Aegle marmelos), etc.

Major carnivores found here are tiger, leopard, striped hyena, jackal, jungle cat, leopard cat and rusty spotted cat. Himalayan black bear and sloth bear are also found here. Major herbivores include Asian elephant, chital, sambar, goral, and wild pig. It is home to 315 birds species, 40 species of reptiles and several species of fish.

Sampling Details

a) Camera Trap survey was conducted from 23/12/2013 to 17/1/2014. A total of 86 camera trap stations covering an area of 131 km^2 (Fig. 9.1) resulting in a sampling effort of 2309 trap nights (Table 9.1).

b) Line transect (n=22) for prey were walked during Dec- Jan 2013-14 (Fig. 9.1). Each transect was walked in the morning between 0600 to 0800 hours with three temporal replicates yielding a total walk effort of 111.58 km. (Table 9.2).

Figure 9.1: Distribution of Camera traps (n=86) and line transects (n=22) in Rajaji Tiger Reserve, 2014.

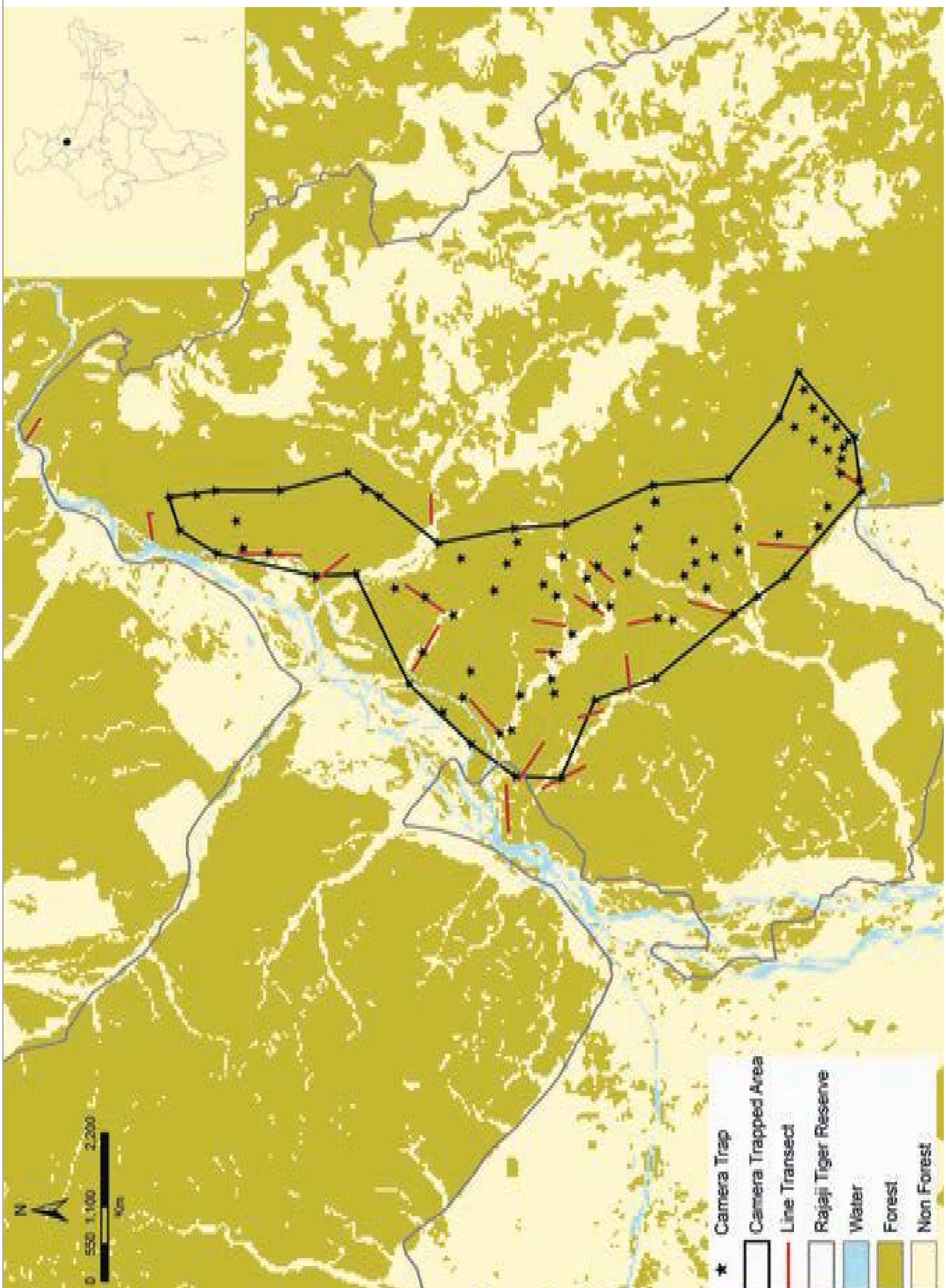


Table 9.1: *Sampling details and tiger density parameter estimates using spatially explicit capture recapture analysis in a likelihood framework for Rajaji Tiger Reserve, 2014.*

Variables	Estimates
Minimum bounding polygon (km^2)	131
Camera Points	86
Trap Nights (effort)	2309
Unique tigers captured	13
Model	g0(.)σ(.)
$\hat{D}$ ML SECR (SE)(per 100 km^2)	2.90(0.87)
Sigma (SE) (km)	4.18(0.87)
go (SE)	0.012(0.003)

SE: Standard error

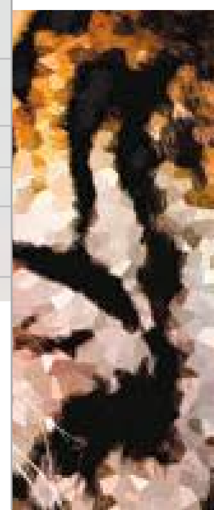
$\hat{D}$ ML SECR: Density estimate from Maximum Likelihood based spatially explicit capture recapture

σ(Sigma): Spatial scale of detection function, g0: Magnitude (intercept) of detection function

Table 9.2: *Model statistics and parameter estimates of line transect (n=22, Total effort 111.58 km) based distance sampling for prey species in Rajaji Tiger Reserve, 2014.*

Species	Model	Chi Sq P Value	Effective strip width (SE)	No. Groups Detected	Mean Group size (SE)	Detection Probability (SE)	Encounter Rate per km	Group Density (SE) per km^2	Individual Density (SE) per km^2
Chital	Uniform Cosine	0.89	37.86 (5.57)	60	2.25 (0.26)	0.39 (0.06)	0.53	7.10 (2.43)	16.02 (5.79)
Sambar	Half normal Hermite	0.93	17.90 (2.26)	36	1.34 (0.08)	0.36 (0.04)	0.32	9.00 (2.74)	12.06 (3.75)
Langur	Half normal Cosine	0.95	37.26 (10.70)	12	4.65 (1.2)	0.64 (0.18)	0.10	1.44 (0.59)	6.77 (3.30)
Wild pig*	NA	NA	NA	5	NA	NA	0.06	NA	NA
Nilgai*	NA	NA	NA	3	NA	NA	0.04	NA	NA
Rhesus macaque*	NA	NA	NA	4	NA	NA	0.07	NA	NA

**Due to small sample size for the species, data could not be analysed in program DISTANCE.*



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Lansdowne Forest Division forms the crucial link between Rajaji and Corbett Tiger Reserves. The four ranges of Lansdowne Forest Division; Laldhang, Kotdwar, Kotri and Dugadda form part of this Rajaji-Corbett connectivity, covering a total area of 433 km^2. Laldhang and Kotdwar, the two ranges on the west have now been included as buffer areas of the recently declared Rajaji Tiger Reserve. Rawasan and Malan are two important perennial rivers that flow through these two ranges. Both these ranges have a long interface with human habitation on the south. On the eastern side, Kotri and Dugadda ranges share border with Kalagarh Tiger Reserve Division of Corbett Tiger Reserve. Kotri range also shares border with Bijnor Forest Division of Uttar Pradesh on its southern side. Kotri and Dugadda ranges form the catchment of rivers Kollu and Khoh, important tributaries of Ramganga River. From an ecological perspective, Kotri and Dugadda ranges are an extension of Corbett Tiger Reserve. The altitude varies from 300, to 1000m and is dominated by Sal mixed forest. The terrain of these four ranges are primarily hilly and is characterized by luxuriant growth of grass species such as Eulaliopsis binata, Chrysopogon fulvus, Nerodia arundinaria, Vetiveria zizanoides and Apluda mutica. The southern slopes in particular are characterized by miscellaneous tree species such as Terminalia tomentosa, Adina cordifolia, Kydia calycina, Lannea coromandelica, Diospyros melanoxylon and Buchnania lanzan. Livestock grazing and lopping for providing fodder to livestock by resident gujjar communities has resulted in habitat degradation in parts of this forest division. Despite huge amount of anthropogenic pressure from the villages located on the south, Lansdowne Forest Division continues to be an important tiger and wildlife habitat in western part of Terai Arc Landscape.

Sampling Details

a) Camera Trap field survey was carried out in Lansdowne Forest Division in May-June, 2014. A total of 63 camera trap stations were set up and sampled simultaneously over 34 occasions accounting for cumulative sampling effort of 1250 trap nights. The minimum bounding polygon for Lansdowne Forest Division 169.95 km^2 (Table 9.3) and (Fig. 9.2).

Variables	Estimates
Minimum bounding polygon (km^2)	169.95
Camera Points	63
Trap Nights (effort)	1250
Unique tigers captured	21
Model	g0(.)σ(.)
$\hat{D}$ ML SECR (SE)(per 100 km^2)	2.78(0.62)
Sigma(SE) (km)	4.26(0.338)
g0 (SE)	0.034(0.007)

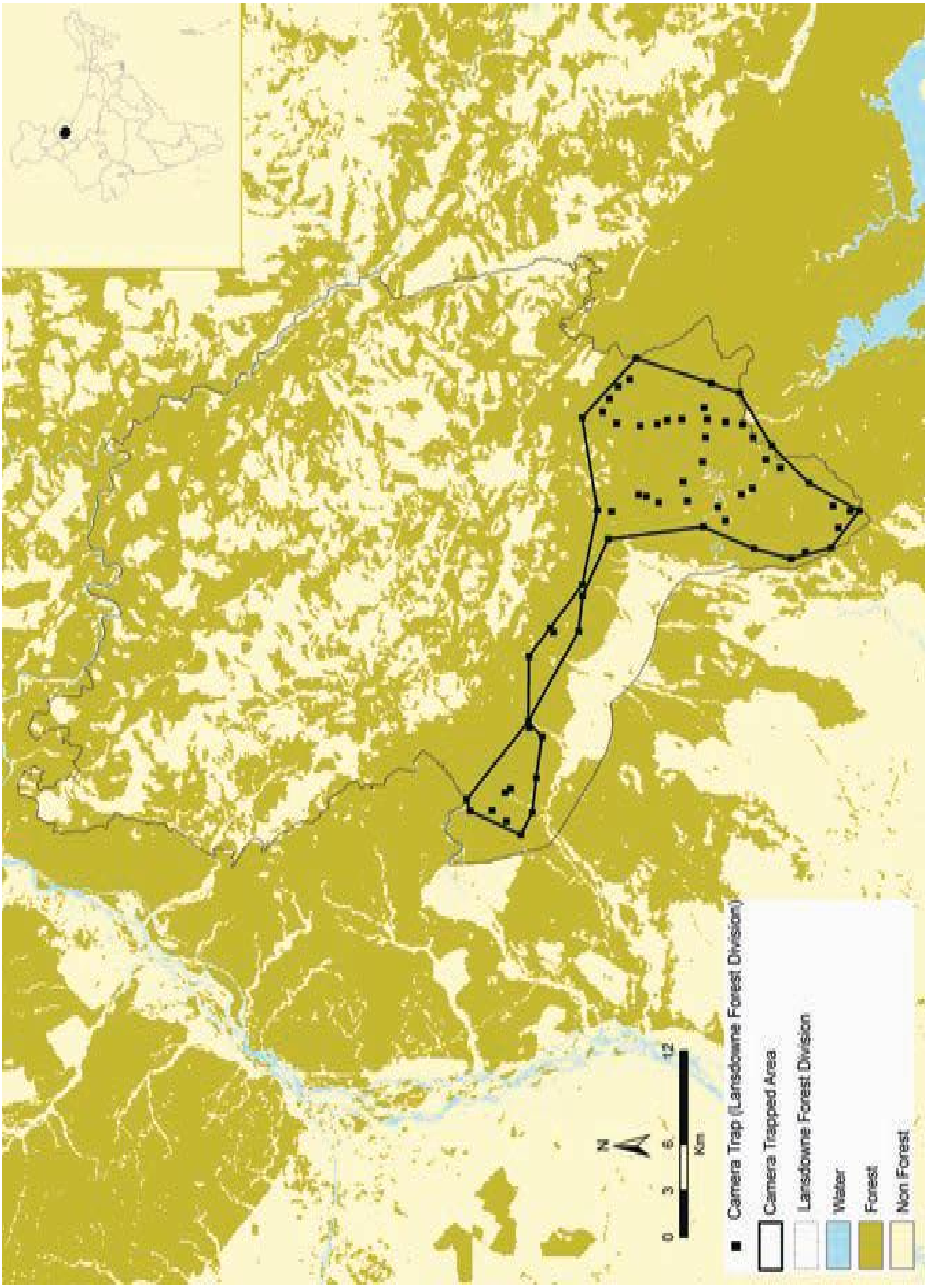
Table 9.3: Sampling details and tiger density parameter estimates in spatially explicit capture -recapture analysis using likelihood framework for Lansdowne Forest Divison, 2014.

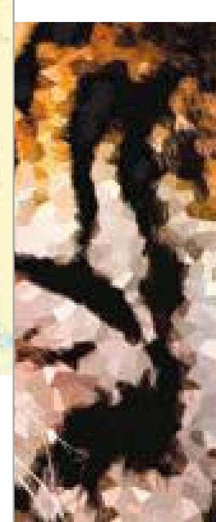
SE: Standard error

$\hat{D}$ ML SECR: Density estimate from Maximum Likelihood based spatially explicit capture recapture

σ(Sigma): Spatial scale of detection function, g0: Magnitude (intercept) of detection function

Figure 9.2: Distribution of Camera traps (n=63)in Lansdowne Forest Division, 2014.





Corbett Tiger Reserve (Uttarakhand)

Shikha Bisht[1], Sudip Banerjee[1], Samir Sinha[2], Saket Badola[2], Prerna Sharma[1], Syed Abrar[1] , Urvashi Sharma[1], Bivash Pandav[1], Parabita Basu[1], Qamar Qureshi[1] and Y. V. Jhala[1].
[1]Wildlife Institute of India and [2]Corbett Tiger Reserve.

Corbett Tiger Reserve (CTR) encompasses a multitude of habitats since it is spread across the Terai, Shivalik Hill Range, bhabhar tract, Ramganga valley and the foothills of Himalayas. It is located within Nainital and Pauri Garhwal districts of the state of Uttarakhand. It lies between 29^0 25' N to 29^0 40' N latitudes and 78^0 5'E to 79^0 5'E longitudes.Corbett Tiger Reserve covers an area of 1288.32 km^2 which includes 520.82 km^2 of Corbett National Park(CNP), 301.18 km^2 of adjoining Sonanadi Wildlife Sanctuary (SWS) and 466.32 km^2 of buffer zone (Barthari 1999). After experiencing several name changes it came to be recognized as CTR, after the famous hunter turned conservationist, Jim Corbett, in the year 1957. The forest divisions of Uttar Pradesh surrounding the tiger reserve namely Bijnore Forest Division (BJD) (80 km^2) and Najibabad Forest Division (NFD) (71.60 km^2) have been incorporated as buffer of the tiger reserve.

The forests of CTR are classified into three major forest types viz. Northern moist deciduous (3C), Northern tropical dry deciduous (5B) and Himalayan sub tropical pine forest (9) (Champion and Seth 1968). Sal (Shorea robusta) is the most dominant tree species growing in the park. Evergreen species like Mallotus philippinensis and Syzygium cuminii are also commonly seen. Other medium sized evergreens include Litsea monopetala, L.glutinosa, and the fragrant Murraya panniculata. Among deciduous species Terminalia alata, T.chebula, Semicarpus anacardium, Lannea coromandelica, Sapium insigne, Lagerstormia parviflora, Butea monsperma, Cassia fistula and Ehretia laevis can be seen throughout the park in good numbers. At several places Bombax ceiba and Anogeissus latifolia can be seen as Sal associates. Phyllanthus emblica, Acacia catechu, Kydia calycina, Dalbergia sissoo and Holoptelia integrifolia can be seen at open sunny places near sots and lining grasslands edges. Plantations of Tectona grandis and Eucalyptus spp. can be seen near the eastern and southern boundaries of the park.

Other than the tiger the park supports felids like leopard, leopard cat, jungle cat, rusty spotted cat and fishing cat. Other carnivores include the golden jackal, sloth bear and Himalayan black bear. Herbivores include elephants, sambar, chital, barking deer, hog deer, goral and serow. Nilgai is seen mostly in the disturbed fringes. Small Indian civet, Himalayan palm civet and common palm civet are found along with mustelids like yellow throated marten and mongoose. Black napped hare and Indian porcupine are of common occurrence. The Ramganga river system also supports a good population of smooth coated otters. Among reptiles, a good population of gharials and mugger can be seen in the river as well as the reservoir. Snakes like king cobra, cobra and python are also found in the park. Among other reptiles are the rock agama, monitor lizard and various turtle species like, Indian black turtle and tricarinate hill turtle (Bharthari 1999).

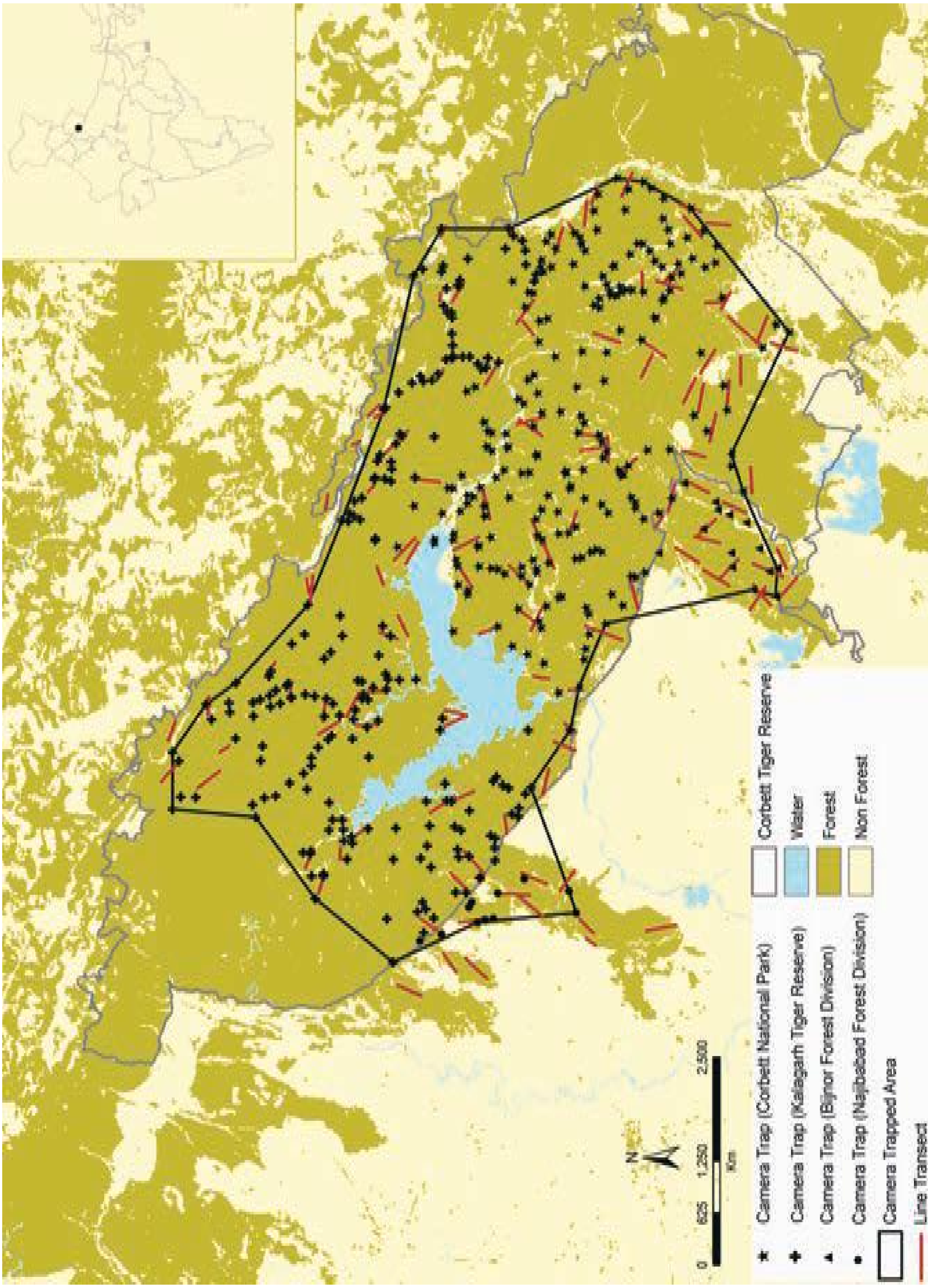
The avifauna of CTR and its adjoining forest divisions is very rich and more than 549 species of resident and migratory birds have been reported from CNP.

Corbett is the largest source population for tigers in Shivalik-Gangetic landscape and responsible for the remarkable recovery of tiger population in this landscape. The corridors connecting Corbett with the surrounding forest divisions and protected areas are crucial for the long term survival of this metapopulation.

Sampling Details:

a) *Camera traps were deployed in 4 different blocks, viz, CNP (6/3/2014 25/5/2014), SWS (18/4/2014 to 23/6/2014), BFD (6/3/2014 to 13/05/2014) and NFD (9/3/2014 to 9/4/2014). A total of 444 camera trap locations covering an area of 1271.32 km^2 (Fig.9.3) resulted in a sampling effort of 14631 trap nights (Table 9.4).*

Figure 9.3: Distribution of Camera traps (n=444)and line transects (n=126) in Corbett Tiger Reserve, 2014.



b) Line transect (n=126) for prey were walked during March- June 2014 (Fig.9.3). Each transect was walked in the morning between 0600 to 0800 hours with three temporal replicates yielding a total walk effort of 570.49 km (Table 9.5)

c) Carnivore sign survey was carried out during March- June 2014 in 70 beats comprising of 15 km walk effort in each beat. The total effort in CTR and its adjoining forest was 837.31 km (CNP- 341.55 km, SWS- 415.55 km, NFD - 37.47 km and BFD- 43.14 km).

Table 9.4: *Sampling details and tiger density parameter estimates in spatially explicit capture recapture in likelihood framework for Corbett Tiger Reserve and its adjoining forest divisons, 2014.*

Variables	Estimates
Minimum bounding polygon (km^2)	1271.32
Camera Points	444
Trap Nights (effort)	14631
Unique tigers captured	176
Model	g0(.)σ(.)
$\hat{D}$ ML SECR (SE)(per 100 km^2)	11(0.80)
Sigma (SE) (km)	2.23 (0.0036)
go (SE)	0.03 (0.001)

SE: Standard error

$\hat{D}$ ML SECR: Density estimate from Maximum Likelihood based spatially explicit capture recapture

σ(Sigma): Spatial scale of detection function, g0: Magnitude (intercept) of detection function

Table 9.5: *Model statistics and parameter estimates of line transect (n=126, Total effort 570.49 km) based distance sampling for prey species in Corbett Tiger Reserve, 2014.*

Species	Model	Chi Sq P Value	Effective Strip Width (SE)	No. Groups Detected	Mean Group size (SE)	Detection Probability (SE)	Encounter Rate per km	Group Density (SE) per km^2	Individual Density (SE) per km^2
Barking Deer	Hazard Cosine	0.91	33.17(4.65)	86	1.34(0.05)	0.35(0.05)	0.15	2.27(0.43)	3.06(0.59)
Chital	Hazard Cosine	0.91	35.18 (2.3)	261	9.9(0.59)	0.44(0.02)	0.45	6.5 (0.78)	64.38 (8.6)
Elephant	Uniform Cosine	0.98	67.27(6.7)	32	5.91(1.10)	0.57(0.05)	0.05	0.41(0.09)	2.46(0.74)
Langur	Half normal Simple	0.86	33.61(2.8)	71	12.40(1.10)	0.45(0.03)	0.12	1.85(0.39)	23.18(5.87)
Nilgai	Half normal Simple	0.87	35.17(4.4)	30	4.86(0.49)	0.47(0.05)	0.05	0.74(0.24)	3.63(1.25)
Sambar	Half normal Hermite	0.92	41.16(2.64)	162	2.71(0.12)	0.53(0.03)	0.27	3.34(0.37)	9.09(1.1)
Wildpig	Uniform Cosine	0.84	36.04(2.8)	55	6.90(0.87)	0.58(0.04)	0.09	1.26(0.21)	8.7(1.84)

Terai West Forest Division (Uttarakhand)

Surender Mehra[1], Rahul[1], J. P. Singh[1], Harish Guleria[2], Meraj Anwar[2] & Jimmy Borah[2] .
[1]Uttarakhand Forest Department, [2]World Wide Fund for Nature, India

Three forest divisions (Terai West, Terai Central and Terai East) encompass the Terai tract of Uttarakhand. These three forest divisions lie immediately south of the Bhabar tract of Uttarakhand. Terai West Forest Division shares its boundary with Amangarh Tiger Reserve of Uttar Pradesh on the North West and Corbett Tiger Reserve as well as Ramnagar Forest Division on the north. The forests of Terai West Division are contiguous with the forests of Terai Central Division on the east. The Terai Central Forest Division maintains its connectivity with Ramnagar Forest Division through two important corridors; Boar River corridor and Nihal-Bhakhra corridor (Johnsingh et al. 2004). Terai Central Forest Division extends up to Lalkuan in the east. With the loss of Gola River corridor, the connectivity between Terai Central and Terai East Forest Divisions has been totally lost. East of Gola River, Terai East Forest Division extends all the way up to Pilibhit Tiger Reserve in Uttar Pradesh. Forests of Terai East Division are contiguous with Haldwani Forest Division. The corridor near Khatima (Kilpura-Khatima corridor, south of Tanakpur) is the major bottleneck in Terai East Forest Division and forms an important connectivity between Pilibhit Tiger Reserve (through Surai Range of Terai East FD) and Nandhour Wildlife Sanctuary (in Haldwani FD).

The three Terai forest divisions lie entirely in the terai zone with characteristic flat topography and fine alluvial soil deposits. Extensive plantations of commercially valuable species were raised during the 60's and these have replaced much of the natural vegetation. The vegetation here is dominated by exotics like teak and eucalyptus. In the south these forests give way to agricultural fields and fast urbanizing settlements. Disturbance is reported to be high due to pressures from high human densities, particularly along the southern boundary of this region. Within the forest there is presence of traditional pastoralist and nomadic communities such as the gujjars and bhotiyas who practice grazing and agriculture in the forest. Major pressures on wildlife habitat are from resource extraction such as boulder mining and timber removal.

Sampling Details

a) Camera Trap field survey was carried out in Terai West Forest Division from 9/6/2014 to 28/6/2014. A total of 30 camera trap stations were set up and sampled simultaneously over 20 occasions accounting for cumulative sampling effort of 600 trap nights. The minimum bounding polygon for Terai West Forest Division was 74.30 km^2 (Table 9.6) and (Fig. 9.4).

Table 9.6: Sampling details tiger density parameter estimates in spatially explicit capture mark-recapture analysis using likelihood framework for Terai West Forest Divison, 2014.

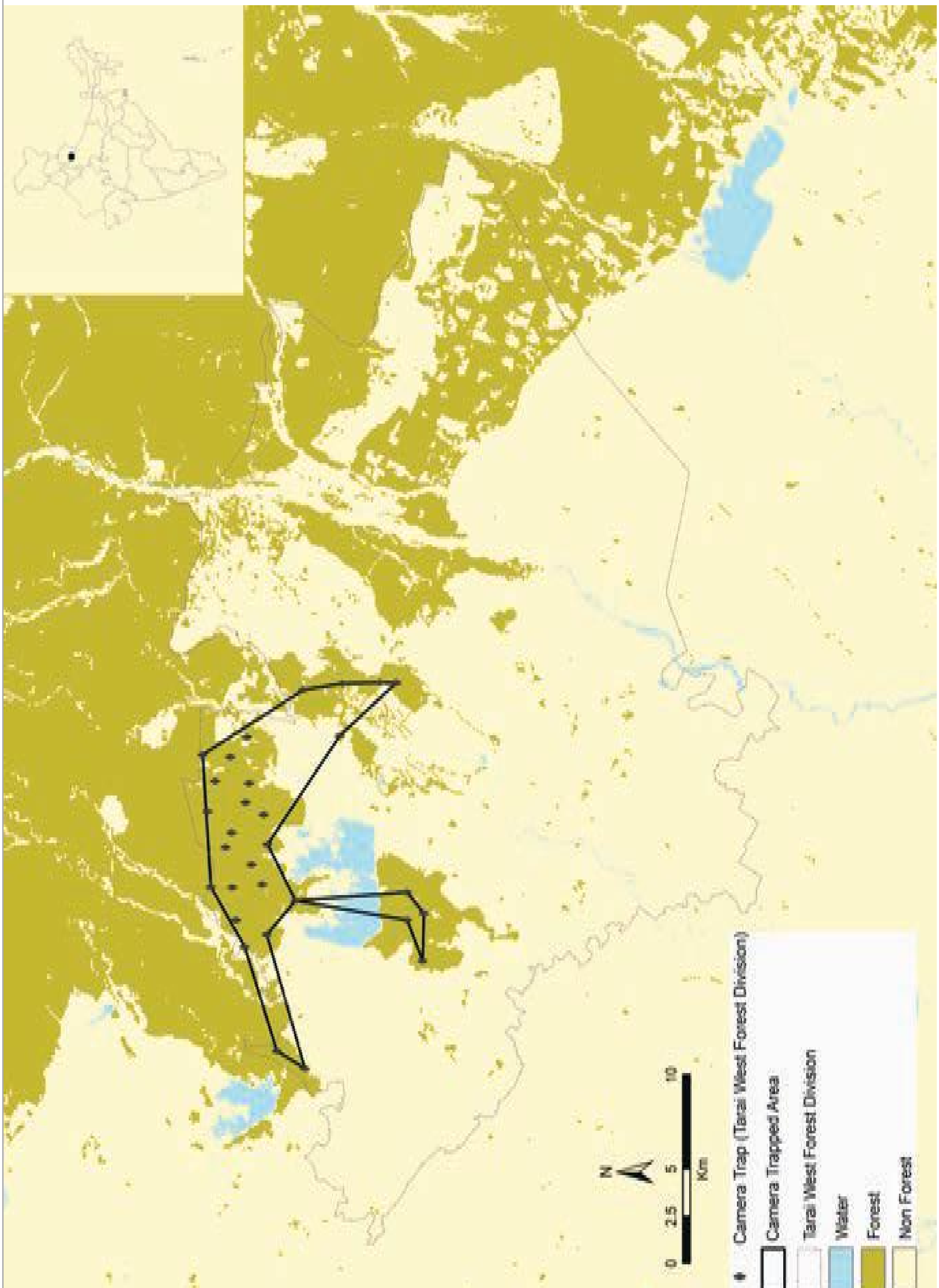
Variables	Estimates
Minimum bounding polygon (in km^2)	74.30
Camera Points	30
Trap Nights (effort)	600
Unique tigers captured	8
Model	g0(.)σ(.)
$\hat{D}$ ML SECR (per 100 km^2)	3.88(1.60)
Sigma(SE) (km)	3.41(0.69)
g0 (SE)	0.018(0.007)

SE: Standard error

$\hat{D}$ ML SECR: Density estimate from Maximum Likelihood based spatially explicit capture recapture

σ(Sigma): Spatial scale of detection function, g0: Magnitude (intercept) of detection function

Figure 9.4: Distribution of Camera traps (n=30)in Terai-West Forest Division, 2014



Haldwani Forest Division (Uttarakhand)

C. S. Sanwal[1], Sanatan[1], Parag Madhukar Dhakate[1], R.C. Kandpal[1], Prakash Arya[1], Navin Pant[1], Harish Guleria[2], Meraj Anwar[2] & Jimmi Borah[2].
[1]Forest Department of Uttarakhand & [2]World Wide Fund for Nature, India

The five ranges of Haldwani forest division (Chakata, Nandhour, Danda, Jaulasal and Sharda) cover an area of about 600 km^2 and are bound by the Gola River to the West, and Sharada River to the east. To the west of Haldwani division across the Gola River lies the forests of Ramnagar and Terai Central Forest Divisions. In the north-east, Dogadi range of Champawat Forest Division forms an important connectivity with forests of Haldwani. In the south, forests of Haldwani are surrounded by the forests of Ransali, South Jaulasal and Kilpura ranges of Terai East Forest Division. Together with Champawat and Terai East Forest Divisions, Haldwani forest division forms a compact patch of nearly 1,200 km^2 of important tiger habitat on the eastern most part of Uttarakhand. Across the Sharada River, forests of Haldwani are contiguous with forests of Nepal through the Boom-Brahmadev corridor above Tanakpur.

Forests of Haldwani are characterized by hilly terrain with a loose substrate made up of coarse sediments and interspersed with several seasonal and few perennial streams. The Nandhour rivier flows east to west through the forests of Haldwani, before entering the Terai region. Nandhour has large swathes of undisturbed forest which are devoid of human habitation. The Nandhour wildlife sanctuary, within area of 380 km^2, lies at the centre of the Haldwani Division.

Historical references including writings of the legendary Jim Corbett stand testimony to the faunal richness of this division (Corbett, 1944, Corbett 1954). Forests of Haldwani once supported significant populations of tigers and leopards owing to plentiful prey such as sambar, wild pig and spotted deer. Other major herbivores of the area include elephant, goral and serow. Both sloth bear and Himalayan black bear are known to occur in the forests of Haldwani. Alongside its mammalian fauna the region hosts a rich diversity of birds pecies comprising of Himalayan endemics and vagrants from Nepal. Although past studies have indicated a declining status of large mammals in this region (Johnsingh et al. 2004, 2010; Johnsingh and Pandav, 2008), conservation efforts in Haldwani has gained considerable momentum with the recent declaration of Nandhour Wildlife Sanctuary. Haldwani division holds enormous potential for conserving tiger and is one of the important recovery zones in the country.

Sampling Details

a) Camera Trap field survey was carried out in Haldwani Forest Division from 16/6/2013 to 22/9/2013. A total of 105 camera trap stations were set up and sampled simultaneously over 20 occasions accounting for cumulative sampling effort of 2100 trap nights. The minimum bounding polygon (km^2) for Haldwani Forest Division was 176.07 km^2 (Table 9.7) and (Fig. 9.5).

Table 9.7: Sampling details and tiger density parameter estimates using spatially explicit capture mark-recapture analysis using likelihood framework for Haldwani Forest Divison, 2014

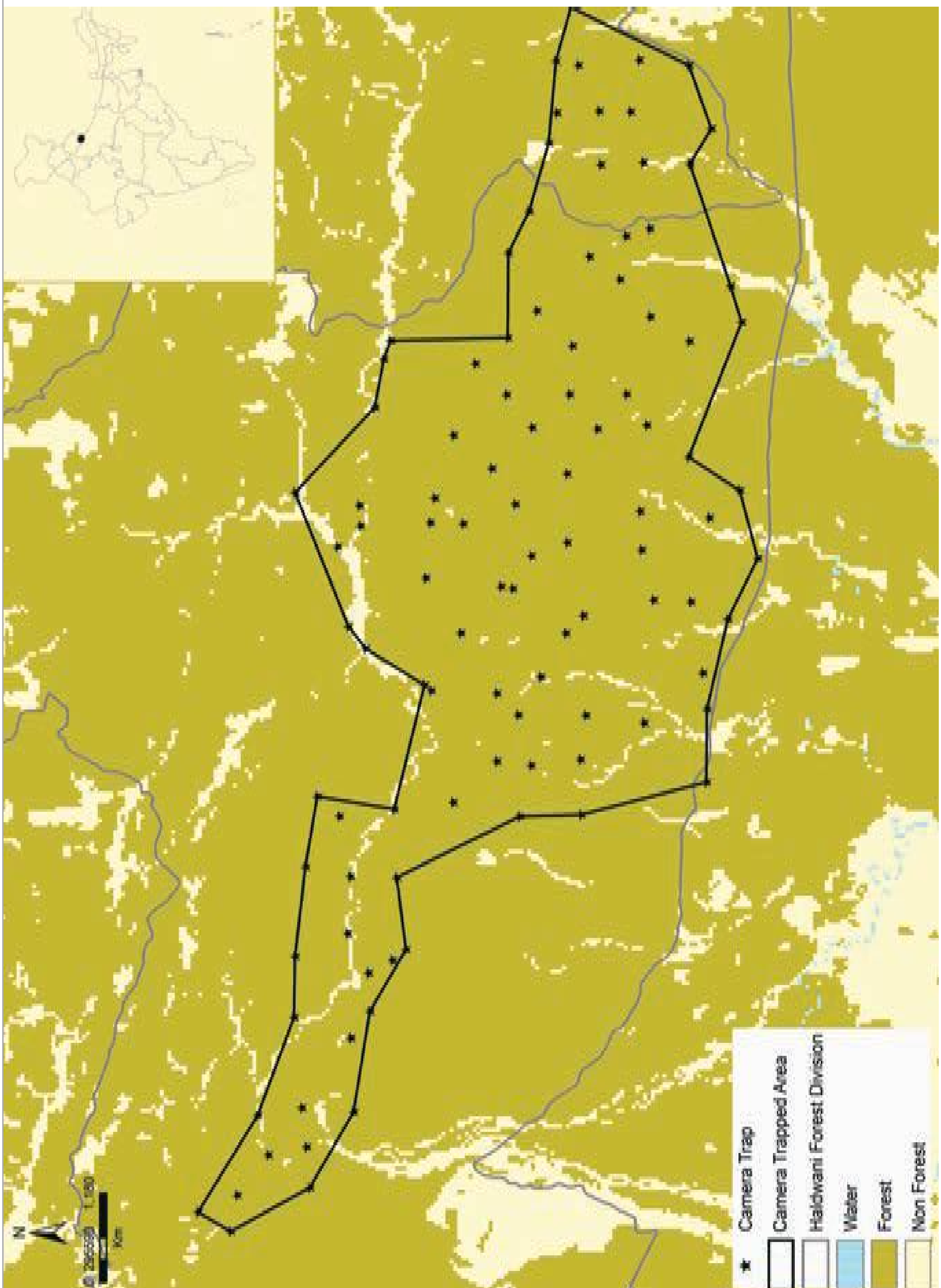
Variables	Estimates
Minimum Bounding Polygon (km^2)	176.07
Camera Points	105
Trap Nights (effort)	2100
Unique tigers captured	11
Model	g0(.)σ(.)
$\hat{D}$ ML SECR (SE) (per 100 km^2)	2.9(1.00)
Sigma (SE)(km)	2.1(0.37)
g0 (SE)	0.015(0.006)

SE: Standard error

$\hat{D}$ ML SECR: Density estimate from Maximum Likelihood based spatially explicit capture recapture

σ(Sigma): Spatial scale of detection function, g0: Magnitude (intercept) of detection function

Figure 9.5: Distribution of Camera traps (n=105) in Haldwani Forest Division, 2014.



Ramnagar Forest Division (Uttarakhand)

Kahkashan Naseem, Gopal Singh Karki*, Meraj Anwar[1], Harish Guleria[1], Jimmy Borah[1], Aisho Sharma Adhikarimayum[2], Bhaskar Jyoti Bora[2], Ranjana Pal[2], Rahul K Talegaonkar[2], Ravi Sharma[2], R. B. Bhagat[2], Urjit Mahesh Bhatt[2], Parabita Basu[2], Y. V. Jhala[2] and Qamar Qureshi[2].*

Ramnagar Forest Division (RFD) is located between the Rivers of Kosi in the west and Gola in the east. It lies between 29° 13' N - 29° 34' N latitudes and 76° 06' E - 79° 33' E longitudes. RFD is in the Nainital district of Uttarakhand district and is included in the Western circle of Kumaon region. Spread across an area of 487.37 km², this division is constituted by Kosi (86.18 km²), Kota (85.42 km²), Dechori (102 km²), Kaladhungi (113.9 km²) and Fatehpur (99.85 km²) ranges. Ramnagar FD came into existence in 1911 by notification no. 159/XIV-44, which was earlier part of Kumaon and Garwal forest divisions between 1886 and 1911. In the north of this division are Almora and Nainital divisions, while Terai West and Terai Central divisions are on the southern boundary. The forests of Corbett tiger reserve and Haldwani divisions border the west and east of the Ramnagar FD respectively. Five rivers, Kosi, Dabka, boar, Nihal and Bhakra flow through the region. Many seasonal and perennial streams are also present in the forest of this division. According to Champion and Seth (1968), the major forest types occuring in Ramnagar FD are a) Northern tropical semi-evergreen, b) North Indian moist deciduous, c) Tropical fresh water swamp, d) North tropical dry deciduous and d) Himalayan subtropical chir pine forest. The area is mostly covered by moist Sal forest and mixed type of forest. There is also the presence of Teak plantations, which were planted to decrease the threat of encroachments. Common trees found in this division are Anogeissus latifolia, Terminalia bellerica, Syzizium sp., Lagerstroemia parviflora, Mallotus phillipinensis, Cassia fistula, Adina cordifolia and Linnea coromandelica. Major understory vegetation consists of Clerodendron viscosum, Lantana camara, Parthenium sp., Adhatoda vasica and Colebrookia oppositifolia. The geographical area is divided into rocky area, plateau region and low lying area which gets affected by floods during the rainy season. Major mammalian fauna in this region include tigers, leopards, leopard cat, jungle cat, rusty spotted cat, red fox, jackal, Himalayan black bear, sloth bear, Indian porcupine, elephant, goral, serow, chital, sambar, muntjac and Indian pangolin.

Sampling Details

a) Camera Trap field survey was carried out in Ramnagar Forest Division from 5/12/2013 to 22/1/2014 in Block 1 and from 2/2/2014 to 22/3/2014 in Block 2. A total of 70 camera trap stations were set up and sampled over 49 occasions for each block accounting for cumulative sampling effort of 3404 trap nights. The minimum bounding polygon (km²) for Ramnagar Forest Division was 192.87 km² (Table 9.8) and (Fig. 9.6).

b) Line transect surveys were carried out in Ramnagar Forest Division between June and July 2014. The surveys were conducted along 24 line transects (Fig. 9.6). Each transect was walked in the morning from 0600 to 0800 hours to obtain 3 temporal replicates which resulted in a total walk effort of 153.98 km (Table 9.9).

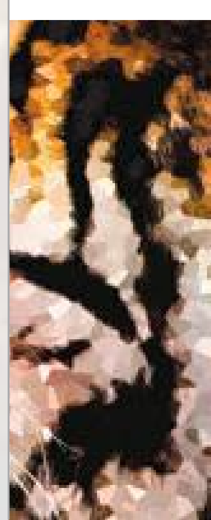


Figure 9.6: Distribution of Camera traps (n=70) line transects (n=24) in Ramnagar Forest Division, 2014.

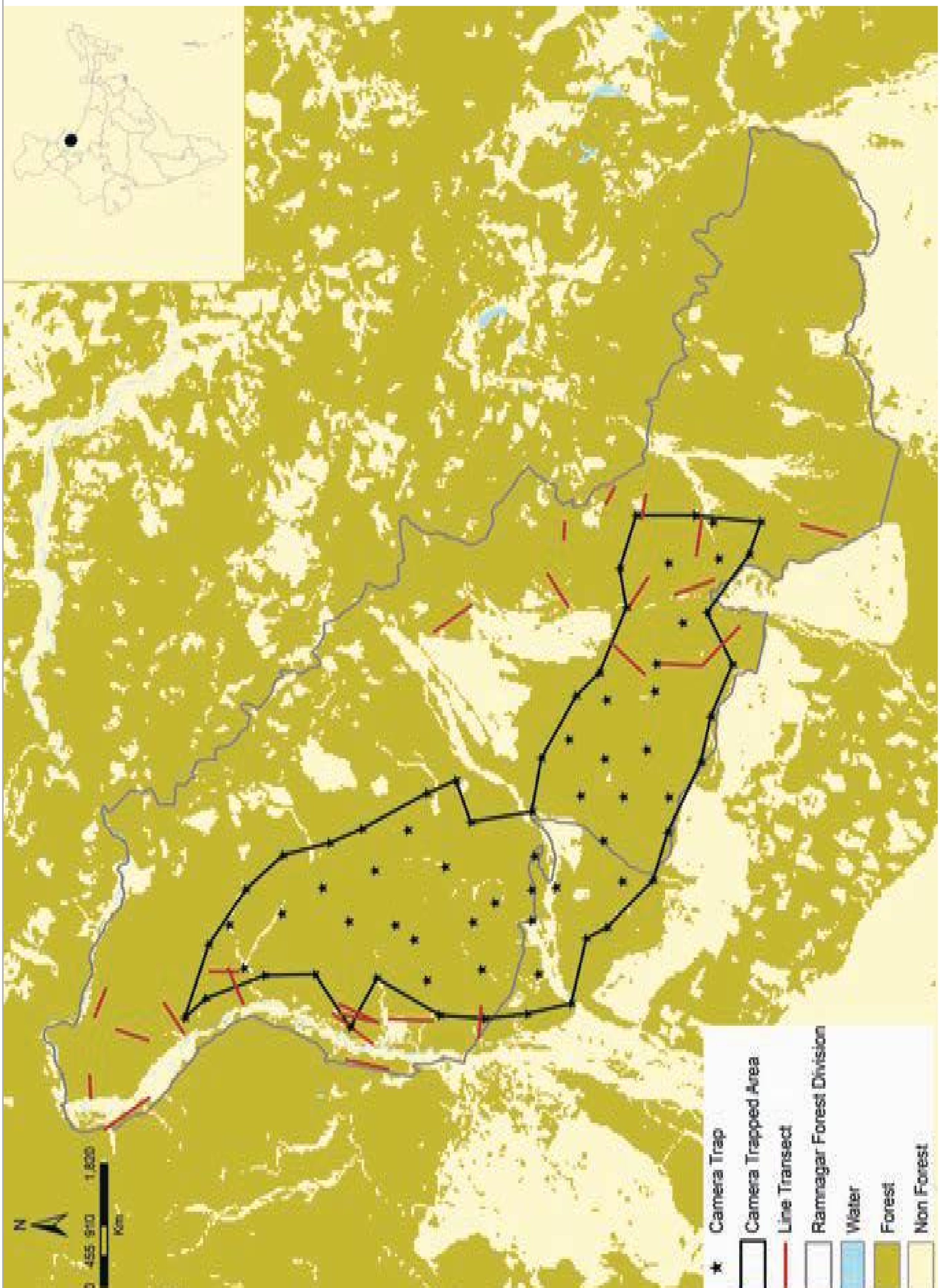


Table 9.8: Sampling details and tiger density parameter estimates using spatially explicit capture mark-recapture analysis using likelihood framework for Ramnagar Forest Divison, 2014

Variables	Estimates
Minimum bounding polygon (km^2)	192.87
Camera Points	70
Trap Nights (effort)	3404
Unique tigers captured	41
Model	g0(.)σ(.)
$\hat{D}$ML SECR (SE)(per 100 km^2)	9.71(1.53)
Sigma (SE) (km)	1.74(0.06)
g0 (SE)	0.06(0.004)

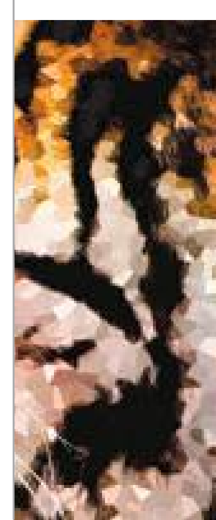
SE: Standard error

$\hat{D}$ ML SECR: Density estimate from Maximum Likelihood based spatially explicit capture recapture

σ(Sigma): Spatial scale of detection function, g0: Magnitude (intercept) of detection function

Table 9.9: Model statistics and parameter estimates of line transect (n=24, Total effort 153.98 km) based distance sampling for prey species in Ramnagar Forest Division, 2014.

Species	Model	Chi Sq P Value	Effective Strip Width (SE)	No. Groups Detected	Mean Group size (SE)	Detection Probability (SE)	Encounter Rate per km	Group Density (SE) per km^2	Individual Density (SE) per km^2
Chital	Hazard Polynomial	0.92	39.28(12.22)	54	8.61(1.73)	0.39(0.12)	0.35	4.46(2.06)	38.43(19.35)
Sambar	Uniform Cosine	0.85	57.84(6.97)	37	2.29(0.24)	0.39(0.048)	0.24	2.08(0.70)	4.78(1.69)
Barking Deer	Uniform Cosine	0.64	25.23(6.26)	13	1.31(0.16)	0.33(0.08)	0.08	1.67(0.85)	2.18(1.15)
Langur	Hazard Polynomial	0.67	50.79(8.99)	34	3.64(0.56)	0.55(0.09)	0.22	2.17(0.55)	7.90(2.35)
Rhesus macaque	Uniform Cosine	0.63	35.75(2.98)	23	6.23(1.67)	0.54(0.05)	0.15	2.09(0.59)	13.01(5.04)



Terai East Forest Division (Uttarakhand)

Meraj Anwar, Harish Guleria and Jimmy Borah.
World Wide Fund for Nature, India.

The forested area of three ranges of Terai East forest division namely, Kilpura (area 61.1 km²), Khatima (91.8 km²) and Surai (158.3 km²) form a wildlife corridor, connecting the Mahof range of Pilibhit TR with the Sharda range of Nandhour WLS. Administratively this corridor is managed under the Udhamsingh nagar district of Uttarakhand state of India. The area of this corridor is approximately 130 km^2 with a length (North to South) of about 22 km^2. At some places it is as narrow as 1 km and is completely disjointed by a canal and human habitation (eg. Lal Kothi bridge, 28⁰ 56' 30.1" N, 80⁰ 01' 04.6" E). The forests of Khatima range are a vital link in the chain of connectivity between Nandhour WLS (Haldwani FD), Pilibhit FD and the forests in Nepal. This serves as a corridor for several large mammal species, including tiger and a population of c. 30-40 elephants that are confined to Haldwani FD and part of Terai east FD. Terai east FD faces severe encroachment as exemplified by Khatima range of which, at least 6 km² is under encroachment by about 800 families. The forests of Khatima range are highly disturbed from settlements (Pachoria, Ghosi kuan, Amanwa, Burahi) along the right bank of the Sharda canal. As a result, the movement of large mammals between Kilpura and Surai ranges has virtually come to an end. Encroachment related habitat loss has been exacerbated by linear breakages in the forests, resulting from the alignments of the Sharda canal and Tanakpur-Khatima highway road (Johnsingh et al. 2004). A number of Gujjar families along with their livestock also reside in the Kilpura and Surai range. Perennial sources of water in the corridor are Jagbora and Sharda rivers, and Sharda canal. Lohia, Sania and Khara nullahs are among seasonal streams of the area.

Important tree species recorded in this corridor are Shorea robusta, Mallotus phillipinensis, Terminalia alata, Trewia nudiflora, Syzium cumini, Holoptelia integrifolia, and Lagerstroemia parviflora. Plantation of Eucalyptus sp., Tectona grandis and Miliusa velutina are also found here. Encounter rate of tiger and leopard signs in this corridor was recorded as 0.2 ± 0.1 and 0.1 ± 0.0 (signs/km) respectively (Rajapandian et al 2010). Important mammalian fauna of this forest are tiger, leopard, sloth bear, chital, sambar, muntjac, nilgai and wild pig. Smaller cats are represented by jungle cat, leopard cat and rusty-spotted cat.

Sampling Details

a) Camera Trap field survey was carried out in Terai East Forest Division from 11/9/2014 to 4/10/2014. A total of 64 camera trap stations were set up and sampled simultaneously over 24 occasions accounting for cumulative sampling effort of 1536 trap nights. The minimum bounding polygon for Terai East Forest Division was 164.17 km^2 (Table 9.10) and (Fig 9.7).

Table 9.10: Sampling details and tiger density parameter estimates using spatially explicit capture mark-recapture analysis using likelihood framework for Terai East Forest Divison, 2014

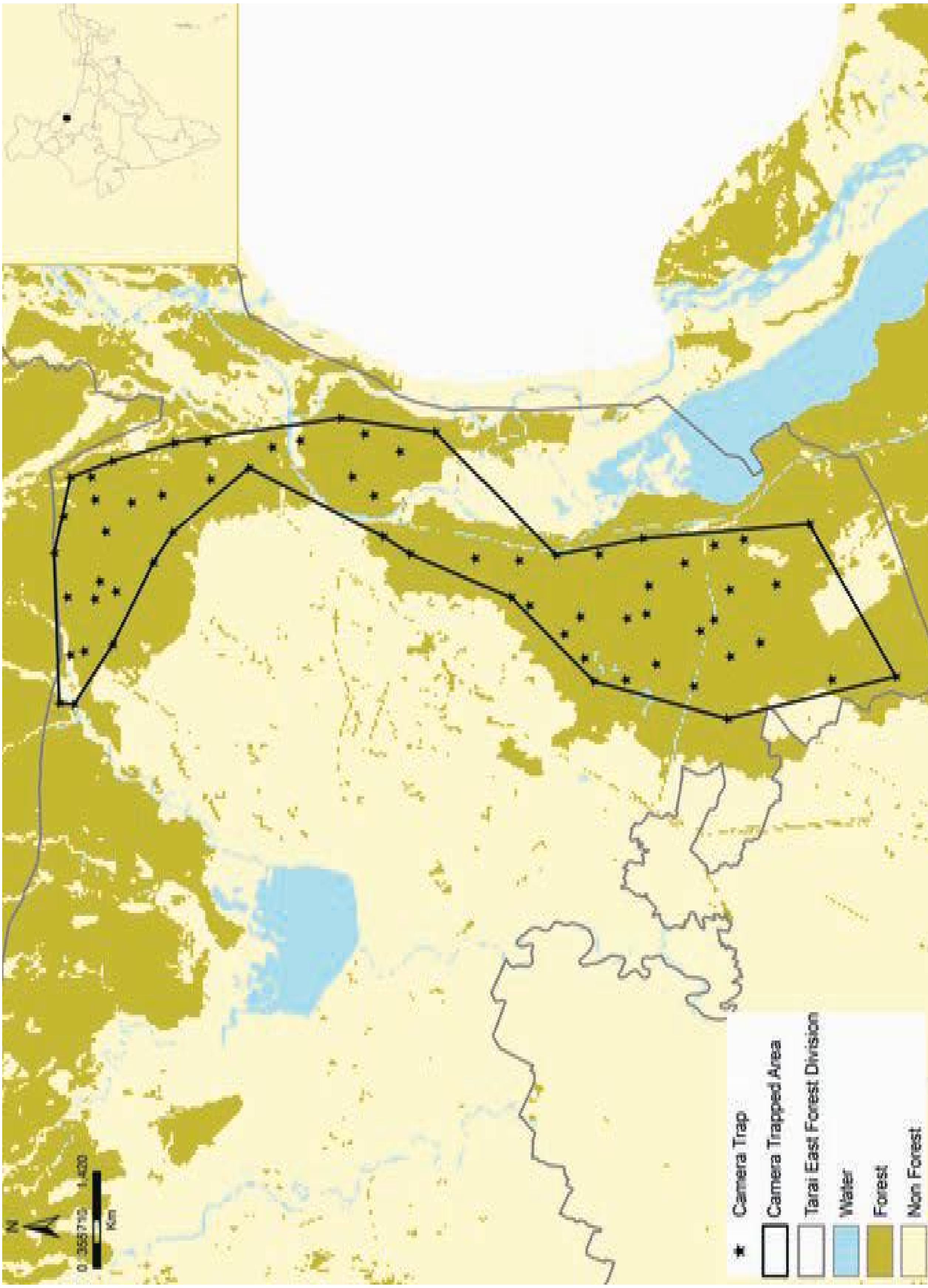
Variables	Estimates
Minimum bounding polygon (km^2)	164.17
Camera Points	64
Trap Nights (effort)	1536
Unique tigers captured	12
Model	g0(.)σ(.)
$\hat{D}$ ML SECR (SE) (per 100 km^2)	2.53(0.78)
Sigma (SE) (km)	3.43(0.4)
g0 (SE)	0.029(0.007)

SE: Standard error

$\hat{D}$ ML SECR: Density estimate from Maximum Likelihood based spatially explicit capture recapture

σ(Sigma): Spatial scale of detection function, ^g0: Magnitude (intercept) of detection function

Figure 9.7: *Distribution of Camera traps (n=64) in Terai east forest division, 2014.*



This study documented tigers in all of the three ranges of Terai East forest division. Elephants were not recorded from the Surai range. Other wild animals documented from this corridor were leopard, jungle cat, rusty spotted cat, sloth bear, nilgai, chital, sambar, muntjac and wild pig. Human interference was also recorded in the three ranges of this corridor. Out of 66 camera stations, four camera traps from two locations were stolen. Camera traps were not redeployed on these two sites therefore total no. of sites where cameras were operational throughout the session remained 64.

The three ranges (Kilpura, Khatima and Surai) of Terai East FD are the only conduit between recently declared Nandhour WLS and Pilibhit TR, and is facing habitat loss and fragmentation due to ever increasing human interference in terms of encroachment, over grazing and linear development (road NH 125, Khatima-Tanakpur railway line and Sharda canal). In the present study tigers were recorded using the southern bottleneck between Khatima and Surai forests and were recorded in Khatima range (Nakhatal patch) from which tigers were not detected in earlier surveys (Johnsingh et al 2004, Rajapandian et al 2010).

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Dudhwa National Park (Uttar Pradesh)

Kamlesh K. Maurya, Rohit Ravi, Mudit Gupta, Ashish Bista, Dabeer Hassan, Radheshyam, Sher Singh.
World Wide Fund for Nature, India.

Dudhwa National Park (DNP) extends between 28° 40' N - 28^0 23' N latitudes and, 80° 31' E - 80^0 54' E longitudes, in the Lakhimpur Kheri District of Uttar Pradesh, India. The park has a number of large wetlands and alluvial grasslands. Historically this park was famed for it's Sal timber, and later as a premier hunting area. DNP is a part of the Dudhwa Tiger Reserve.

Two main rivers, Mohana (in the North) and Suheli (in the South), act as essential water sources in DNP. Dudhwa has a tenuous connectivity to the Basanta and the Laljhari forests in Nepal. Dudhwa is characterized by extensive tracts of Sal forests, interspersed with tall grass lands, large wetlands and seasonal streams. The Park is famous for its small population of reintroduced greater one-horned rhinoceros (Rhinoceros unicornis), which is restricted to a fence enclosure in the Suheli flood plains. Some of the major carnivores inhabiting DNP include tiger, leopard, fishing cat, jungle cat, leopard cat, sloth bear, and large Indian civet. The important herbivores of the reserve include elephant, chital, sambar, hog deer, barking deer, barasingha, nilgai and wild pig. This park has a good population of barasingha, Bengal florican and hispid hare.

Sampling Details

a) *Camera Trap field survey was carried out in two blocks by the forest department with technical assistance from WWF. The survey from 6/2/2014 to 22/4/2014. A total 177 camera trap stations were set up and sampled simultaneously over 37 occasions accounting for cumulative sampling effort of 5478 trap nights. The minimum bounding polygon (km^2) for DNP was 398.86 km^2 (Table 9.11) and (Fig. 9.8).*

Variables	Estimates
Minimum Bounding Polygon (km^2)	398.86
Camera Points	177
Trap Nights (effort)	5478
Unique tigers captured	21
Model	g0(.)σ(.)
$\hat{D}$ ML SECR (SE)(per 100 km^2)	2.06(0.46)
Sigma (SE) (km)	2.91(0.13)
g0 (SE)	0.034(0.004)

SE: Standard error

$\hat{D}$ ML SECR: Density estimate from Maximum Likelihood based spatially explicit capture recapture

σ(Sigma): Spatial scale of detection function, g0: Magnitude (intercept) of detection function

Table 9.11: *Sampling details and tiger density parameter estimates using spatially explicit capture mark-recapture analysis using likelihood framework for Dudhwa Forest Divison, 2014*

Considering the prey density (10.53 -13.64 ungulates/km^2) available in DNP (Chanchani et al. 2014), estimates of tiger density arrived from spatial estimators appear to be ecologically realistic. However, some of the park areas are still empty due to lack of sufficient prey availability and anthropogenic pressure, especially northern side.

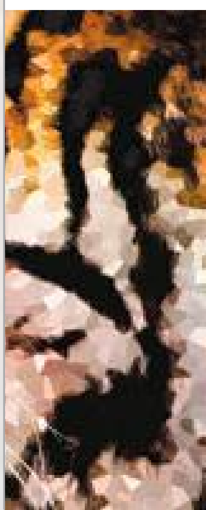
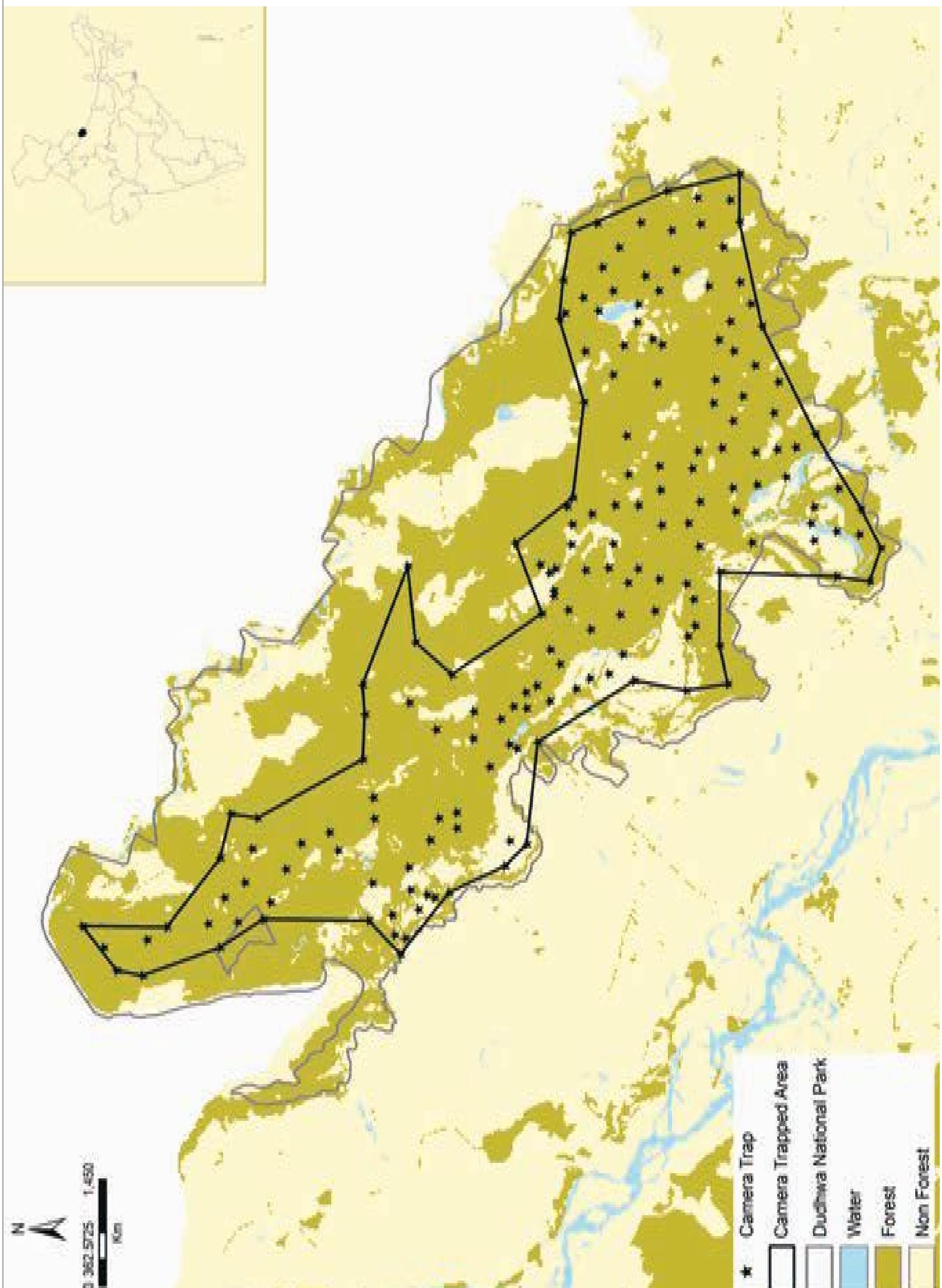


Figure 9.8: *Distribution of Camera traps (n= 177) in Dudhwa National Park, 2014.*



Kishanpur Wildlife Sanctuary – (Dudhwa Tiger Reserve) (Uttar Pradesh)

Kamlesh K. Maurya, Rohit Ravi, Mudit Gupta, Ashish Bista, Dabeer Hassan, Radheshyam and Sher Singh.
World Wide Fund for Nature, India.

Kishanpur Wildlife Sanctuary (28° 23′ N - 27° 85' N latitudes and 81° 02′ E - 81° 23' E longitudes), straddles Gola Tehsil in Lakhimpur District and the Powayan Tehsil in Shahjehanpur District in Uttar Pradesh, India. It lies on the southern side of the Sharda River and covers an area of 227 km^2. The area of the Sanctuary was once part of the South Kheri Forest Division, and the Sharada River flows along a section of its eastern boundary. This site is also a part of Dudhwa Tiger Reserve, and is connected with South Kheri Forest Division.

This sanctuary is connected with Pilibhit Tiger Reserve to the north and with the South Kheri Forest Division to the south. Habitat is a forest mosaic of grassland, Sal and teak forest. The major attractions here are the large herds of Swamp deer. Along with these, the pristine habitat is shared by tiger, leopard, fishing cat, jungle cat, sloth bear, while prey species includes the spotted deer, sambar, hog deer, barking deer or Indian muntjac, nilgai and wild pig.

Sampling details

a) Camera Trap field survey was carried out in Kishanpur Wildlife Sanctaury from 20/11/2013 to 14/1/2014. A total of 62 camera trap stations were set up and sampled simultaneously over 58 occasions accounting for cumulative sampling effort of 3485 trap nights. The minimum bounding polygon (km^2) for Kishanpur Wildlife Sanctuary was 187.87 (Table 9.12) and (Fig. 9.9).

Table 9.12: Sampling details and tiger density parameter estimates using spatially explicit capture mark-recapture analysis using likelihood framework for Kishanpur Wildlife Sanctuary, 2014

Variables	Estimates
Minimum bounding polygon (km^2)	187.87
Camera Points	62
Trap Nights (effort)	3485
Unique tigers captured	30
Model	g0(.)σ(.)
$\hat{D}$ ML SECR (SE)(per 100 km^2)	8(1.48)
Sigma (SE) (km)	2.06(0.07)
g0 (SE)	0.06(0.005)

SE: Standard error

$\hat{D}$ ML SECR: Density estimate from Maximum Likelihood based spatially explicit capture recapture

σ(Sigma): Spatial scale of detection function, g0: Magnitude (intercept) of detection function

Kishanpur WLS is perhaps one of the better sites in the landscape - on account of canals, rivers and buffer forests that help restrict the entry of village dwellers into the forest, and therefore likely support the highest density of breeding tigresses within this landscape (Chanchani et al. 2014). However, it must be noted that there are several small village enclaves within Kishanpur WLS. The highway from Khutar to Palia that passes through the central region of Kishanpur Wildlife Sanctuary bisects the sanctuary and tigers have suffered fatalities in road accidents on this highway. Extensive lengths of railway line also run through Kishanpur, and trains operate at high speeds (often 60 km/ph or faster), both during the day and at night. The impacts of these sources of disturbance on wildlife, especially in forests that are already narrow and fragmented, need to be addressed. It is imperative that the connectivity of the park is maintained with other areas.

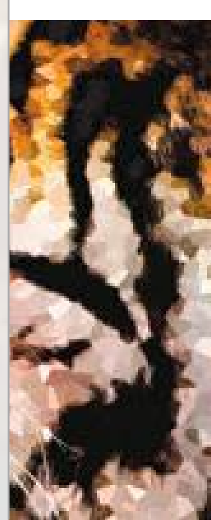
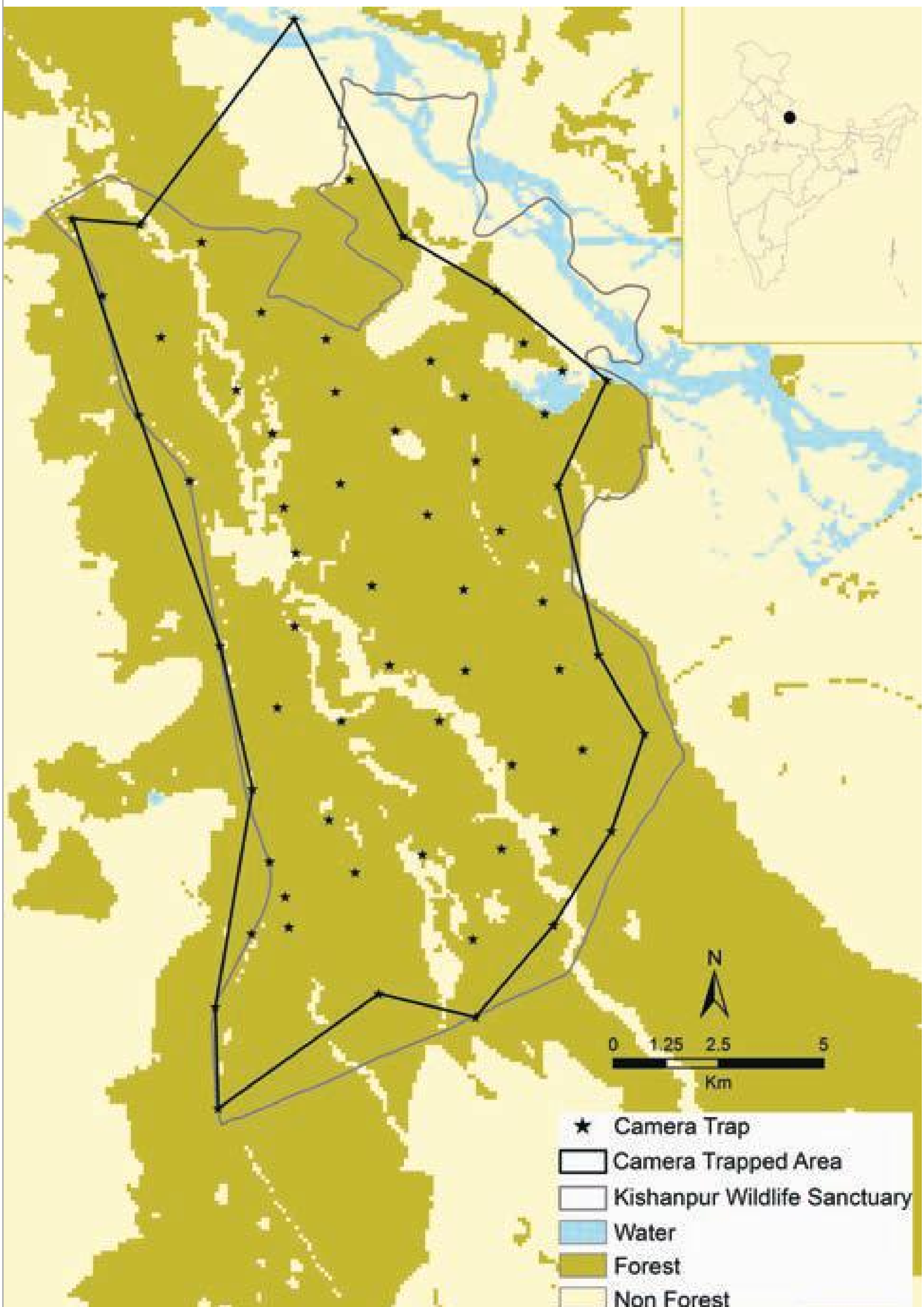


Figure 9.9: Distribution of Camera traps (n = 62) in Kishanpur Wildlife Sanctuary, 2014.



Katarniaghat Wildlife Sactuary (Dudhwa Tiger Reserve) (Uttar Pradesh)

Pranav Chanchani, Ashish Bista, Rekha Warrier, Shweta Nair, Ruchir Sharma, Dabeer Hassan, Mudit Gupta, Rohit Ravi, D Almeida, M., Sher Singh Bisht, Ram Bharose Lal, Palu Chauhan, Kuldeep Singh, Santosh Kumar, Balwinder Singh, Data Ram, Dharminder and Mahesh.
World Wide Fund for Nature, India

Katerniaghat Wildlife Sanctuary (KWLS) is located along the India-Nepal border in Bahraich District of Uttar Pradesh. The Karnali River which flows through Bardia National Park, enters KWLS in its North West corner as the Girwa River, and flows through a portion of the sanctuary, and into a reservoir, that feeds into Ghaghra River. The Khata corridor is a narrow, linear path of riparian forest along the Karnali River in Nepal, and connects Bardia National Park with KWLS, and serves as a conduit for the movement of tigers, elephants and rhinoceros. Other threatened species in KWLS include the gangetic dolphin and gharial, both of which occur in the Girwa River. The forests of KLWS are diverse: riparian areas are dominated by bombax and acacia which grow in grassland areas, and there are extensive tracts of cane as well. The central portions of Katerighat WLS (Nishangara, Murtiah and Dharmapur ranges) are dominated by sal, Terminalia alata and Mallotus phillippiensis, and the forests in these areas have few canopy openings. By contrast, the eastern Ranges of the sanctuary are dominated by teak plantations, and mixed deciduous forests with lower prevalence of sal. About 25 km^2 of the sanctuary, a region referred to as the 'seed farm', comprises of fallow agricultural lands that are now being replaced by grasses, shrubs and weedy species. The seed farm was managed by the central government, and was under agriculture until 2012, when these areas were transferred to the Sanctuary. The seed farm grasslands support high densities of wild and domestic ungulates. Katerniaghat is highly disturbed on account of high levels of cattle grazing across the sanctuary, because there are >13 villages within the forest, with multiple roads and a railway line that bisects the sanctuary. It is home to a number of endangered species including gharial, tiger, rhino, Gangetic dolphin, swamp deer, hispid hare, Bengal florican, white-backed and long-billed vultures.

Sampling details

a) *Camera Trap field survey was carried out in KWLS from 19/11/2012 to 20/2/2013. A total of 111 camera trap stations were set up and sampled simultaneously over 42 occasions accounting for cumulative sampling effort of 3155 trap nights. The minimum bounding polygon (km^2) for KWLS was 384.41 km^2 (Table 9.13) and (Fig. 9.10).*

Variables	Estimates
Minimum Bounding Polygon (km^2)	384.41
Camera Points	111
Trap Nights (effort)	3155
Unique tigers captured	17
Model	$g0(.)\sigma(.)$
$\hat{D}$ ML SECR (SE)(per 100 km^2)	2.53(0.62)
Sigma (SE) (km)	5.36(0.28)
g0 (SE)	0.037(0.004)

Table 9.13: *Sampling details and tiger density parameter estimates using spatially explicit capture mark-recapture analysis using likelihood framework for Katerniaghat Wildlife Sanctuary, 2014*

SE: Standard error

$\hat{D}$ ML SECR: Density estimate from Maximum Likelihood based spatially explicit capture recapture

σ(Sigma): Spatial scale of detection function, ^g0: Magnitude (intercept) of detection function

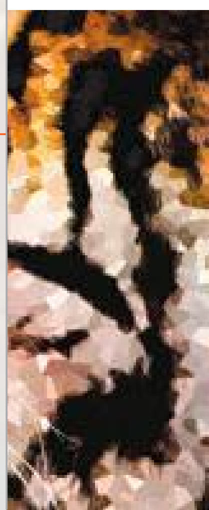
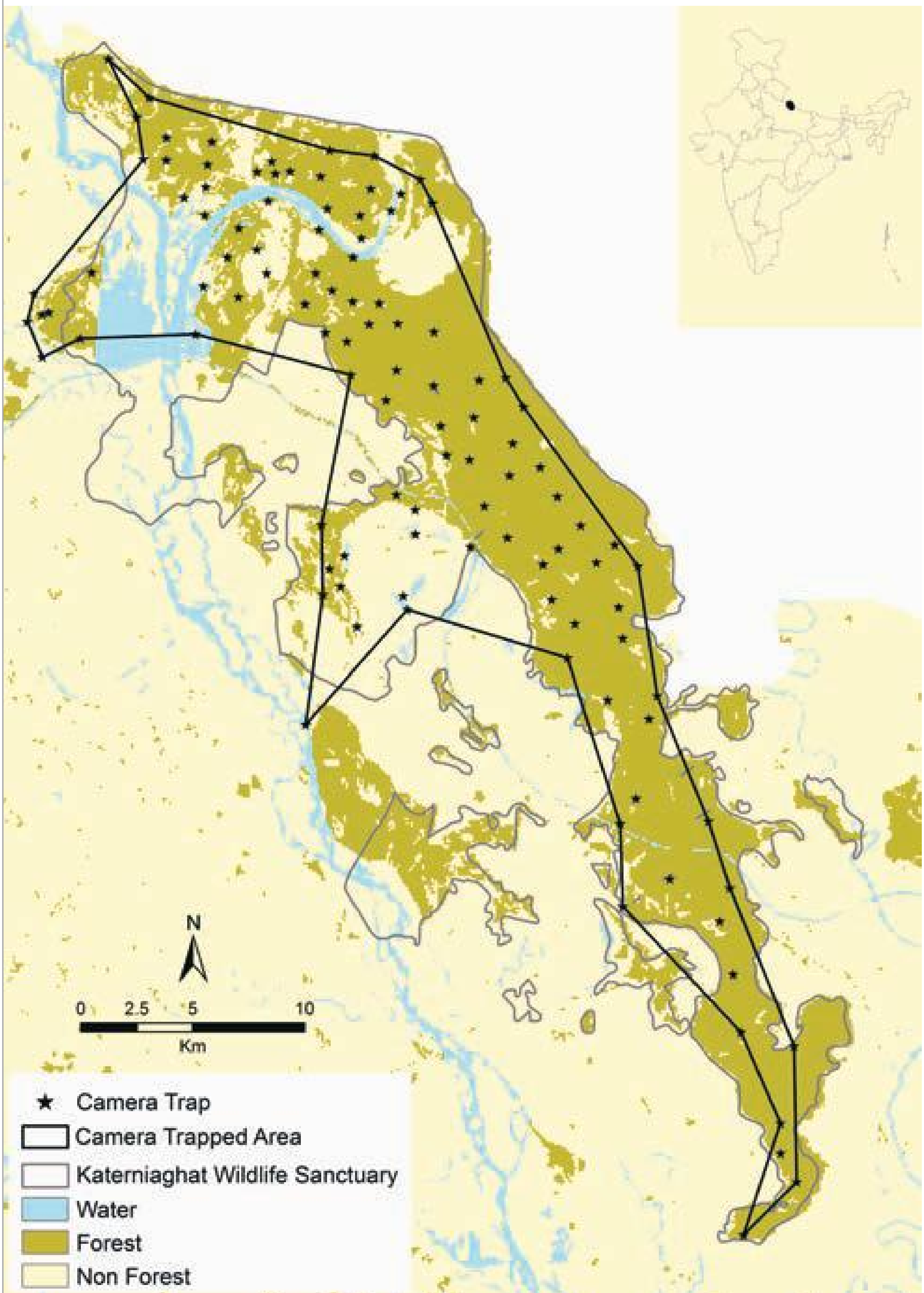


Figure 9.10: Distribution of Camera traps (n=111) in Katerniaghat Wildlife Sanctuary, 2014.



The distribution of tigers and ungulates in KWLS are highly heterogeneous, with higher densities along the Girwa River, and in the seed farm area, and significantly lower densities in Kakraha, Moripur, Dharmapur and Murtiah ranges, which make up > 50% of the sanctuary's total area. Low productivity of the forests is a likely explanation. This low forage value of forest for chital and other grazing herbivore was likely due to a shrub dominated understory, and overgrazing by livestock as well as poaching. Remarkably, a small tiger population has persisted in the Sanctuary, largely because of productive grassland and riparian habitats along the Girwa river and connectivity with other parts of Dudhwa Tiger Reserve. The persistence of tigers in KWLS has also been attributed to the successful restoration and conservation of the Khata corridor that connects with Bardia National Park of Nepal. Key management challenges in KWLS are (1) restoring and protecting highly disturbed tiger habitats in the seed farm, and Kakraha and Motipur ranges of the sanctuary. The seed farm poses a vexing problem, because the ample availability of fallow land has turned the area into a common grazing ground, used by many thousands of cows and buffaloes each day. (2) Intensive protection and habitat management measure that will enhance prey densities in Dharmapur and Murtuah ranges. Grassland patches need to be promoted and suitably managed. (3) Protecting areas around the Khata and Karnali corridors to ensure that their integrity is not compromised. The proposed construction of new roads along the international border, both in India and Nepal, may disrupt this fragile corridor and proper mitigation measures need to be incorporated to ensure wildlife passage ways.

Pilibhit Tiger Reserve (Uttar Pradesh)

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World Wide Fund for Nature, India.

Pilibhit Tiger Reserve located in the Pilibhit District of Uttar Pradesh, extends between 28°47' N - 28° 27' N latitudes and 79° 54' E - 80° 18' E longitudes, covering an area of 1074 km^2. It is connected with the terai-bhabar forests of the Surai range in the Terai East Forest Division in the north-west, and with Kishanpur WLS in the south-east. This reserve also provides connectivity to Shukla Phanta wildlife reserve in Nepal, and with Kishanpur WLS in India, through the Lagga-Bagga forest block, and Tatarganj area of North Kheri Forest Division. The Pilibhit Tiger Reserve was a reserve forest before being declared as tiger reserve. The forest in the reserve mainly consists of Sal as well as some teak. The reserve also has small area of grassland and all these are nurtured by various canals, rivers and a reservoir.

The reserve has rich fauna which includes large and small carnivores like the tiger, leopard, fishing cat, jungle cat and rusty spotted cat, along with large Indian civet, small Indian civet, Asian palm civet, and honey badger. The important herbivores of the reserve include chital, barking deer, sambar, barasingha, hog deer, nilgai, wild pig and four horned antelope.

Sampling Details

a) Camera Trap field survey was carried out in Piliphit Tiger Reserve from 29/4/2014 to 27/6/2014. A total of 175 camera trap stations were set up and sampled simultaneously over 36 occasions accounting for cumulative sampling effort of 4484 trap nights. The minimum bounding polygon for Piliphit Tiger Reserve was 520.33 km^2 (Table 9.14) and (Fig 9.11).

Table 9.14: Sampling details and tiger density parameter estimates using spatially explicit capture mark-recapture analysis using likelihood framework for Pilibhit Tiger Reserve, 2014

Variables	Estimates
Minimum bounding polygon (km^2)	520.33
Camera Points	175
Trap Nights (effort)	4484
Unique tigers captured	23
Model	$g0(.)\sigma(.)$
$\hat{D}$ ML SECR (SE)(per 100 km^2)	2.6(0.55)
Sigma (SE) (km)	4.38(0.33)
g0 (SE)	0.011(0.0017)

SE: Standard error

$\hat{D}$ ML SECR: Density estimate from Maximum Likelihood based spatially explicit capture recapture

σ(Sigma): Spatial scale of detection function, g0: Magnitude (intercept) of detection function

Distance Sampling

Line transects were marked and data recorded according to protocol developed by Jhala et al (2013). All transects were walked 3-4 times in the early morning and late evening hours by two or three trained field biologists. Line transect data was analyzed in program Distance 6.0 (Thomas et al. 2010) to estimate detection probability and density of ungulates. Despite substantial effort, the total numbers of animal detected were low for some of the species. We used only those species having sufficient number of detection for estimating species specific density. Half normal cosine detection model was fitted to the data for density estimation (Table 9.15).

Figure 4.11: Distribution of Camera traps (n = 175) in Pilibhit Tiger Reserve, 2014.

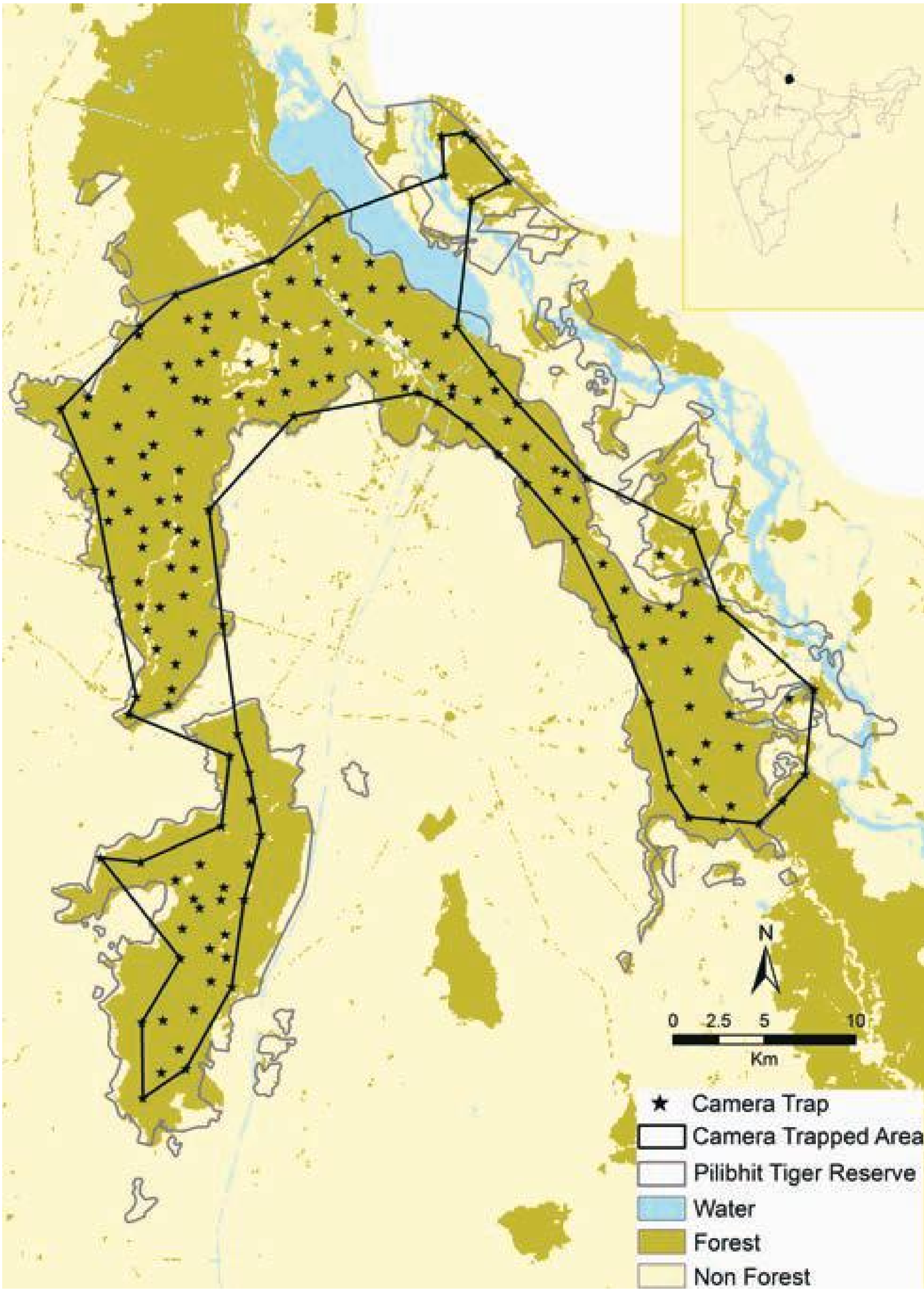


Table 9.15: Model statistics and parameter estimates of line transect (n=46, Total effort 418.6 km) based distance sampling for prey species in Piliphit Tiger Reserve, 2014.

Species	Model	Chi Sq P Value	Effective Strip Width (SE)	No. Groups Detected	Mean Group Size (SE)	Detection Probability (SE)	Encounter Rate (SE) per km	Group Density(SE) per km^2	Individual Density (SE) per km^2
Nilgai	Half normal cosine	0.99	40.93 (3.72)	79	4.82 (0.53)	0.45 (0.04)	0.19 (0.03)	2.37 (0.39)	11.37 (2.40)
Chital	Half normal cosine	0.98	50.85 (2.85)	150	10.33 (1.01)	0.43 (0.02)	0.36 (0.05)	3.54 (0.53)	39.13 (7.19)

Pilibhit has emerged as a prominent site for tigers in the TAL. It is likely Pilibhit's tiger population persists on account of its proximity to other tiger occupied areas, most notably Kishanpur Wildlife Sanctuary. Pilibhit would benefit more by active patrolling along forest edges, and along river and stream courses. Increased management focus and protection in sensitive areas particularly along the Sharada River, in Lalpur, Banganj and Ghunchai blocks (Mala Range), Deoria and in Surai ranges would be beneficial. There should be effort to enhance trans-boundary monitoring, particularly for the Sharda River forests and Lagga Bagga area. For restoring key corridors, it would be imperative to (a) reduce human pressure and cattle grazing in corridor zones; (b) restore forest-cover; (c) engage with agriculturalists to provide safe passage for animals while ensuring human safety (d) engineer wildlife underpasses/ bridges/ flyovers for some highways and canals.

Valmiki Tiger Reserve (Bihar)

Kamlesh K. Maurya, Mudit Gupta and Jimmy Borah.
World Wide Fund for Nature, India

Valmiki Tiger Reserve (VTR) extends between at 27° 13' N - 27° 26' N latitudes and 84° 41' E - 83° 54' E longitudes, with an area of 901 km^2. The only tiger reserve in the state of Bihar, India, VTR is located in the extreme north-eastern corner of the state, along the international border with Nepal in West Champaran district. In the west the reserve is bounded by the Gandak River. It is contiguous with Nepal's Chitwan National Park on the north, sharing a forested boundary of approximately ~100 km. It is also tenuously connected with Sohagibarwa Wildlife Sanctuary in Uttar Pradesh, India.

The topography of VTR is characterized by bouldary hills and doon valleys, drained by numerous rivers and streams which gradually merge with flat alluvial plains in the south. These rivers and streams are the major sources of water. It represents one of the last patches of forests having a unique combination of the terai-bhabar vegetation, which harbours rich fauna of several endemic and globally endangered species such as tiger and greater one-horned rhinoceros. The Asian elephant infrequently migrates from Chitwan National Park, Nepal. The forest of VTR is home to of other felids, canids, ursids, viverrids, such as leopard, fishing cat, jungle cat, leopard cat, Indian fox, dhole, sloth bear, and large Indian civet. The important prey species of the reserve include spotted deer, sambar, hog deer, nilgai, wild pig, and gaur.

Sampling details

a) Camera Trap field survey was carried out in Valmiki Tiger Reserve by the forest department with technical assistance from WWF. The survey was done in four Blocks. The sampling started from 8/2/2013 to 14/6/2013 total of 270 camera trap stations were set up and sampled over 119 occasions for all the Blocks accounting for cumulative sampling effort of 6384 trap nights. The minimum bounding polygon for Valmiki Tiger Reserve was 912.09 km^2 (Table 9.16) and (Fig. 9.12).

b) Line transect surveys were carried out in Valmiki Tiger Reserve between February - June 2014. The surveys were conducted along 116 line transects (Fig. 9.12). Each transect was walked in the morning and evening with 4-6 temporal replicates which resulted in a total walk effort of 2191 km (Table 9.17).

Variables	Estimates
Minimum bounding polygon (km^2)	912.09
Camera Points	270
Trap Nights (effort)	6384
Unique tigers captured	23
Model	g0(.)σ(.)
$\hat{D}$ ML SECR (SE)(per 100 km^2)	1.49(0.32)
Sigma (SE) (km)	5.46(0.27)
g0 (SE)	0.021(0.002)

Table 9.16: Sampling details and tiger density parameter estimates using spatially explicit capture mark-recapture analysis using likelihood framework for Valmiki Tiger Reserve, 2013

SE: Standard error

$\hat{D}$ ML SECR: Density estimate from Maximum Likelihood based spatially explicit capture recapture

σ(Sigma): Spatial scale of detection function, g0: Magnitude (intercept) of detection function

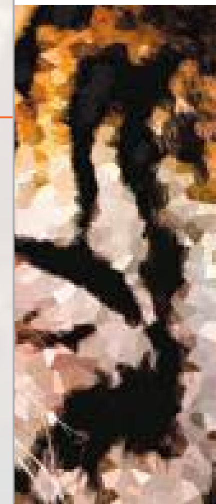


Figure 9.12: Distribution of Camera traps (n=270) and line transects (n=116) in Valmiki Tiger Reserve, 2013.

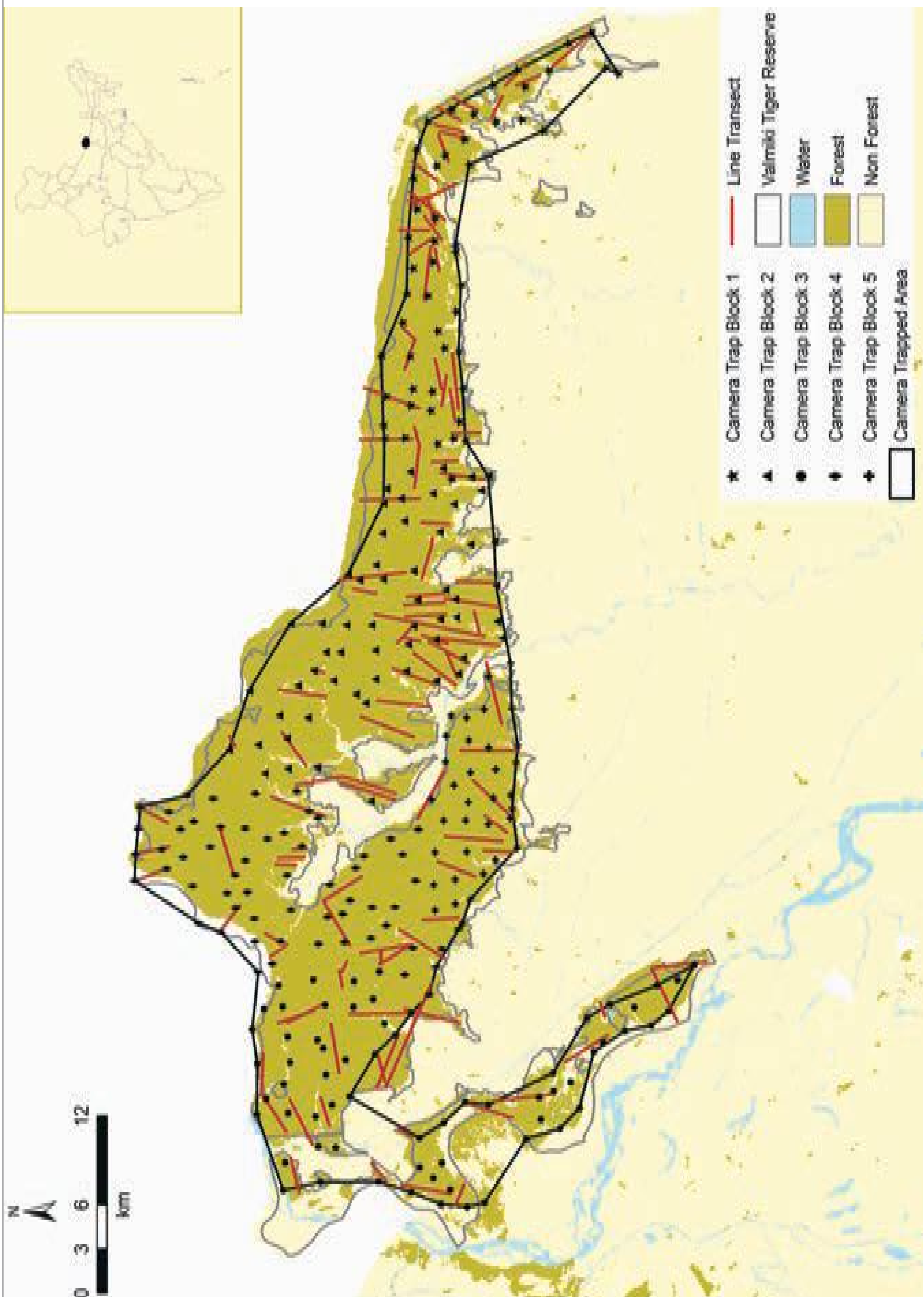


Table 9.17: Model statistics and parameter estimates of line transect (n=116, Total effort 2191 km) based distance sampling for prey species in Valmiki Tiger Reserve, 2014.

Species	Model	Chi Sq P Value	Effective Strip Width (SE)	No. Groups Detected	Mean Group size (SE)	Detection Probability (SE)	Encounter Rate (SE) per km	Group Density (SE) per km^2	Individual Density (SE) per km^2
Chital	Half normal cosine	0.47	45.33 (5.04)	204	4.98 (0.28)	0.37 (0.04)	0.075 (0.54)	0.83 (0.10)	3.98 (0.53)
Nilgai	Half normal cosine	0.67	50.35 (7.94)	126	4.39 (0.35)	0.54 (0.08)	0.10 (0.015)	1.009 (0.22)	4.43 (1.05)
Barking Deer	Half normal cosine	0.87	42.86 (4.45)	224	1.25 (0.04)	0.42 (0.04)	0.08 (0.002)	0.93 (0.102)	1.14 (0.12)
Sambar	Half normal cosine	0.81	43.55 (5.95)	159	1.87 (0.09)	0.54 (0.07)	0.07 (0.003)	0.83 (0.12)	1.55 (0.23)
Wild pig	Half normal cosine	0.93	41.23 (5.74)	131	4.22 (0.27)	0.41 (0.05)	0.06 (0.003)	0.78 (0.11)	2.80 (0.46)

Central India & Eastern Ghats Landscape

Sariska Tiger Reserve (Rajasthan)

Dibyadeep Chatterjee, Dibyendu Mondal, K. Sankar, Qamar Qureshi.
Wildlife Institute of India

Sariska Tiger Reserve (STR) is situated in the Aravalli hills in Alwar district of Rajasthan, and extends between 76°20' E to 76°32' E longitudes and 27° 15' N to 27° 24' N latitudes (Joshi et al., 2011).The total area of the tiger reserve is 881 km^2. The Alwar-Thanaghazi-Jaipur state highway passes through the reserve and 2000 vehicles ply on it every day, disturbing wildlife to a great extent (Johnsingh et al., 1997). Another state highway that passes through the reserve Sariska-Kalighati-Pandupol road which is 20 km in length (Sankar, 1994). Currently there are 29 villages within the tiger reserve of which nine are located in the National Park area (Sankar et al. 2010). In 1966-67, Guwadas, Kalighati and Slopka were relocated. In 1976-77, village Karnakawas was relocated. Village Bhagani, Umri and Rotkela were relocated in the year 2007, 2012 and 2013 respectively.

In 2004, tigers were poached to extinction in Sariska Tiger Reserve . Between July 2008 and January 2013, eight tigers (five females and three males) were reintroduced in Sariska from Ranthambhore. The present population of tigers in STR is 13, which includes nine adults, and four full grown cubs (>12 months).

The vegetation of this region is tropical dry deciduous forest and tropical thorn forest (Champion & Seth, 1968). Anogeissus pendula is the dominant tree species covering over 40 per cent area of the forest (Sankar 1994). While some valleys support Butea monosperma and Zizyphus mauritiana, Dendrocalamus strictus is extremely limited in distribution and is found only along well drained reaches of the streams and moist cooler parts of the hills. The wild ungulates found in Sariska are chital, sambar, nilgai and wild pig. Apart from tiger, other carnivores present are leopard, striped hyena, golden jackal, jungle cat and desert cat. Caracal was also reported in the recent past. In winter (commences in November), the temperature drops to 3^0 C. From mid March till the end of June, Sariska experiences summer, followed by a rainy season in July and August. STR receives an average rainfall of 650mm (Sankar, 1954).

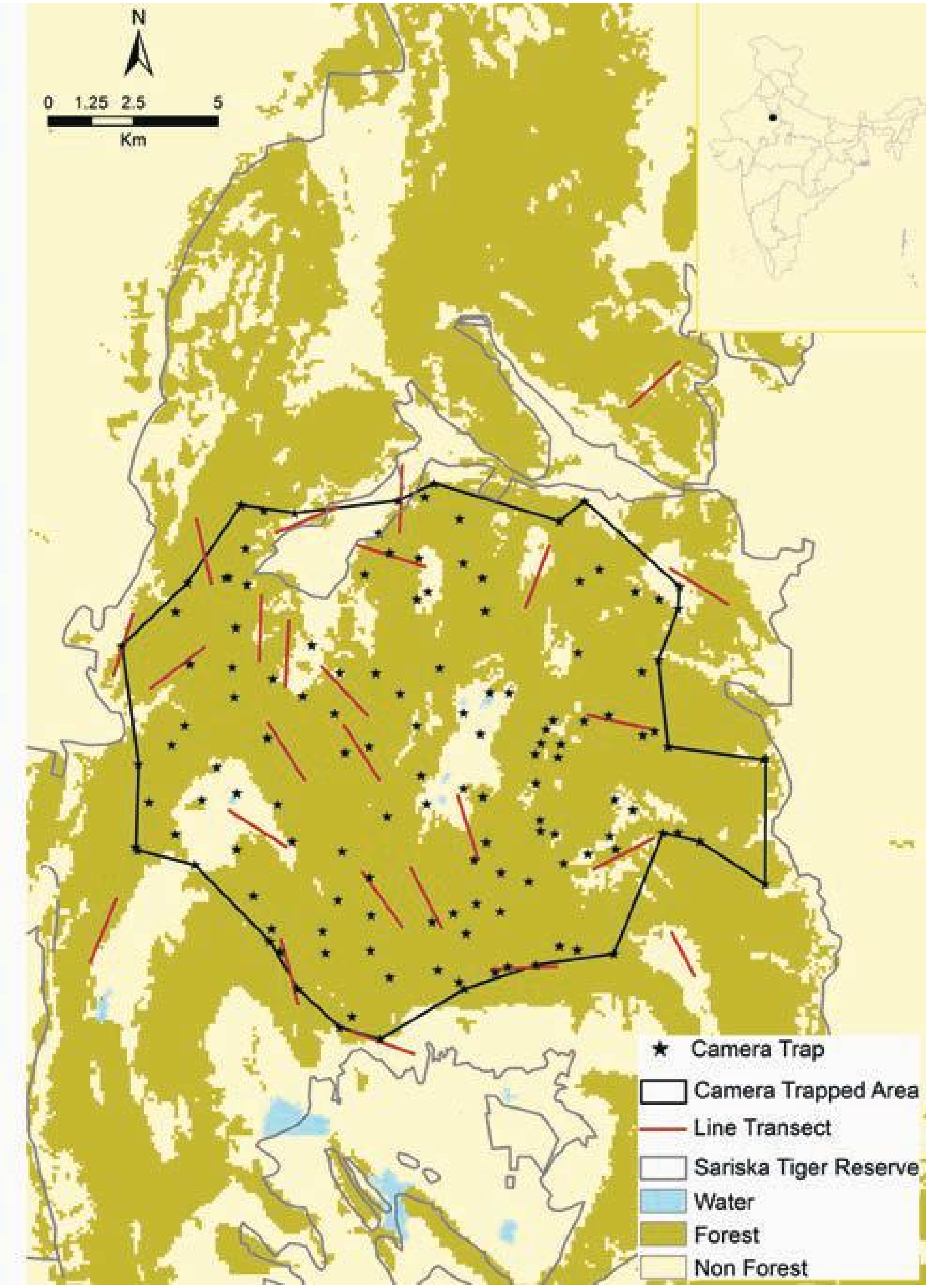
Sampling Details

a) Camera traps were deployed in two blocks consisting of 61 and 78 detectors respectively and sampled for a total of 50 days (Fig 9.13). The sampling period was from 18th Feb 2014 to 20th April 2014, covering an area of 208.42 km^2 (minimum bounding polygon) (Table 9.18).

b) A total of 24 line transects were surveyed thrice (Fig 9.13), yielding a walk effort of 144.3 km (Table 9.19)

c) Sign surveys were conducted in all 25 beats, comprising 3 walks of 5 km each. The total walk effort was 375 km.

Figure 9.13: Location of camera traps (n=139) and line transects (n=25) in Sariska Tiger Reserve, 2014.



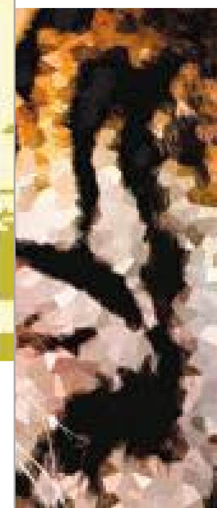


Table 9.18: Sampling details and parameter estimates of tiger from camera trap based capture mark-recapture analysis in Sariska Tiger Reserve, 2014.

Variables	Estimates (SE)
Minimum bounding polygon (km^2)	208.42
Camera Points	139
Trap Nights (effort)	2284
Unique tigers captured (Mt+1)	7
Model	$g0(.)\sigma(.)$
$\hat{D}$ ML SECR (SE)(per 100 km^2)	1.65 (0.65)
Sigma (SE) (km)	2.7 (0.23)
g0 (SE)	0.03 (0.01)

SE: Standard error

$\hat{D}$ ML SECR: Density estimate from Maximum Likelihood based spatially explicit capture recapture

σ(Sigma): Spatial scale of detection function, g0: Magnitude (intercept) of detection function

Table 9.19: Model statistics and parameter estimates of line transect (n=24, Total effort 144.3 km) based distance sampling for prey species in Sariska Tiger Reserve, 2014.

Species	Model	Chi Sq P value	Effective Strip Width (SE)	No. Groups Detected	Mean Group size (SE)	Detection Probability (SE)	Encounter Rate per km	Group Density (SE) per km^2	Individual Density (SE) per km^2
Nilgai	Half normal cosine	0.88	26.59 (3.72)	47	2.53 (0.29)	0.59 (0.08)	0.32	6.12 (1.63)	15.5 (4.49)
Chital	Half normal cosine	0.98	32.95 (5.51)	33	5.45 (0.96)	0.73 (0.12)	0.22	3.46 (1.32)	18.92 (7.9)
Wild pig	Half normal cosine	0.19	34.02 (5.06)	17	4.5 (0.84)	0.42 (0.06)	0.11	1.73 (0.97)	7.94 (4.65)
Sambar	Half normal cosine	0.95	24.49 (3.72)	33	2.96 (0.36)	0.54 (0.08)	0.22	4.66 (1.44)	13.86 (4.58)

Keladevi Wildlife Sanctuary (Rajasthan)

Sailaja Nayak, Sunny Shah, Jimmy Borah, Deepankar Nirmal, Mahipal Singh Hada, Narayan Singh, Rajulal Gurjar.
World Wide Fund for Nature, India

Keladevi WLS (KWLS) is the northern extension of the Ranthambore National Park. The sanctuary is located in the Karauli district of Rajasthan and is made up of the erstwhile Karauli and Sapotra blocks. It is spread over a total area of 674 km^2, within the longitudes 76°37' E - 77°13' E and latitude 26°2' N - 26°21' N. KWLS is bound on the west by the river Banas and on the south by the river Chambal. The forest area that comprises the sanctuary is home to several pastoral and agricultural communities who are dependent substantially on its resources for their livelihood.

The vegetation type is of the dry deciduous type with a predominance of Anogiesus pendula, locally known as dhok and Zizyphus scrubland. The terrain is characterised by some valleys and river gorges, locally referred to as khos. Due to higher moisture retention and cooler temperatures, these khos are considered very suitable habitats for wildlife and nurture a wide variety of flora and fauna. The fauna commonly reported from this area includes nilgai, sambar, chital, chinkara, leopard, striped hyena, wolves, sloth bears, golden jackal, ratel, jungle cat, and porcupine, among a host of other species. Transient tigers from Ranthambhore have occasionally been reported at Keladevi. Relocation strategies for the villages inside KWLS should be revised and improvised so that more space is available for wildlife. Flattening of ravines in the Banas and Chambal river and their tributaries for expanding agriculture is causing loss of habitat connectivity in the landscape. Rigorous patrolling, monitoring, law enforcement and involvement of local stake holders for the alternative livelihoods is the need of the hour.

Sampling details

a) Camera traps were deployed opportunistically at a few selected sites, since it was not possible to deploy the traps in a capture-mark-recapture framework due to intense anthropogenic pressures. The cameras were installed in the evening and taken out in the morning to minimise theft (Fig. 9.14). Thirteen camera trap locations in three blocks were operated for 33 days between 12th October and 18th November 2014.

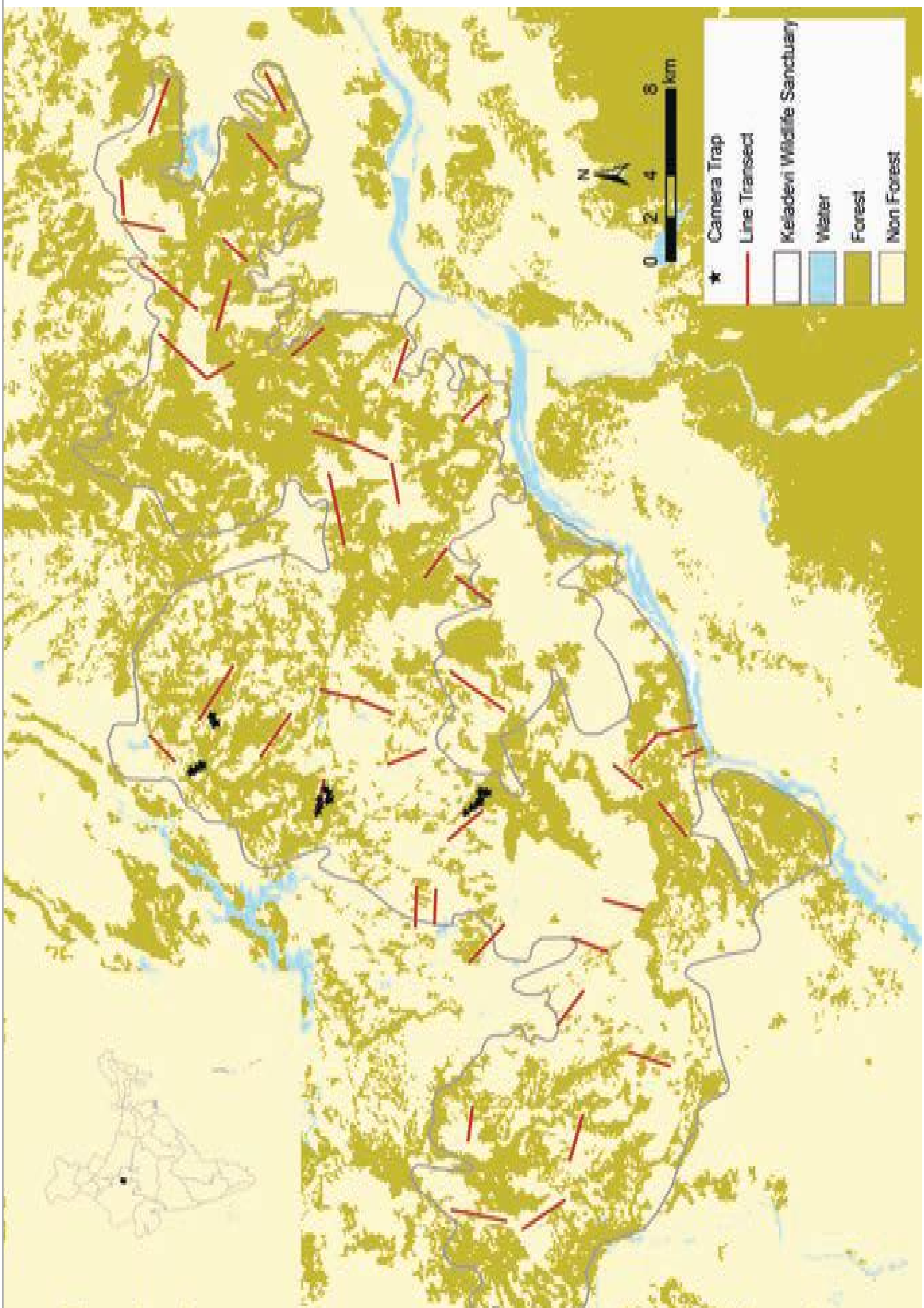
b) Number of spatial transects were 38 with 2 temporal replicates and a walk effort of 204.4 km (Fig. 9.14). Transects were walked between 6AM and 8AM from 14th to 20th November, 2014. Sufficient detections of wild ungulates could not be obtained for estimating their density in program DISTANCE (Table 9.20)

A sub adult tiger (T-71) was photo-captured in Gadhigaonkho, Karanpur range of Keladevi WLS on 20th November late evening which dispersed from Khandar range of Ranthambhore National Park. Two leopard individuals were identified in the sampled area. Abundance for tiger and leopard was not estimated due to small sample size.

Table 9.20: Model statistics and parameter estimates of line transect (n=38, total effort of 204.4 km) based distance sampling for prey species in Keladevi Wildlife Sanctuary, 2014.

Species	Model	Chi Sq P value	Effective Strip Width (SE)	No. Groups Detected	Mean Group size (SE)	Detection Probability (SE)	Encounter Rate per Km	Group Density (SE) per km^2	Individual Density (SE) per km^2
Nilgai	Uniform Cosine	0.47	31.32 (6.48)	24	2.88 (1.08)	0.61 (0.13)	0.03	0.55 (0.24)	1.59 (0.9)
Chinkara	NA	NA	NA	2	NA	NA	0.01	NA	NA

Figure 9.14: Distribution of Camera traps (n=13) and line transects (n=38) in Keladevi Wildlife Sanctuary, 2014.



Ranthambhore Tiger Reserve (Rajasthan)

Ayan Sadhu, Deepti Gupta, Kainat Latafat, Nikunj Jambu, Sumi George, Y.V. Jhala, Qamar Qureshi.
Wildlife Institute of India

The Ranthambhore Tiger Reserve (RTR) includes Ranthambhore National Park (RNP), Sawai Man Singh Sanctuary (SWM) and Keladevi Wildlife Sanctuary (KWLS). It consists of a core area of about 1113.36 km^2 with a buffer zone of about 297.92 km^2, totalling 1411.28 km^2. The Reserve is located between the latitudes of $25^0$41' N - 26^0 22' N and longitudes of $76^0$16' E - $77^0$14' E. RTR is located at the junction of the Aravallis and Vindhya ranges (great boundary fault). The terrain of the reserve is varying, from highly undulating to flat valleys, with the dominant terrain being hills with steep slopes. The protected area is at an altitude of 244 m to 507 m above mean sea level, with the predominant climate being Sub-tropical dry type. Several water bodies located in the park provide relief during extreme heat in summer for forest inhabitants.

The forest is mainly an edaphic climax and belongs to the subgroup 5B-Northern Tropical Dry Deciduous Forests and subgroup 6B-DS1-Ziziphus shrub (Champion and Seth 1968). The area is representative of dry deciduous Anogeissus pendula forests sub type in association with Acacia, Butea, Capparis, Zizyphus and Prosopis species.

The Reserve's heterogeneous habitat supports about 32 species of mammals, 300 species of birds (both resident and migratory), 12 species of reptiles and a few amphibians. The predator guild consists of seven felid species: tiger, leopard, caracal, fishing cat, jungle cat, desert cat and rusty spotted cat, and golden jackal, striped hyaena, sloth bear, and ratel. Rodents such as the Indian gerbil, and Indian Bush rat are common in the reserve. Black naped hare and five-striped palm squirrel are also found in the reserve (Jhala et al. 2014).

Sampling details

a) Camera trap survey was carried out from 30th April to 20th June 2014. A total of 359 camera traps covering an area of 349.27 km2 (Fig. 9.15) resulted in a sampling effort of 8159 trap nights (Table 9.21).

b) Line transect (n= 95) for prey were walked during February-April 2014 (Fig. 9.15). Each transect was walked once in the morning between 0600 to 0800 hours, yielding an effort of 190.38 km (Table 9.22). At every 400m of each line transect, plots were laid to assess human disturbance, vegetation, and dung counts.

c) Carnivore sign survey was carried out during February-April 2014 in 76 beats comprising of 15 km walk in each beat (total effort: 375 km).

Variables	Estimates (SE)
Minimum bounding polygon (km^2)	349.27
Camera Points	359
Trapping effort (days)	8159
Unique tigers captured	39
Model	g0(.) σ(.)
$\hat{D}$ ML SECR (SE)(per 100km^2)	6.4 (1.03)
Sigma (SE) (km)	1.72 (0.05)
g0(SE)	0.05 (0.003)

Table 9.21: Sampling details and parameter estimates of tiger from camera trap based capture mark-recapture analysis in Ranthambhore Tiger Reserve, 2014.

SE: Standard error

$\hat{D}$ ML SECR: Density estimate from Maximum Likelihood based spatially explicit capture recapture

σ(Sigma): Spatial scale of detection function, g0: Magnitude (intercept) of detection function

Figure 9.15: Distribution of camera traps (n=359) and line transects (n=95) in Ranthambhore Tiger Reserve, 2014.

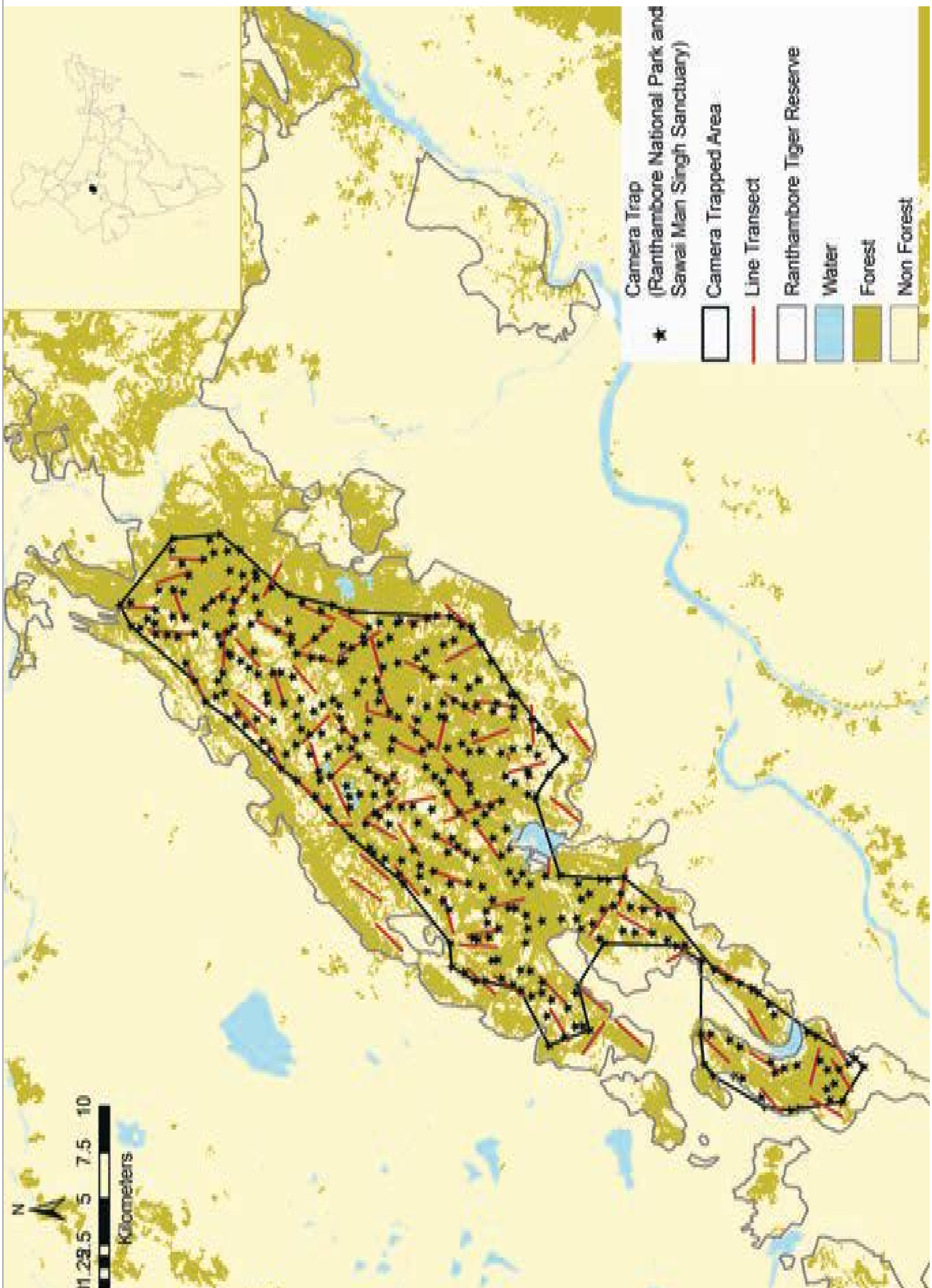


Table 9.22: Model statistics and parameter estimates of line transect (n=95, total effort of 190.38 km) based distance sampling for prey species in Ranthambhore Tiger Reserve, 2014.

Species	Model	Chi Sq P value	Effective Strip Width (SE)	No. Groups Detected	Mean Group size (SE)	Detection Probability (SE)	Encounter Rate per km	Group Density (SE) per km^2	Individual Density (SE) per km^2
Chital	Half normal cosine	0.83	62.45 (4.03)	141	7.15 (0.59)	0.45 (0.03)	0.74	5.93 (0.97)	33.80 (6.52)
Sambar	Half normal cosine	0.71	50.67 (3.50)	111	4.62 (0.40)	0.42 (0.03)	0.58	5.75 (0.87)	25.67 (4.56)
Nilgai	Hazard rate cosine	0.52	66.95 (7.59)	42	3.31 (0.46)	0.42 (0.05)	0.22	1.65 (0.35)	5.45 (1.39)
Langur	Hazard rate cosine	0.95	23 (5.15)	29	12.55 (1.83)	0.2 (0.062)	0.15	3.31 (0.99)	41.56 (13.79)
Wildpig	NA	NA	NA	10	NA	NA	0.05	NA	NA

Mukundara Hills Tiger Reserve (Rajasthan)

Ayan Sadhu, Bhaskar Bora, Dimpi Patel, Kainat Latafat, Shravana Goswami, Subrata Gayen, Y.V. Jhala, Qamar Qureshi.
Wildlife Institute of India

Mukundara Hills Tiger Reserve (MHTR) covers an area of 759 km^2, with a core and buffer area of 417 km^2 and 342.82 km^2 respectively. It is spread across four districts of Rajasthan: Kota, Bundi, Chittorgarh and Jhalawar. It was formerly known as Mukundara Hills National Park and was declared as a tiger reserve in the year 2012. The Mukundara Hills Tiger Reserve currently does not have tigers but serves as a natural extension to the Ranthambhore Tiger Reserve within the larger landscape to accommodate dispersing large carnivores from Ranthambhore. The tiger reserve has connections with other protected areas within the state, namely Ranthambore, Ramgadhvishdhari and Bhainsaroghar. Further, it is also connected to the Gandhi Sagar sanctuary in Madhya Pradesh.

MHTR is a dry deciduous forest (Champion and Seth 1968) and is dominated by Anogeissus pendula, A. latifolia, Acacia catechu, Zizyphus mauratiana, Flacouritia indica, and Acacia leucofloea. A large number of medicinal plants are also found here. The mammalian fauna includes leopard, Indian wolf, sloth bear, hyena, jungle cat, Indian fox, desert cat, ratel, chital, sambar, nilgai and chinkara. Pangolin was also photo-captured during camera trap sampling.

Sampling Details

a) Camera trapping was carried out in two blocks (Fig 9.16). In block 1, a total of 33 camera trap stations were operated for 10 days (from 21st November 2014 to 30th November 2014) and in block 2, a total of 73 camera stations were operated for 11 days (from 7th December 2014 to 17th December 2014). Total trapping effort was of 1771 trap nights. Camera traps were operated only at night due to logistic constraints of cameras being stolen during the day (Table. 9.23).

b) Line transect surveys were carried out in MHTR between 10th November 2014 to 18th December 2014 (Fig. 9.21). Total 36 random lines each of two kilometers were walked once in the morning hours (0600 to 0800 hours) with total effort of 72km (Table 9.24).

Table 9.23: Sampling details and parameter estimates of leopard from camera trap based capture mark-recapture analysis in Mukundara Hills Tiger Reserve, 2014.

Variables	Estimates (SE)
Minimum bounding polygon (km^2)	58.94
Camera Points	106
Trap Nights (effort)	1771
Unique Leopards captured	16
Model name	g0(.)σ(.)
$\hat{D}$ ML SECR (per 100 km^2)	11.22 (3.14)
Sigma (SE) (km)	1.21 (0.16)
g0 (SE)	0.03 (0.009)

SE: Standard error

$\hat{D}$ ML SECR: Density estimate from Maximum Likelihood based spatially explicit capture recapture

σ(Sigma): Spatial scale of detection function, g0: Magnitude (intercept) of detection function

Figure 9.16: Distribution of camera traps (n=106) and line transect (n=36) in Mukundara Tiger Reserve, 2014.

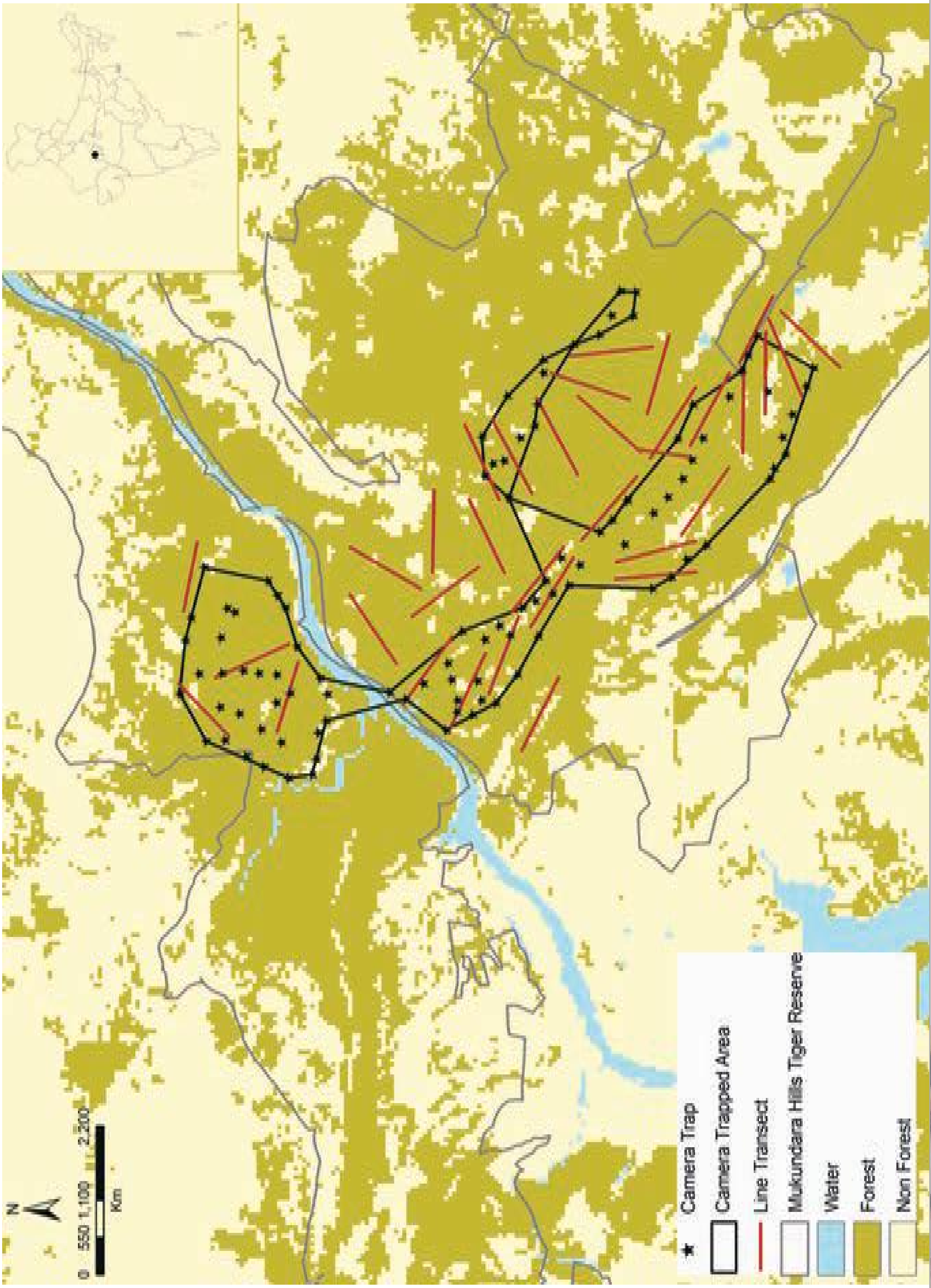


Table 9.24: Model statistics and parameter estimates of line transect (n=36, total effort of 72 km) based distance sampling for prey species in Mukundara Hills Tiger Reserve, 2014.

Species	Model	Chi Sq P value	Effective Strip Width (SE)	No. Groups Detected	Mean Group size (SE)	Detection Probability (SE)	Encounter Rate per Km	Group Density (SE) per km²	Individual Density (SE) per km²
Nilgai	Half normal Cosine	0.99	51.76 (10.77)	22	3.2 (0.56)	0.88 (0.18)	0.24	2.84 (0.91)	9.12 (3.35)
Chital	NA	NA	NA	8	NA	NA	0.11	NA	NA
Chinkara	NA	NA	NA	11	NA	NA	0.15	NA	NA
Sambar	NA	NA	NA	3	NA	NA	0.05	NA	NA
Wild pig	NA	NA	NA	1	NA	NA	0.01	NA	NA

The area has high biotic pressure which needs to be reduced for wildlife populations to build up and subsequently be able to support tigers. The tiger reserve should be managed in the context of being part of the Ranthambore metapolulation; therefore habitat connectivity with the source population and neighbouring reserves is of vital importance.

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Ramgarh Vishdhari Wildlife Sanctuary (Rajasthan)

Jimmy Borah. Sailaja Nayak, Sunny Shah, Deepankar Nirmal, Mahipal Singh Hada,
Narayan Singh, Raju Lal Gurjar. World Wide Fund for Nature, India

Ramgarh Vishdhari Wildlife Sanctuary (RVWLS) is a single, compact and large (307 km^2) forest patch in Hadoti region of Rajasthan. RVWLS lies in the south-eastern part of Rajasthan between 24° 59' N and 25° 53' N latitudes and 75° 19' E to 76° 49' E longitudes. Prior to the formation of the state of Rajasthan, these forests were a part of the erstwhile Bundi princely state and were managed as a hunting reserve. The major tree species found are Prosopis juliflora and Anogeissus pendula. The large prey and carnivore species found in the sanctuary are sambar, chital, nilgai, wild pig, rhesus macaque, leopard, sloth bear, and hyaena. It is an important sanctuary and also a crucial corridor between Ranthambhore and Mukundra Hills Tiger Reserve. However, there is immense anthropogenic pressure inside the area. Improved protection and improving prey abundance is the need of the hour in the sanctuary. Once these two aspects are addressed, the sanctuary may recuperate into suitable tiger habitat.

Sampling details

a) Fifty camera traps were deployed in four blocks for a period of 44 days between 29th March and 15th June 2014 (Fig. 9.17). The total effort was 2050 trap nights, with the minimum bounding polygon being 90.79 km^2 (Table 9.25).

b) There were 23 line transects which were walked thrice resulting into 141 km of walk effort (Fig. 9.17). The timing of walks was between 06:00 AM to 08:30 AM and 03:30 PM to 05:30 PM. The period of sampling was from 15th April, 2014 to 28th June, 2014 (Table 9.26).

Table 9.25: Sampling details of camera trap sampling in Ramgarh Visdhari Wildlife Sanctuary, 2014.

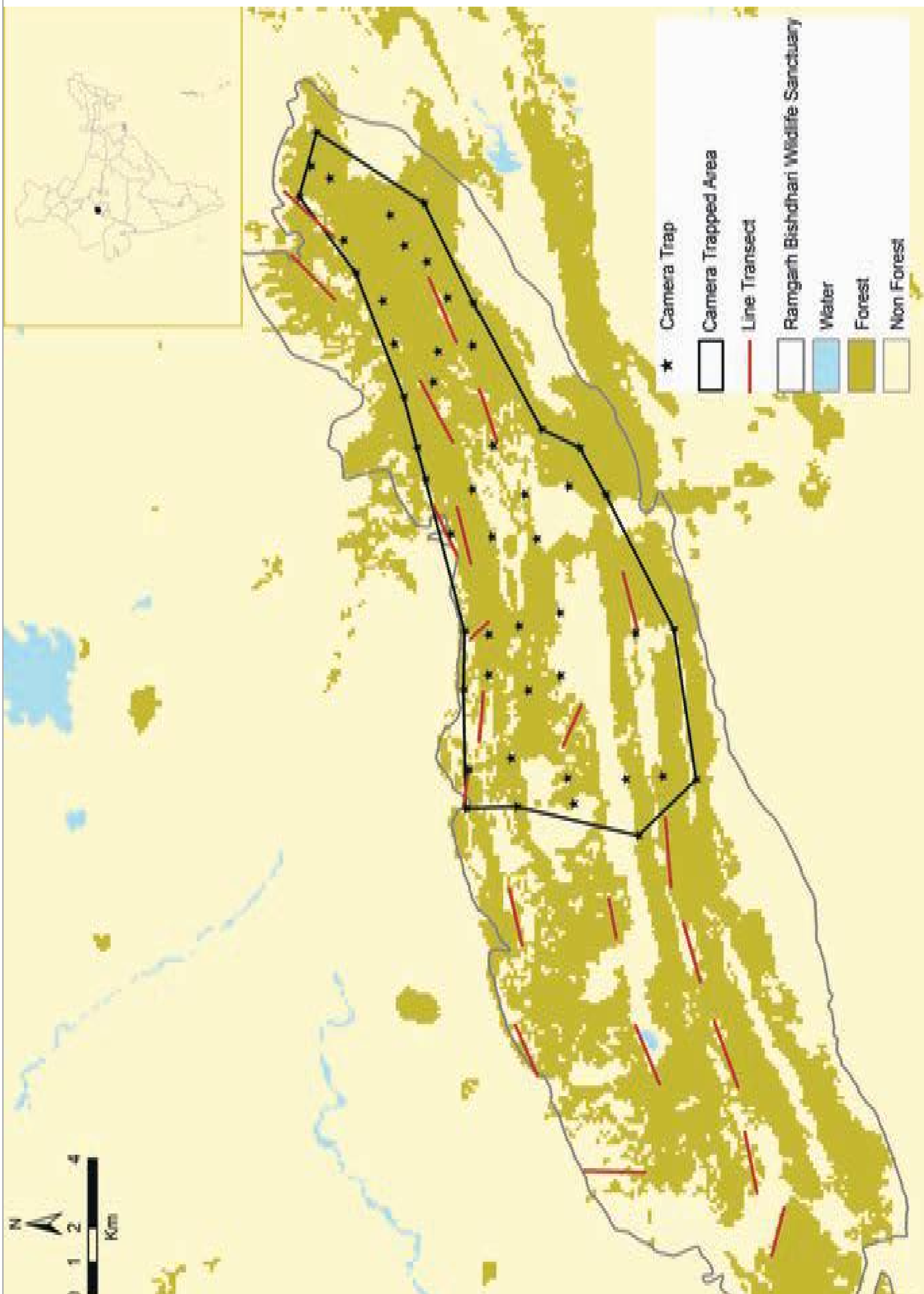
Variables	Estimates (SE)
Minimum bounding polygon (km^2)	90.79
Camera Points	50
Trap Nights (effort)	2050
Unique tigers captured	1
Unique leopards captured	7

Table 9.26: Model statistics and parameter estimates of line transect (n=23, total effort of 141 km) based distance sampling for prey species in Ramgarh Visdhari Wildlife Sanctuary, 2014.

Species	Model	Chi Sq P value	Effective Strip Width (SE)	No. Groups Detected	Mean Group size (SE)	Detection Probability (SE)	Encounter Rate per Km	Group Density (SE) per km^2	Individual Density (SE) per km^2
Nilgai	Half normal Cosine	0.57	13.55 (2.17)	35	2.23 (0.22)	0.34 (0.05)	0.81	29.88 (8.91)	66.58 (20.96)
Sambar	NA	NA	NA	1	NA	NA	0.007	NA	NA

Ramgarh can act as a stepping stone corridor between Ranthambhore and Mukundara, hence it's crucial to improve the level of protection as well as secure a sufficient prey base. Apart from destruction of forested habitat due to developmental activities, (e.g. mining, construction, etc.), poaching, grazing and wood cutting consist severe threat to the wildlife of Ramgarh.

Figure 9.17: Distribution of camera traps (n=50) and line transect (n=23) in Ramgarh Visdhari Wildlife Sanctuary, 2014.



Kuno Wildlife Sanctuary (Madhya Pradesh)

Bipin C.M., Nilesh Abaso Patil, J. Charles Leo Prabu, Urvashi Sharma, Parabita Basu, Qamar Qureshi, Y. V. Jhala.
Wildlife Institute of India.

Kuno Wildlife Sanctuary is situated in Sheopur district of Madhya Pradesh. The sanctuary lies between 25°30'-25°53' N latitudes and 77°07'-77°26' E longitudes and spread over an area of 344.68 km². The sanctuary is part of the Kuno wildlife division which covers an area of 1235.39 km². The division comprises of eight ranges, with Palpur east and Palpur west ranges forming the Sanctuary. The six ranges in the buffer area are Moravan east and west, Sironi north and south, Agara east and west. The area is classified as Semi-arid zone (4b), Gujarat- Rajputana biogeographic region (Rodgers et al. 2002). The elevation ranges from 238m to 498m above Mean Sea level. The south-eastern portion of this landscape is patchily connected to Madhav National Park and on to Panna Tiger reserve, through Shivpuri forest area. On the north-western side, this forest region is contiguous with Ranthambore Tiger Reserve, across the river Chambal.

The forest types found in this region are: Northern tropical dry deciduous forest, Southern tropical dry deciduous forest, Anogeissus pendula forest & scrub, Boswellia forest, Butea forest, Dry savannah forest & grassland, Tropical riverine forest. Commonly found weeds in this area include Cassia tora and Argemone mexicana (Champion & Seth 1968).

The major herbivores found in this area are chital, sambar, nilgai, wild pig, chinkara, blackbuck and common langur. Carnivores include leopard, sloth bear, striped hyeana, grey wolf, golden jackal, Indian fox, and ratel. One male tiger which dispersed from Ranthambore Tiger Reserve is seen moving in and around the Sanctuary since December 2010.

Sampling details

a) Camera trapping was done in June and July 2014. A total of 117 camera stations were sampled simultaneously over 32 sampling occasions (Fig. 9.18). The total sampling effort was 2438 days. The camera trap area for Kuno Wildlife Division was 103.35 km² (Table 9.27).

b) A total of 77 line transects were sampled (51 line transects in the Sanctuary and 26 line transects in the buffer zone (Fig. 9.18). On every walk, prey species observed along with their group sizes was recorded. The total sampling effort was 298.65 km (Table 9.28).

Table 9.27: Sampling details and parameter estimates of leopard from camera trap based capture mark-recapture analysis in Kuno Wildlife Sanctuary, 2014.

Variables	Estimates (SE)
Minimum bounding polygon (km²)	103.35
Camera Points	117
Trap Nights (effort)	2438
Unique leopards captured	25
Model	g0(.)σ(.)
$\hat{D}$ SECR (per 100 km²)	9.12 (1.92)
Sigma (SE) (km)	1.83 (0.13)
g0 (SE)	0.03 (0.004)

SE: Standard error

$\hat{D}$ ML SECR: Density estimate from Maximum Likelihood based spatially explicit capture recapture

σ(Sigma): Spatial scale of detection function, g0: Magnitude (intercept) of detection function

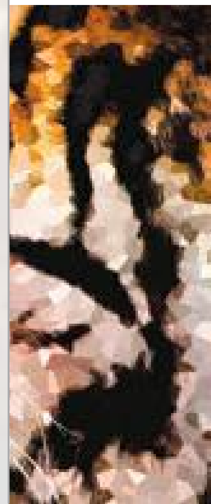
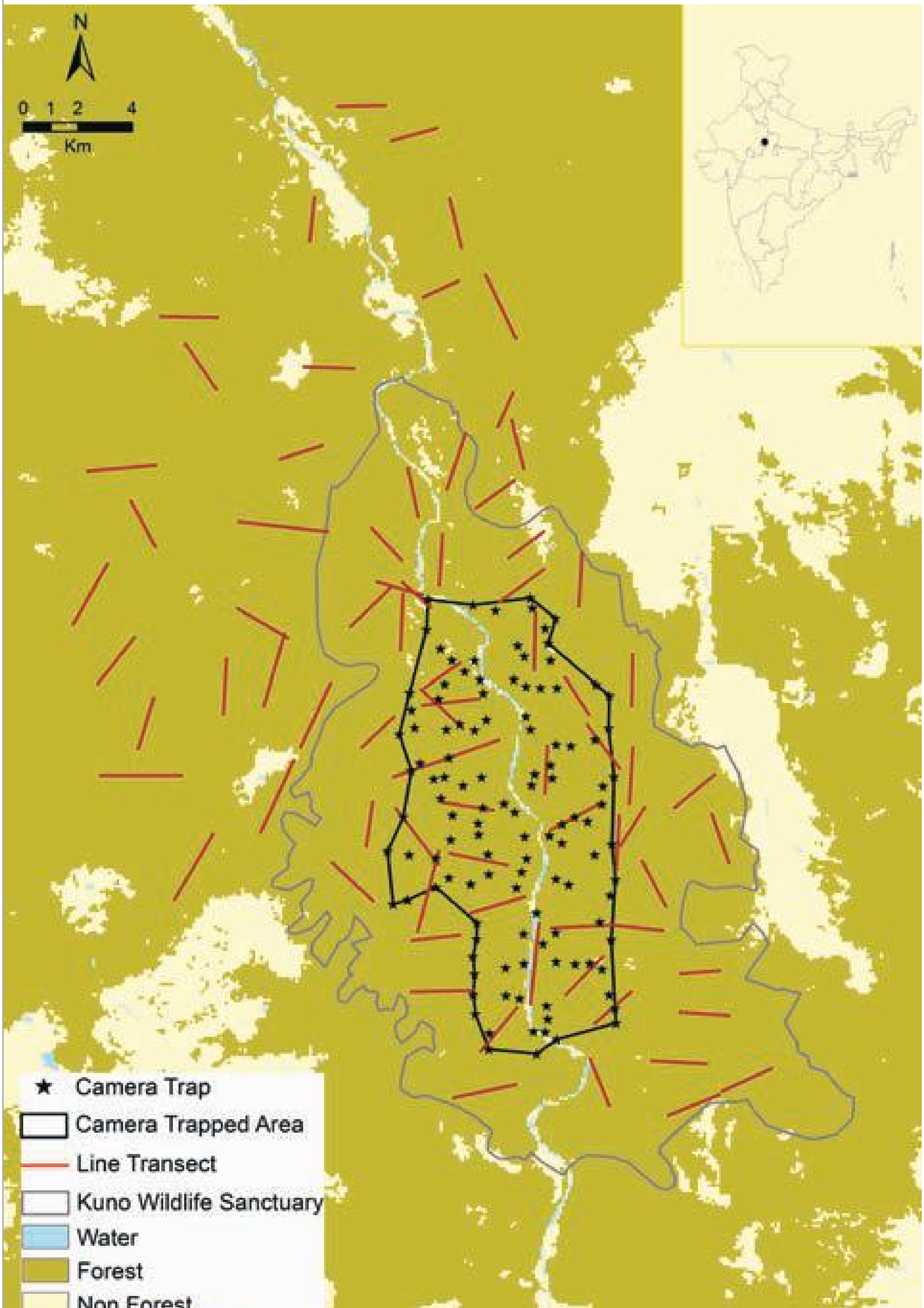


Figure 9.18: Distribution of camera traps (n=117) and line transect (n=77) in Kuno Wildlife Division, 2014.



Twenty three photographs of one adult male tiger were obtained during the sampling period. The tiger was photographed at six camera trap locations. Density of tiger could not be estimated due to photo-capture of a single individual.

Table 9.28: Model statistics and parameter estimates of line transect (n=77, total effort of 298.65 km) based distance sampling for prey species in Kuno Wildlife Divison, 2014.

Species	Model	Chi Sq P value	Effective Strip Width (SE)	No. Groups Detected	Mean Group size (SE)	Detection Probability (SE)	Encounter Rate per Km	Group Density (SE) per km^2	Individual Density (SE) per km^2
Chital	Half normal Cosine	0.93	53.13 (3.97)	173	11.33 (1.56)	0.33 (0.02)	0.58	5.45 (0.74)	39.84 (6.54)
Langur	Half normal Cosine	0.71	48.72 (6.65)	50	9.26 (1.03)	0.3 (0.04)	0.02	1.712 (0.34)	19.23 (5.11)
Nilgai	Half normal Simple. polynomial	0.67	73.79 (6.86)	46	3.17 (0.35)	0.37 (0.03)	0.02	1.04 (0.18)	3.31 (0.69)
Sambar	Half normal Cosine	0.89	44.85 (4.55)	57	2.56 (0.29)	0.32 (0.03)	0.02	2.13 (0.39)	5.58 (1.17)
Wildpig	Half normal Simple. polynomial	0.96	45.32 (4.95)	37	2.76 (0.31)	0.38 (0.04)	0.12	1.37 (0.28)	3.77 (0.89)

Kuno forms part of the Ranthambore – Madhav landscape and has the potential to serve as a source for tiger or other large carnivores like lions or cheetah as per the policy and management decisions of their reintroduction. It has shown remarkable recovery post reduction of human pressures in the sanctuary made possible by relocation of human settlements.

Panna Tiger Reserve (Madhya Pradesh)

Manjari Malviya[1], Mriganka Sekar Dutt[1], Sunal Kumar Roamin[1], K. Ramesh[1], R.S. Murti[2].
[1]Wildlife Institute of India, [2]Panna Tiger Reserve

Panna Tiger Reserve is situated in the northern part of Madhya Pradesh and is spread over Panna (373.55 km^2) and Chatarpur (169.12 km^2) districts. Panna Tiger Reserve extends between 79° 45' E - 80° 09' E longitudes and 24° 27' N - 24°46' N latitudes, covering an area of 542.66 km^2. The altitude ranges between 330 to 540m, with an average annual precipitation of 1100mm and temperature ranging from 5° C to 45° C. Panna Tiger Reserve is situated in the Vindhya hill range and is a part of contiguous forested landscape of about 3,000 km^2. One of the most significant ecological aspects of the reserve is that the district of Panna marks the northernmost boundary of natural distribution of teak and the eastern limits of teak-kardhai (Anogeissus pendula) mixed forest. The Ken River, which flows through the Reserve from south to north, is home to Gharial and Muggar, among other aquatic fauna. The terrain of the reserve is characterized by extensive plateaux and gorges. The topography in the Panna district part of the Reserve can broadly be divided into three distinct tablelands - the upper Talgaon plateau, the middle Hinauta plateau and the Ken valley. In 2009, the tiger population of Panna became extinct (Ramesh et al. 2013), mostly due to poaching. In the same year, reintroduction program was implemented with an initial population of two females and one male (in 2009), and later on supplemented with two more females in 2011 (Ramesh et al. 2013). The present carnivore guild consists of tiger, leopard, sloth bear, striped hyena, wild dog, jungle cat, and golden jackal. Major herbivore fauna present here are, sambar, chital, nilgai, chinkara, four-horned antelope, and wild pig.

Sampling Details

a) Camera trap sessions were carried out from December 2014 to March 2015 in three blocks with 39, 36 and 32 detectors deployed in each (Fig. 9.19). The resultant density estimate for all the three blocks is given in Table 9.29.

b) There were a total of 39 spatial transects with 3 temporal replicates and a walk effort of 225.6 km (Fig. 9.24, Table 9.30).

A total of 18 tigers are present (5 collared individual), which are all monitored on continuous basis.

Table 9.29: Sampling details of camera trap based mark-recapture for leopard in Panna Tiger Reserve, 2014.

Variables	Estimates
Minimum bounding polygon (km^2)	368.06
Camera Points	107
Trap Nights (effort)	2337
Unique leopards captured	24

Figure 9.19: Distribution of camera traps (n=107) and line transect (n=39) in Panna Tiger Reserve, 2014.

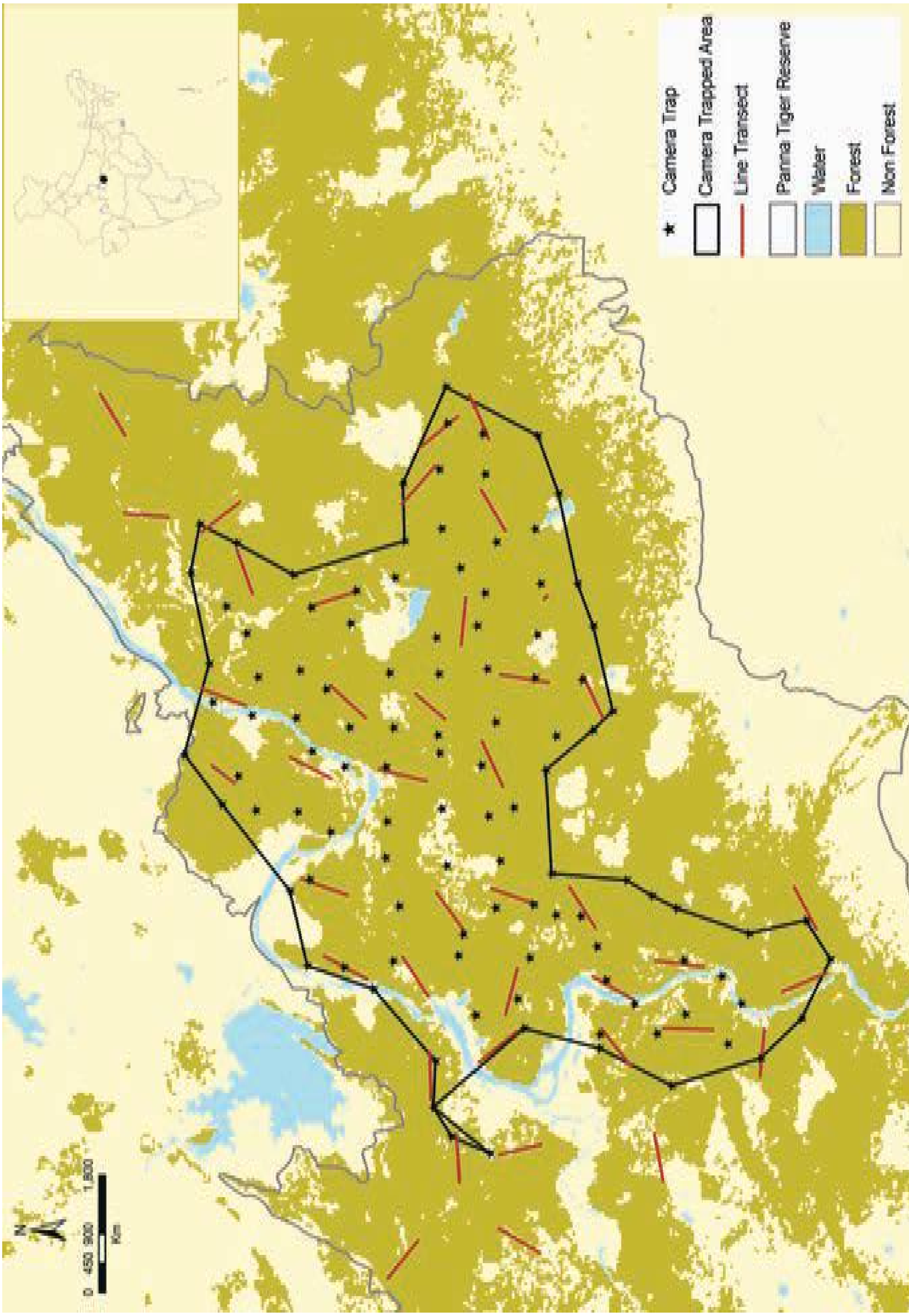


Table 9.30: Model statistics and parameter estimates of line transect (n=39, total effort of 225.6 km) based distance sampling for prey species in Panna Tiger Reserve, 2014

Species	Model	Chi Sq P value	Effective Strip Width (SE)	No. Groups Detected	Mean Group size (SE)	Detection Probability (SE)	Encounter Rate per Km	Group Density (SE) per km²	Individual Density (SE) per km²
Chinkara	Uniform Polynomial	0.77	37.25 (3.63)	11	1.91 (0.25)	0.62 (0.061)	0.05	0.66 (0.26)	0.87 (0.37)
Chital	Half normal Cosine	0.72	57.82 (9.27)	27	7.22 (1.42)	0.53 (0.00)	0.12	1.04 (0.36)	9.17 (3.70)
Langur	Uniform Polynomial	0.81	37.09 (3.89)	34	8.97 (0.76)	0.53 (0.06)	0.13	1.79 (0.45)	18.63 (5.31)
Nilgai	Uniform Cosine	0.80	40.71 (1.98)	65	3.54 (0.30)	0.51 (0.02)	0.28	3.43 (0.5)	11.34 (1.96)
Peafowl	Half normal Cosine	0.86	37.62 (6.60)	19	3.52 (0.48)	0.38 (0.07)	0.08	1.12 (0.36)	4.26 (1.59)
Sambar	Uniform Cosine	0.67	50.37 (2.19)	54	2.36 (0.22)	0.50 (0.02)	0.24	2.33 (0.41)	5.03 (1.01)
Wild pig	Uniform Cosine	0.95	50(0)	14	4.64 (0.80)	0.42 (0.03)	0.06	0.62 (0.17)	2.88 (0.94)

Panna tiger reserve has shown good recovery of its reintroduced tiger population, but the reserve is threatened by development projects like the Ken-Betwa river, project which will be detrimental for the reserve as a whole.

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Sanjay-Dubri Tiger Reserve (Madhya Pradesh)

K Raman
Madhya Pradesh Forest Department

Sanjay-Dubri Tiger Reserve is spread over an area of 1674.511 km^2 and is situated on the north eastern part of Madhya Pradesh, bordered by Guru Ghasidas National Park on the south. It is part of the Bandhavgarh-Sanjay-Guru Ghasidas-Palamau landscape and has been identified as one of the four potential tiger meta-population landscapes which are currently in need of conservation inputs. The Sanjay Tiger Reserve includes Sanjay National Park, Sanjay (Dubri) Sanctuary & proposed buffer zone. It lies between longitudes 81°30' E - 82° 15' E and latitudes 23° 46' - 24°15' North. Winters starts from end of October and lasts till mid February. The onset of monsoon is from July and continues till mid October.

The sanctuary comprises of 80 percent sal forest and the remaining is classified as miscellaneous forest. No sightings of wild dog has been recorded after 1986. Prey species recorded are chinkara, nilgai, chital, sambar and barking deer.

Camera trap surveys were carried out from 8th March to 7th April 2013. A total of 27 camera trap stations were setup covering an area of 186.96 km^2 (minimum bounding polygon) (Fig. 9.20). Additionally, adjacent Reserve Forests (11 trap stations) were also surveyed, together accounting for a cumulative sampling effort of 918 trap nights (Table 9.31).

Table 9.31: Sampling details of camera trap survey in Sanjay Dubri Tiger Reserve, 2013.

Variables	Estimates
Minimum bounding polygon (km^2)	186.96
Camera Points	27
Trap Nights (effort)	918
Unique tigers captured	6

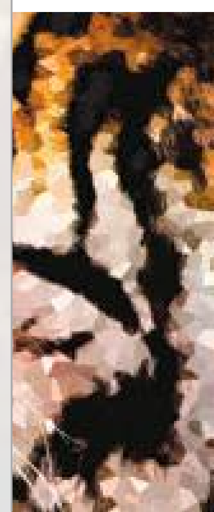
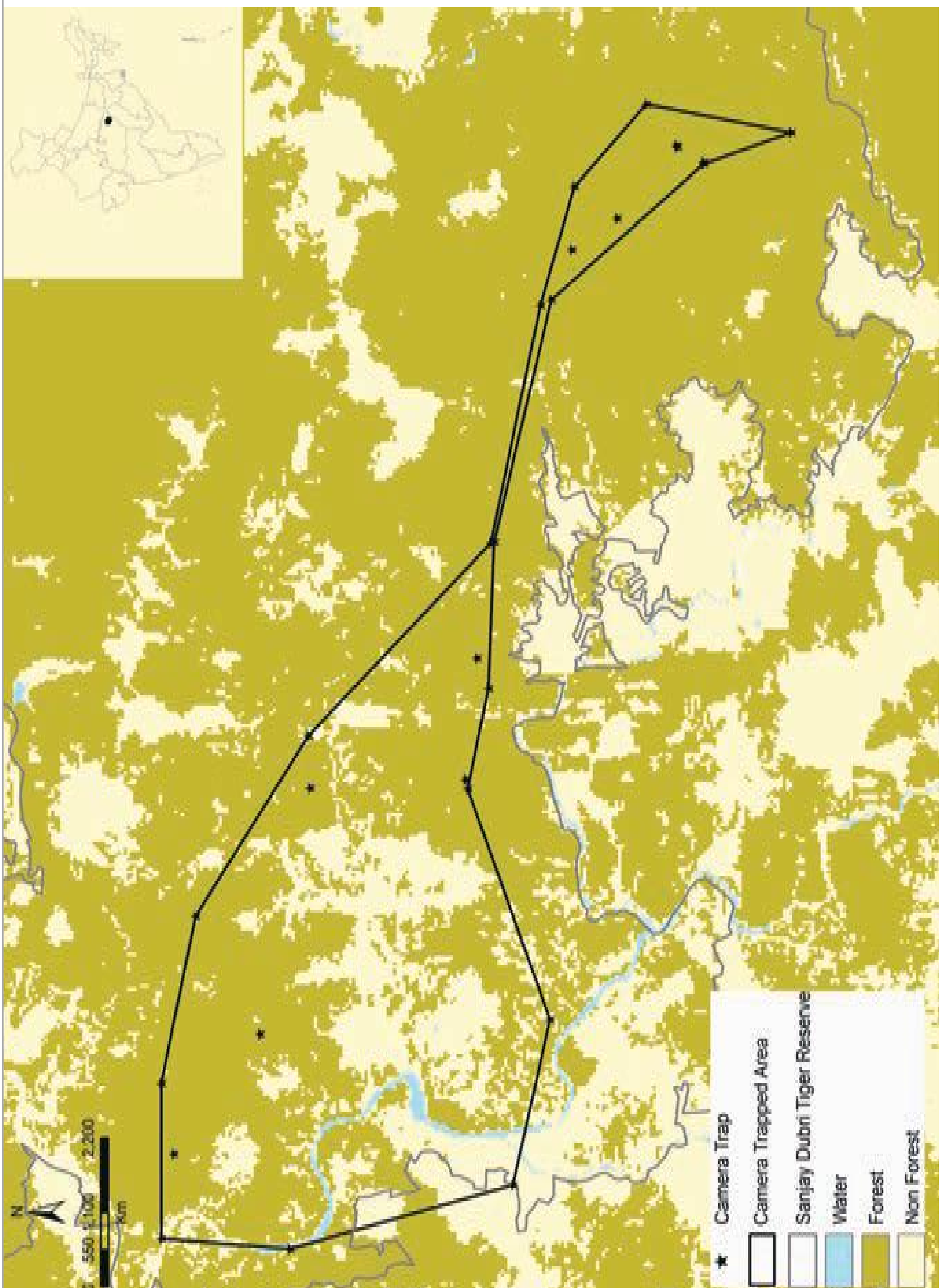


Figure 9.20: ***Distribution of camera traps (n=27) in Sanjay Dubri Tiger Reserve, 2013.***



Bandhavgarh Tiger Reserve (Madhya Pradesh)

Sudhir Kumar[1], Y. V. Jhala[2] and Qamar Qureshi[2].
[1]Bandhavgarh Tiger Reserve & [2]Wildlife Institute of India

Bandhavgarh Tiger Reserve (BTR) is situated in the state of Madhya Pradesh and located between the Vindhyan and the eastern flanks of Satpura hill ranges. The reserve lies between 23°30' 08" to 23°57' 01" North latitude and 80°47' 05" to 81°11' 43" East longitude. Bandhavgarh Tiger Reserve comprises of a core area of 716.46 km^2 and a buffer area of 820.15 km^2, with the total area of the reserve being 1536.7 km^2. The core area of the Tiger Reserve is further divided into two conservation units viz. Bandhavgarh National Park (448.84 km^2) and Panpatha Wildlife Sanctuary (264.28 km^2). A majority of the BTR lies in Umaria Forest Division, while the remaining portion lies in Katni Forest Division (Gopal 1991). The Tiger Reserve lies within the tropical zone, having three distinct seasons viz. summer (March-June), monsoon (July-October) and winter (November-February).

Vegetation of Bandhavgarh Tiger Reserve is classified under five categories (Champion and Seth 1968). Moist peninsular low level Sal forest, northern dry mixed deciduous forest, dry deciduous scrub, dry grassland and West Gangetic moist mixed deciduous forest. The Tiger Reserve supports a diverse assemblage of herbivores such as chital, sambar, nilgai, wild pig, barking deer, four-horned antelope, and chinkara. Gaur used to exist in Bandhavgarh, but became locally extinct due to the loss of corridor. The last small population of gaur migrated out of Bandhavgarh in 1995 (Sankar et al. 2013). Fifty gaur were reintroduced from Kanha Tiger Reserve in 2011 (Sankar et al. 2013). Bandhavgarh Tiger Reserve supports a wide variety of large, medium and small sized carnivores such as tiger, leopard, dhole, sloth bear, stripe necked mongoose, etc. The presence of wolf, striped hyena and Indian fox has also been recorded from the fringes of the park. The three striped squirrel (Funambulus palmarum) and Indian pangolin (Manis crassicaudata) also occur in the reserve.

Sampling Details

a) Camera trap field surveys were carried out in Bandhavgarh from 8thMarch 2013 to 7th April 2013 (Fig. 9.21). A total of 216 camera trap stations were setup and sampled for 62 occasions resulting in a sampling effort of 12836 trap nights (Table 9.32).

Variables	Estimates (SE)
Minimum bounding polygon (km^2)	580.03
Camera Points	216
Trap Nights (effort)	12836
Unique tigers captured	60
Model	g0(.)σ(.)
$\hat{D}$ ML SECR (per 100 km^2)	4.47 (0.58)
Sigma (SE) (km)	3.18 (0.09)
g0 (SE)	0.02 (0.002)

Table 9.32: Sampling details and parameter estimates of tiger from camera trap based capture mark-recapture analysis in Bandhavgarh Tiger Reserve, 2013.

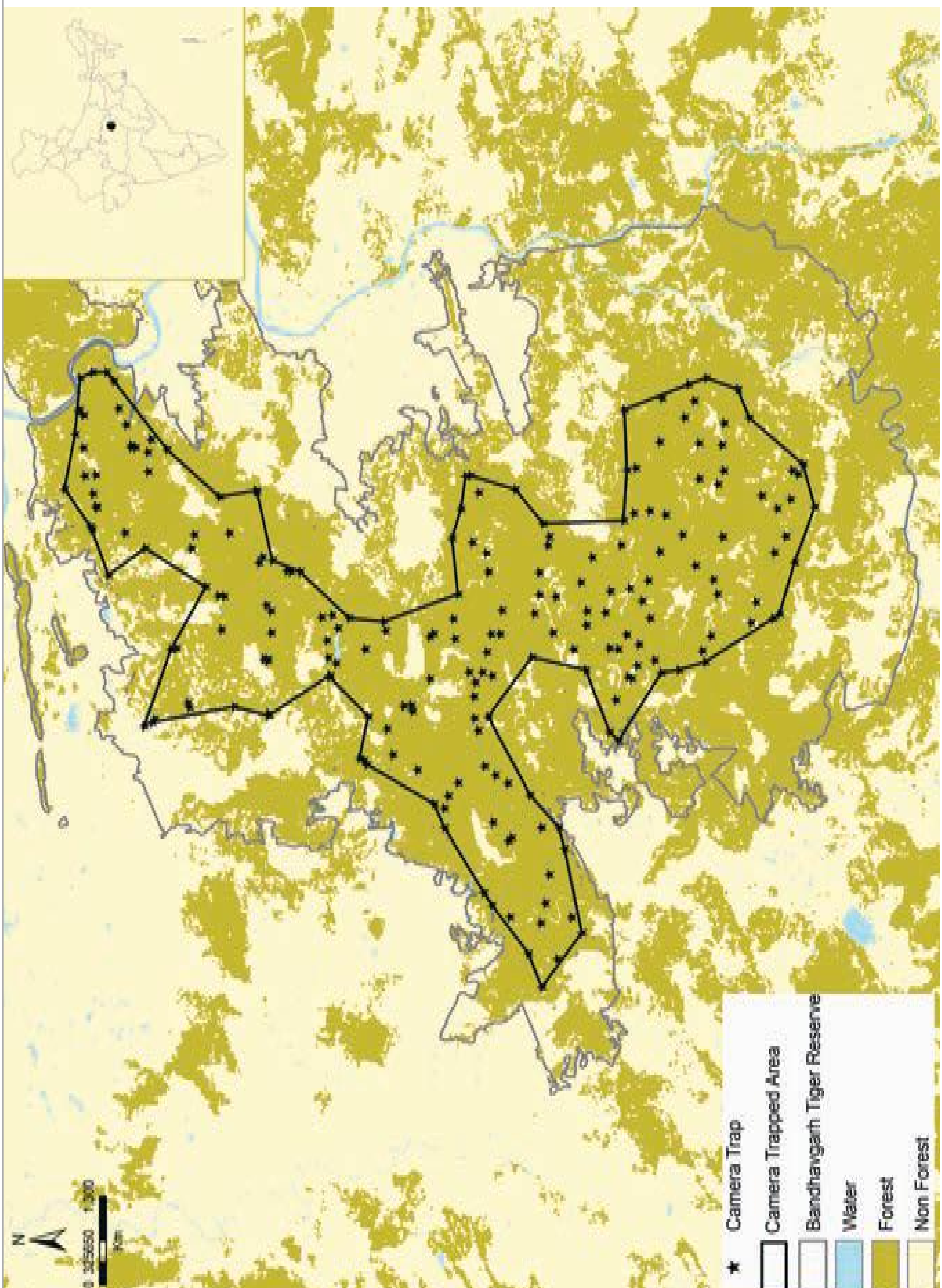
SE: Standard error

$\hat{D}$ ML SECR: Density estimate from Maximum Likelihood based spatially explicit capture recapture

σ(Sigma): Spatial scale of detection function, g0: Magnitude (intercept) of detection function

Connectivity with Sanjay-Dubri Tiger Reserve is important as Bandhavgarh acts as source population for Sanjay-Dubri Tiger Reserve, and Guru Ghasidas National Park. The forested landscape extends up to Palamau Tiger Reserve. Corridor connectivity with Achanakmar-Kanha is in poor condition.

Figure 9.21: Distribution of camera traps (n=216) in Bandhavgarh Tiger Reserve, 2013.



Satpura Tiger Reserve (Madhya Pradesh)

Bhaskar Bora[1], J. Charles Leo Prabu[1], Nilesh Patil[1], Paul P. Predit[1], Ravi Sharma[1], Rohan B. Bhagat[1], Deepan Chackaravarty[1], Shameer T.T[1], Syed Abrar[1], Subrata Gayen[1], Qamar Qureshi[1], R. P. Singh[2], A. Mishra[2], Y.V. Jhala[1]
[1]Wildlife Institute of India, [2]Satpura Tiger Reserve

Satpura Tiger Reserve (22° 19' 28" N to 22° 45' 30" N and 77° 53' 48" E to 78° 34' 0" E) was established in 1999. The reserve is located in Hoshangabad district of Madhya Pradesh with an area of 2133.30 km^2 (core tiger habitat - 1339.26 km^2, buffer - 794.04 km^2). Satpura Tiger Reserve comprises of Panchmari Wildlife sanctuary (north eastern boundary), Satpura National Park and Bori Wildlife Sanctuary (south western boundary). It supports a large number of ethno-medicinal flora and faunal diversity (Pande 2002, Edgaonkar 2008). There are 48 species of mammals, 258 species of avian fauna and 31 species of reptiles (Fellows 2015).

The vegetation of the reserve is mainly categorized as moist deciduous forest. The southern part of basaltic form supports teak (Tectona grandis) and mixed forest, whereas north-eastern sandstone basalt have sal (Shorea robusta) and also few representatives of northern Himalayan genera such as Hypericum, Rubus, Berberis and Pteridium (Hora et.al, 1950).

Large carnivores such as tiger, leopard, wild dog and jackal and small carnivores like smooth coated otter and pangolin are found here. Among the arboreal mammals, Indian Giant squirrel (Ratufa indica) and Indian Flying squirrel (Petaurista petaurista) are also present. Major ungulates and primates consist of sambar, chital, gaur and hanuman langur.

Sampling Details

a) *Camera trapping exercise was conducted during December 2014 to March 2015 in two blocks, with passive camera traps (Cuddeback attack). 276 camera locations were sampled over 77 occasions in both blocks with a cumulative sampling effort of 5868 trap nights (Fig. 9.22).The total camera trap area was 504.38 km^2 (minimum bounding polygon) (Table 9.33).*

b) *A total of 37 line transects were surveyed during the month of December 2014 to March 2015 each with a temporal replicate of three, with a total walk effort of 226 km (Fig. 9.27). Length of each transect was approximately 2 km (Table 9.34).*

Table 9.33: *Sampling details and parameter estimates of capture mark-recapture analysis using camera traps for Tiger at Satpura Tiger Reserve from December 2014 to March 2015.*

Variables	Estimates (SE)
Minimum bounding polygon (km^2)	504.38
Camera Points	276
Trap Nights (effort)	5868
Unique tigers captured	14
Model	g0(.)σ(.)
$\hat{D}$ ML SECR (per 100 km^2)	1.52 (0.42)
Sigma (SE) (km)	3.37 (0.30)
g0 (SE)	0.01 (0.002)

SE: Standard error

$\hat{D}$ ML SECR: Density estimate from Maximum Likelihood based spatially explicit capture recapture

σ(Sigma): Spatial scale of detection function, g0: Magnitude (intercept) of detection function

Figure 9.22: *Distribution of camera traps (n=276) and line transect (n=37) in Satpura Tiger Reserve, 2014.*

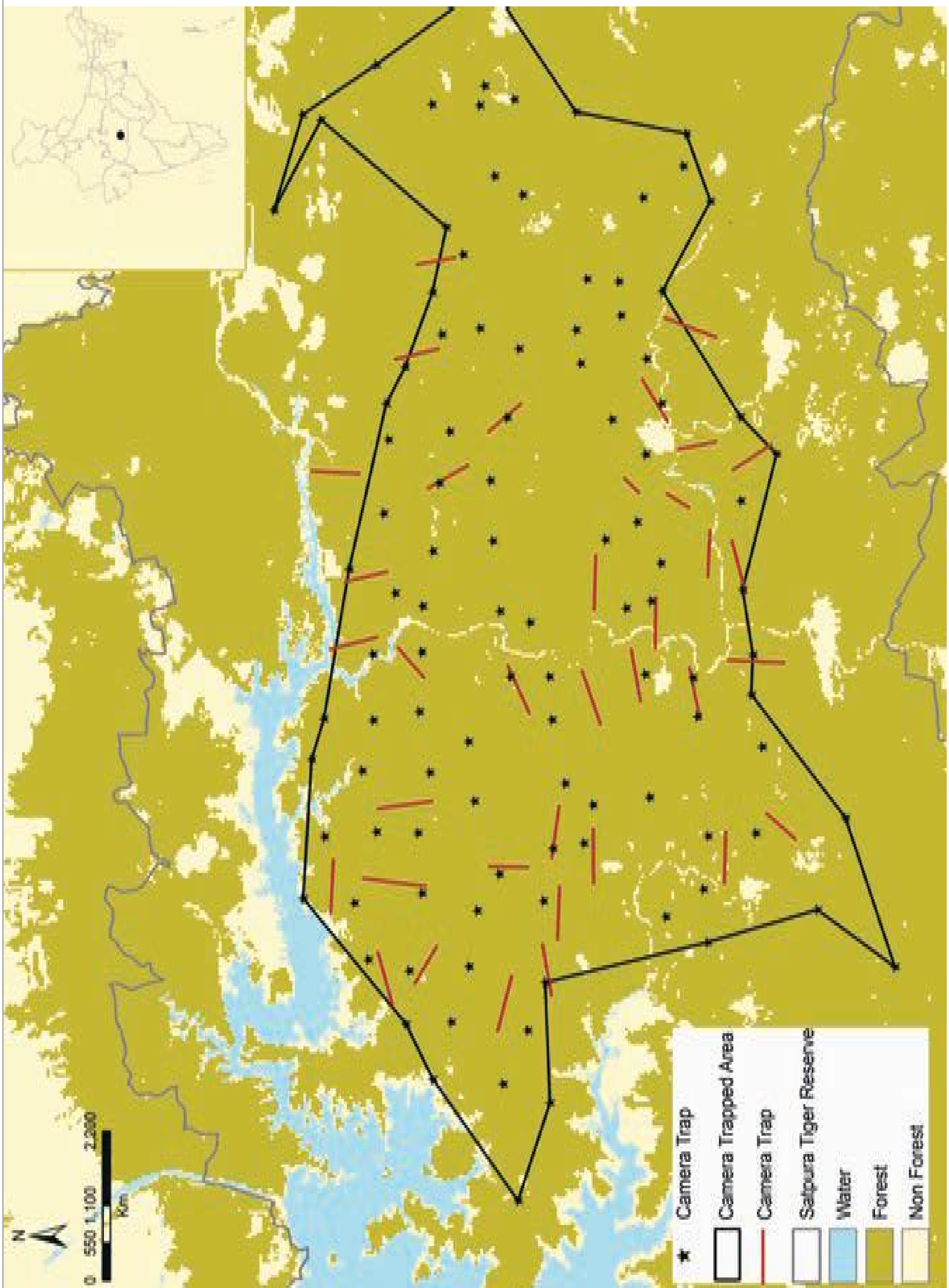


Table 9.34: Model statistics and parameter estimates of line transect (n=37, total effort of 226 km) based distance sampling for prey species in Satpura Tiger Reserve, 2014.

Species	Model	Chi Sq P value	Effective Strip Width (SE)	No. Groups Detected	Mean Group size (SE)	Detection Probability (SE)	Encounter Rate per Km	Group Density (SM) per km²	Individual Density (SM) per km²
Sambar	Hazard polynomial	0.95	38.22 (6.09)	76	2.68 (0.16)	0.60 (0.04)	0.39	4.40 (0.99)	8.96 (2.10)
Chital	Half normal cosine	0.85	73.3 (19.12)	24	6.17 (1)	0.21 (0.09)	0.12	0.72 (0.38)	4.50 (2.58)
Gaur	Hazard polynomial	0.84	137.58 (58.16)	18	8.41 (1.61)	0.50 (0.28)	0.06	0.29 (0.15)	1.57 (0.93)
Wild pig	NA	NA	NA	3	NA	NA	0.01	NA	NA
Barking deer	NA	NA	NA	9	NA	NA	0.04	NA	NA
Nilgai	NA	NA	NA	2	NA	NA	0.009	NA	NA
Rhesus macaque	NA	NA	NA	3	NA	NA	0.01	NA	NA
Langur	Half normal polynomial	0.98	44.48 (4.91)	74	8.88 (0.67)	0.23 (0.02)	0.38	3.68 (0.78)	28.51 (6.56)

Satpura Tiger Reserve has performed a commendable job in relocating human settlements and reducing biotic pressure in the reserve. This management activity is likely to result in an increase of prey biomass and subsequently of the tiger population. However increased vigil is required to control poaching in this landscape which is connected to Melghat in Maharashtra and Pench in Madhya Pradesh.

Phen Wildlife Sanctuary (Madhya Pradesh)

Anup Pradhan[1], Ashish Prasad[1], Jayanta Kumar Bora[1], Meghna Bandopadhyay[1], Neha Awasthi[1], Deb Ranjan Laha[1], Ujjwal Kumar[1], Qamar Qureshi[1], J. S. Chauhan[2], Y.V. Jhala[1]

Phen Wildlife Sanctuary is located within the Mandla district of Madhya Pradesh and was declared as a Wildlife Sanctuary in 1983. The sanctuary is a forest range with its headquarters at Motinala. The geographical extent of this sanctuary is: Latitude 22° 19' 11.6" to 22° 25' 15.2" N and Longitude 80° 07' 19.2" to 80° 57' 26.0" E. The total area of the sanctuary is 110.74 km^2.The protected area has been named after the river Phen. The Phen Wildlife Sanctuary is considered as satellite micro core of the Kanha Tiger Reserve. The plan for restoration of the micro core habitat emphasizes the creation of secure connectivity with Kanha National Park, facilitating safe movement of wild animals.

As per Champion and Seth (1968), the following forest types have been identified in the Phen Wildlife Sanctuary: Moist Peninsular Sal Forests, Southern Tropical Moist Mixed Deciduous Forest, and Southern Tropical Dry Mixed Deciduous Forest. The sanctuary has typical sal forest with all its associates of tree and shrub species. The protected area however, being relatively small, does not support large populations of predators, co-predators and ungulates. Major carnivores include leopard, wild dog, sloth bear and jackal. Among ungulates, chital, sambar, gaur, wild pig, and barking deer are common.

Sampling Details

a) Camera trapping operation was carried out from 16th February to 8th March 2015 (Fig. 9.23). A total of 96 camera trap stations were setup resulting in an effort of 1811 trap nights. The minimum bounding polygon was 98 km^2 (Table 9.35).

b) Line transect (n= 19) for prey were walked (Fig.9.23). Each transect was walked thrice in the morning between 0600 to 0800 hours, yielding an effort of 114 km (Table 9.36). At every 400m of each line transect, plots were laid to access human disturbance, vegetation, and dung counts.

Table 9.35: Sampling details and parameter estimates of leopard from camera trap based capture mark-recapture analysis Phen Wildlife Sanctuary.

Variables	Estimates (SE)
Minimum bounding polygon (km^2)	94
Camera Points	96
Trap Nights (effort)	1811
Unique leopards captured	21
Model	g0(.)σ(.)
$\hat{D}$ ML SECR (SE) (per 100 km^2)	8.49 (1.91)
Sigma (SE) (km)	1.93 (0.1)
g0 (SE)	0.05 (0.01)

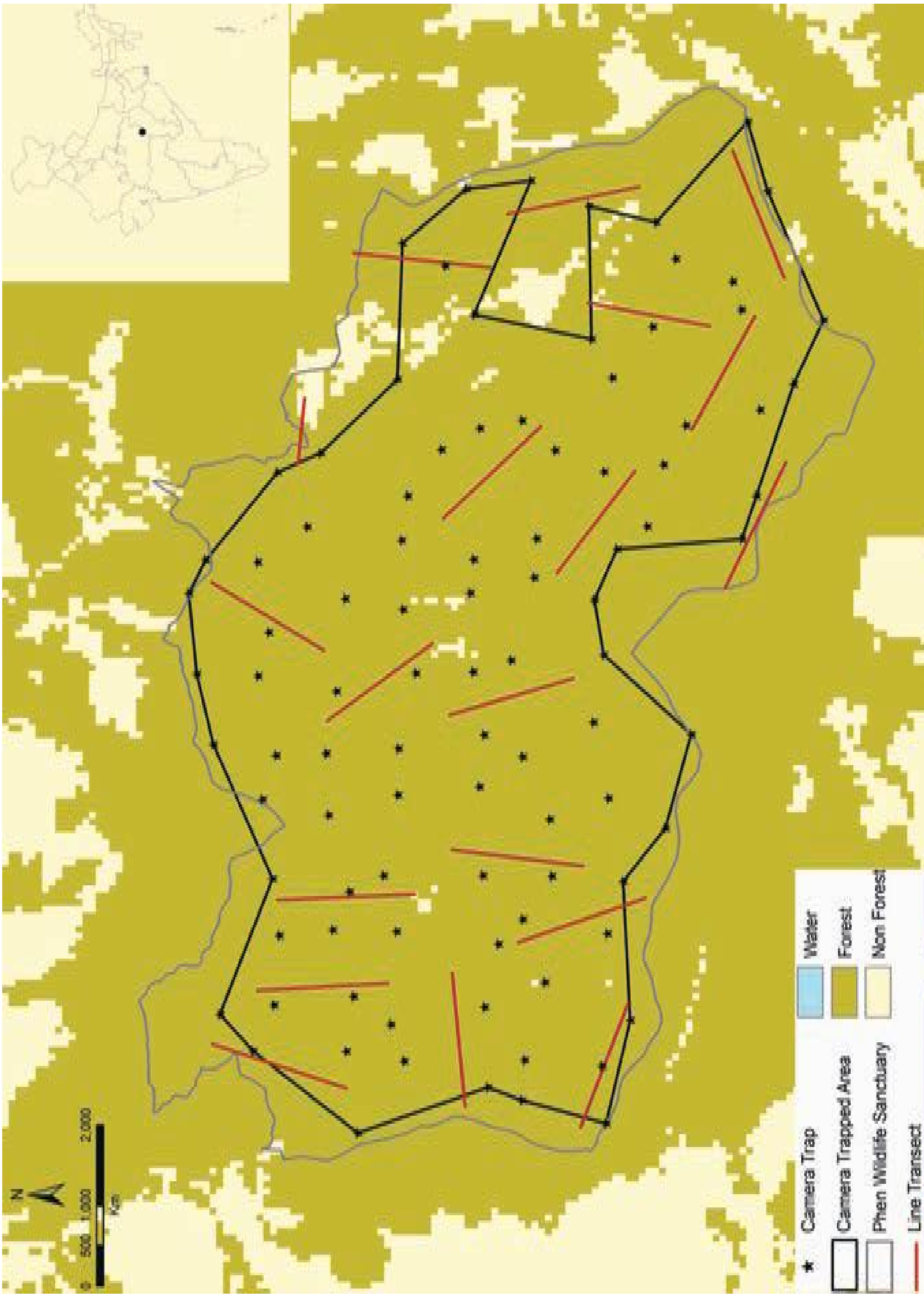
SE: Standard error

$\hat{D}$ ML SECR: Density estimate from Maximum Likelihood based spatially explicit capture recapture

σ(Sigma): Spatial scale of detection function, ^g0: Magnitude (intercept) of detection function

Note: During camera trapping session, no tiger was photo captured.

Figure 9.23: *Distribution of camera traps (n=96) and line transect (n=19) in Phen Wildlife Sanctuary.*



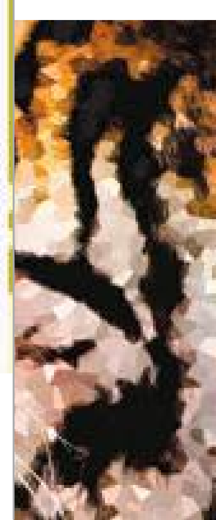


Table 9.36: Model statistics and parameter estimates of line transect (n=19, total effort of 114 km) based distance sampling for prey species in Phen Wildlife Sanctuary, 2015.

Species	Model	Chi Sq P value	Effective Strip Width (SE)	No. Groups Detected	Mean Group size (SE)	Detection Probability (SE)	Encounter Rate per Km	Group Density (SE) per km²	Individual Density (SE) per km²
Chital	Hazard rate cosine	0.82	67.08 (4.26)	11	4.52 (1.04)	0.26 (0.01)	0.09	0.71 (0.26)	3.25 (1.40)
Sambar	Hazard rate simple ploynomial	0.80	46.19 (2.57)	20	1.95 (0.26)	0.28 (0.01)	0.17	1.89 (0.53)	3.71 (1.15)
Wild pig	Hazard rate simple polynomial	0.90	44.08 (3.29)	32	5.71 (1.07)	0.27 (0.02)	0.28	3.18 (0.81)	18.2 (5.78)
Barking deer	Hazard rate cosine	0.90	37.78 (2.05)	39	1.20 (0.05)	0.30 (0.01)	0.34	4.52 (0.97)	5.45 (1.20)

Phen Wildlife Sanctuary now a part of the Kanha Tiger Reserve is likely to show good recovery of its ungulate and carnivore populations due to the management inputs of rehabilitation of human settlements and reduction of human pressures. Phen is critically located to form the staging ground for tigers dispersing eastwards towards Achanakmar Tiger Reserve, from Kanha. Its recovery to achieve its potential is important for Phen to perform this role in the metapopulation dynamics of this landscape.

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Kanha Tiger Reserve (Madhya Pradesh)

Ujjwal Kumar[1], Neha Awasthi[1], Anup Pradhan[1], Ashish Prasad[1], Deb Ranjan Laha[1], Jayanta Kumar Bora[1], Rahul K. Talegaonkar[1], Rutu Prajapati[1], Sanjay Xaxa[1], Shravana Goswami[1], Qamar Qureshi[1], O. P. Tiwari[2], R. K. Shukla[2], J.S. Chauhan[2], Y.V.Jhala[1].

Kanha Tiger Reserve, Madhya Pradesh is located between 80°26' E - 81°04' E longitudes and 22°01' N - 27° 27' N latitudes. It is situated in the Maikal hills of Satpura Range and lies in the Deccan peninsula- Central Highland zone 6E of Biogeographic classification of India (Rodgers & Panwar, 1988).The reserve has an excellent interspersion of Dadars (flat hill tops), grassy expenses, dense forests and riverine forests. The reserve prides itself in successfully conserving the three endangered species: tiger, barasingha (Rucervus duvaucelli branderi), and wild dog (Cuon alpinus). Within the National Park, 917.43 km^2 has been notified as the Critical Core, whereas the area of the Buffer Zone Division, 1134.31 km^2, consists of forest land, revenue land and private holdings.

Sampling Details

a) A total of 757 camera trap stations were setup (Fig 9.24). Due to logistic reasons, the core and buffer area were sampled in 3 and 4 blocks respectively. Sampled blocks were run for a minimum of 20 days and maximum of 25 days, accounting for a cumulative sampling effort of 23216 trap nights, from 19.02.2014 to 10.07.2014 (Core) and 05.11.2014 to 14.02.2015 (buffer) (Table 9.37).

b) Systematic stratified line transects were sampled by distance sampling (Buckland et.al.2001) on line transects with an effort of 1266 km walk. Ungulates were surveyed on 211 spatially replicated transects of 2 km length each, with 3 temporal replicates covering the entire study area of 1,440 km^2 (Fig 9.24). Line transects were walked during early morning (6:00 am to 8:00 am) for three consecutive mornings. (Table 9.38 & 9.39).

Table 9.37: Sampling details and parameter estimates of capture mark-recapture analysis using camera traps for Tiger in the core zone from March 2014 to July 2014 and Buffer zone from November 2014 to February 2015.

Variables	Estimates (SE) Core zone	Estimates (SE) Buffer Zone
Minimum bounding polygon (km^2)	777	494
Camera Points	757	265
Trap Nights (effort)	18575	4641
Unique tigers captured	74	20*
Model Name	g0 (.)σ(.)	g0 (.) σ(.)
$\hat{D}$ ML SECR (SE) (per 100 km^2)	6.10 (0.71)	2.01(0.48)
Sigma (SE) (km)	1.90 (0.03)	2.41 (0.23)
go (SE)	0.041 (0.001)	0.034(0.006)

*17 tigers were common between Core & Buffer

SE: Standard error

$\hat{D}$ ML SECR: Density estimate from Maximum Likelihood based spatially explicit capture recapture

σ(Sigma): Spatial scale of detection function, ^g0: Magnitude (intercept) of detection function

Figure 9.24: *Distribution of camera traps (n=1022) and line transect (n=211) in Kanha Tiger Reserve, 2014.*

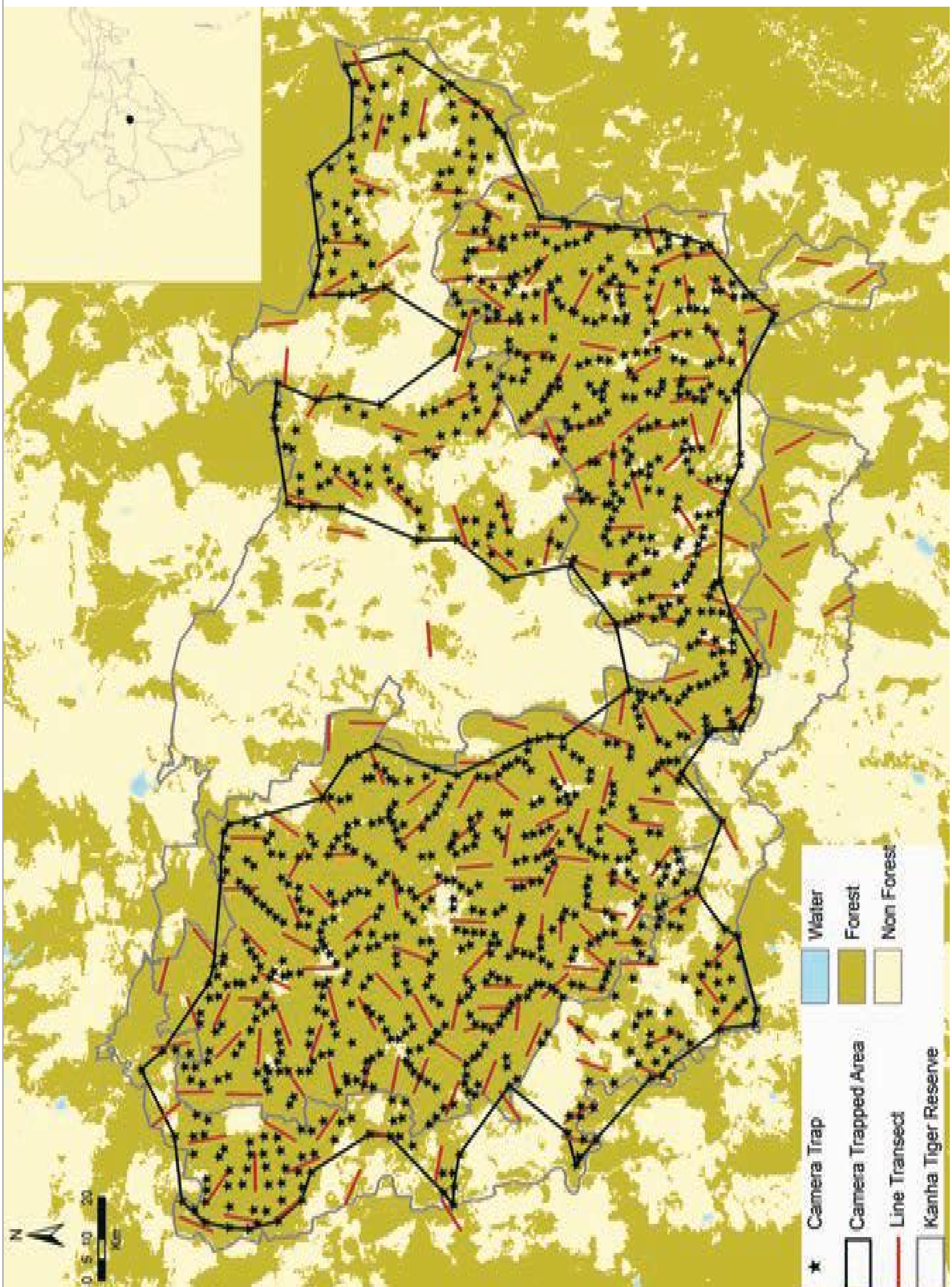


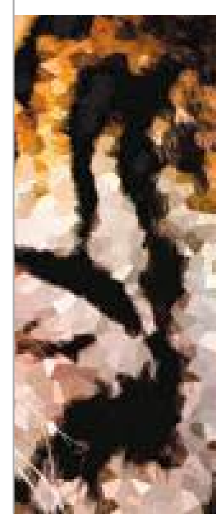
Table 9.38: Model statistics and parameter estimates of line transect (n=150, total effort of 900 km) based distance sampling in Kanha Tiger Reserve (Core) 2014.

Species	Model	Chi Sq P Value	Effective Strip Width (SE)	No. Groups Detected	Mean Group size (SE)	Detection Probability (SE)	Encounter Rate per Km	Group Density (SE) per km^2	Individual Density (SE) per km^2
Chital	Hazard rate cosine	0.82	67.08 (4.26)	367	10.26 (0.57)	0.26 (0.01)	0.40 (0.05)	3.03 (0.44)	31.12 (4.85)
Sambar	Hazard rate simple ploynomial	0.81	46.19 (2.57)	252	2.82 (0.10)	0.28 (0.01)	0.27 (0.03)	3.02 (0.35)	8.55 (1.05)
Gaur	Hazard rate cosine	0.86	44.94 (5.67)	91	5.03 (0.61)	0.19 (0.02)	0.10 (0.02)	1.12 (0.21)	5.65 (1.29)
Wild pig	Hazard rate simple polynomial	0.90	44.08 (3.29)	105	5.14 (0.53)	0.27 (0.02)	0.11 (0.01)	1.32 (0.19)	6.79 (1.21)
Barking deer	Hazard rate cosine	0.90	37.78 (2.05)	124	1.26 (0.03)	0.30 (0.01)	0.13 (0.01)	1.81 (0.21)	2.30 (0.27)
Langur	Hazard rate cosine	0.62	42.50 (2.50)	189	10.21 (0.56)	0.29 (0.01)	0.20 (0.03)	2.46 (0.34)	25.15 (3.80)

Table 9.39: Model statistics and parameter estimates of line transect (n=61, total effort of 366 km) based distance sampling in Kanha Tiger Reserve (Buffer), 2014.

Species	Model	Chi Sq P value	Effective Strip Width (SE)	No. Groups Detected	Mean Group size (SE)	Detection Probability (SE)	Encounter Rate per km	Group Density (SE) per km^2	Individual Density (SE) per km^2
Chital	Half normal cosine	0.82	67.08 (4.26)	77	5.31 (0.50)	0.26 (0.01)	0.20 (0.03)	2.52 (0.42)	13.43 (2.59)
Sambar	Hazard rate cosine	0.81	46.19 (2.57)	37	2.70 (0.29)	0.28 (0.01)	0.09 (0.03)	1.22 (0.41)	3.30 (1.17)
Gaur	Hazard rate cosine	0.86	44.94 (5.67)	9	3.66 (0.62)	0.19 (0.02)	0.02 (0.02)	0.23 (0.12)	0.86 (0.46)
Wild pig	Hazard rate simple polynomial	0.90	44.08 (3.29)	52	4.42 (0.68)	0.27 (0.02)	0.13 (0.01)	1.88 (0.41)	8.32 (2.23)
Barking deer	Hazard rate cosine	0.90	37.78 (2.05)	70	1.26 (0.05)	0.30 (0.01)	0.18 (0.02)	2.47 (0.45)	3.14 (0.59)

Kanha tiger population is a major source of tigers in the Satpura-Maikal landscape of Central India. It's well being ensures the occupancy of Balaghat and Jabalpur forests by tigers, as well as the genetic well being of Pench and Achanakmar tiger populations that exchange dispersing tigers with Kanha.



Melghat Tiger Reserve (Maharashtra)

Dimpi Patel[1], Narendra Mohan Katara[1], Nilesh Patil[1], Paul P. Predit[1], Rajal Pathak[1], Sanjay Xaxa[1], Shravana Goswami[1], Parabita Basu[1], Prachi Mehta[2], Tushar Pawar[2] , Y.V. Jhala[1], Qamar Qureshi[1].

The Melghat Tiger Reserve (1500.49 km²) is a part of the Satpuda-Maikal landscape which is considered as one of the global priority tiger conservation landscape. Melghat includes Gugamal NP, Melghat WLS, Narnala WLS, Ambabarwa WLS and Wan WLS in Maharashtra. Additionally, 1268.03 km² (920.65 km² forest area and 347.38 km² non-forest area) was declared as a "Buffer Zone" of the Melghat Tiger Reserve. The major carnivores and herbivores include tiger, leopard, gaur, wild dog, sloth bear, wolf, wild pig, sambar, chital and chaushinga. Melghat Tiger Reserve is located in 6 E central Highlands Biotic province of Deccan Peninsula Bio-geographic zone. Melghat forms part of a large metapopulation and its connectivity to Satpura, Pench and Bor-Tadoba is a very important aspect for long-term tiger conservation (Yumnam et al. 2014). The landscape is at the juncture of Sal forest (Shorea robusta) from the North and Teak (Tectona grandis) forests from the South. This landscape suffers from threats of overuse by people, habitat loss in corridors and buffer zones, overgrazing by livestock, encroachment, and forest fires.

Sampling Details

a) Camera traps were deployed in two blocks, consisting of 200 and 164 detectors in each, and sampled for 60 and 32 occasions respectively (Fig. 9.25). The resultant density estimations for tiger are given in Table 9.40.

b) A total of 67 spatial line transects were walked with no temporal replicates resulting into walk a total effort of 147.09 km (Fig. 9.25). The number of observations for prey was too low to carry out analysis, hence only encounter rate has been provided (Table 9.41).

c) Number of sign surveys conducted were 77, resulting into walk effort of 433.21 km.

Table 9.40: Sampling details and parameter estimates of tiger from camera trap based capture mark-recapture analysis in Melghat Tiger Reserve, 2014.

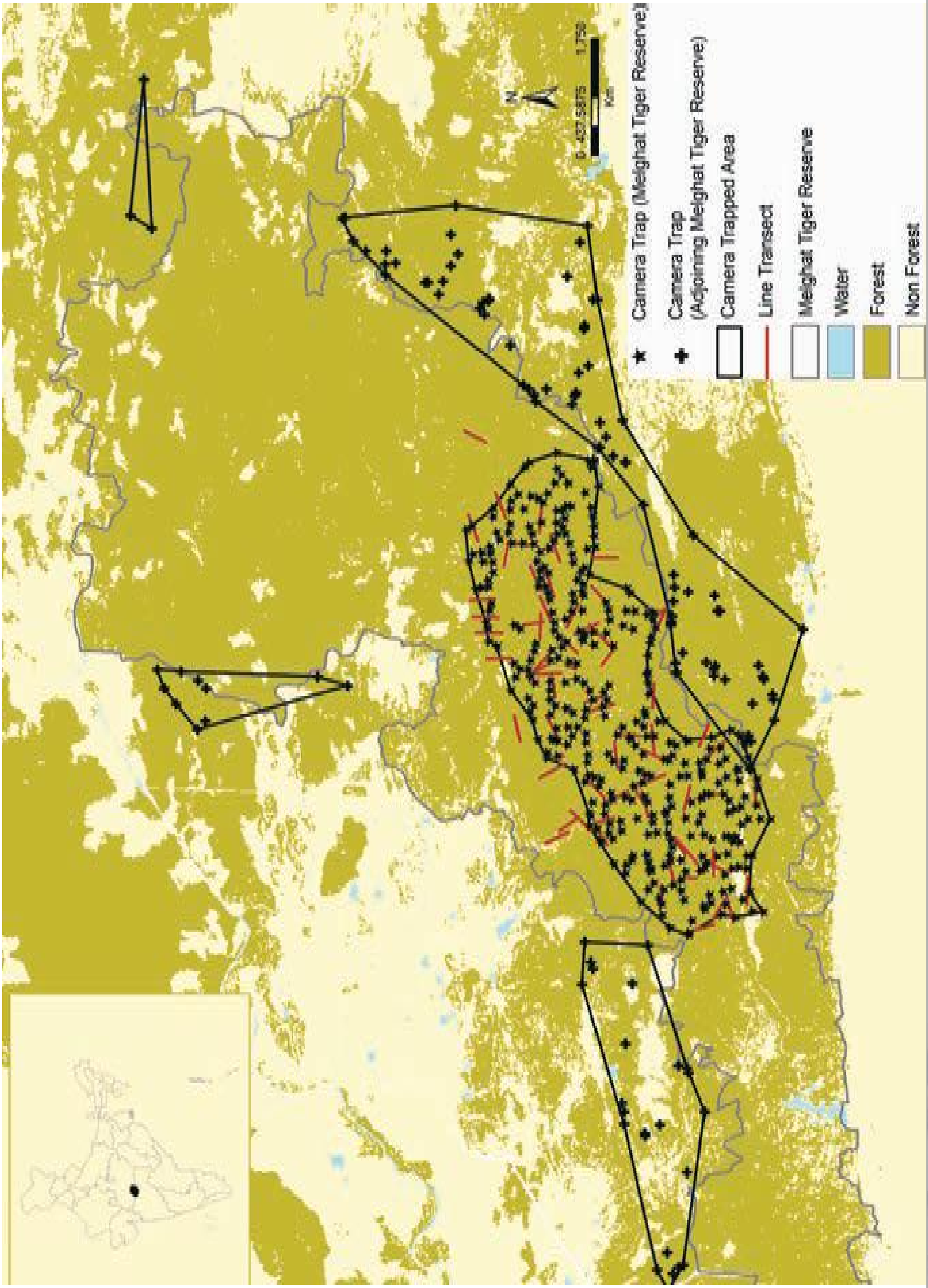
Variables	Estimates (SE)
Minimum bounding polygon (km²)	477.64
Camera Points	364
Trap Nights (effort)	8309
Unique tigers captured	17
Model	g0(.)σ(.)
$\hat{D}$ ML SECR (SE) (per 100 km²)	2.02 (0.51)
Sigma (SE) (km)	3.13 (0.26)
g0 (SE)	0.01 (0.001)

SE: Standard error

$\hat{D}$ ML SECR: Density estimate from Maximum Likelihood based spatially explicit capture recapture

σ(Sigma): Spatial scale of detection function, g0: Magnitude (intercept) of detection function

Figure 9.25: Distribution of camera traps (n=364) and line transects (n=67) in Melghat Tiger Reserve, 2014.



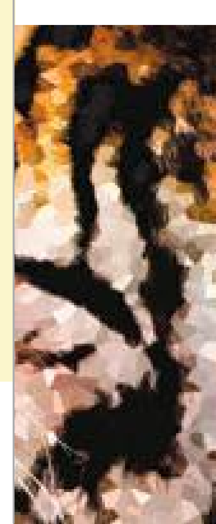


Table 9.41: Encounter rates of prey species seen on line transects (n=67, total effort of 147.09km) in Melghat Tiger Reserve, 2014.

Species	No. of groups detected	Encounter Rate per km
Sambar	5	0.03
Langur	13	0.09
Gaur	6	0.04
Barking deer	1	0.007
Rhesus macaque	1	0.007

Melghat Tiger Reserve has the potential to support a larger tiger population, provided human disturbances are reduced. Management inputs of incentivized voluntary relocation of habitation and reduction of livestock within the tiger reserve are likely to enhance the wild ungulate population and subsequently, the carnivore populations. Once Melghat tiger population increases, tigers could potentially disperse North-eastwards to Satpura and westward towards forests of the Western Ghats – Nashik and Dhule districts.

Pench Tiger Reserve (Madhya Pradesh)

Ahana Dutt, Anindita B. Chatterjee, Deepti Gupta, Dimpi Patel, Ravi Sharma, Shameer TT, Sunanda Sharma, K. Sankar Y.V. Jhala, Qamar Qureshi.
Wildlife Institute of India

Pench Tiger Reserve is located in Seoni and Chindwara districts of Madhya Pradesh. The core area of the tiger reserve includes Pench National Park (292.86 km^2) and Pench Mowghli Wildlife Sanctuary (118.47 km^2), while the buffer zone covers an area of 768.302 km^2. The total area of the reserve is 1179.632 km^2. It is located at 21° 41'35"N and 79° 14' 54"E. It lies along the border of Madhya Pradesh and Maharashtra, separated by a reservoir on the river Pench, from which the reserve gets its name. It consists of forest ranges Gumtara and Karmajhiri. The area has a large tribal population, comprising chiefly of Gonds. The NH44 (old NH7) runs between Nagpur and Jabalpur along the eastern boundary of the reserve for around 10 km and threatens to become a barrier for habitat connectivity with Kanha Tiger Reserve. Appropriate mitigation measures are needed for infrastructural development in this corridor to ensure maintenance of metapopulation structure in this region. The mean annual rainfall is around 1400 mm and temperature ranges from a minimum of 0°C in winters to 45°C in summers. The mean altitude is around 550 m above mean sea level.

The area consists of two main types of forest i.e. Tropical Moist Deciduous Forests (Type 3B/C1c Slightly moist teak forests) and Tropical Dry Deciduous Forests (Type 5A/C1b Dry teak forests, Type 5A/C3 Southern dry mixed deciduous forests), according to Champion and Seth (1968). Apart from tigers, Pench Tiger Reserve supports carnivores like leopard, dhole, sloth bear, hyena, wolf, and jungle cat. Chital, sambar, gaur, nilgai, wild pig, barking deer and chowsingha are the wild ungulate species found in the area.

Sampling Details

a) Camera trap survey was carried out in two blocks for a period of 67 days (Fig. 9.26) with 234 camera trap resulting in a total area of 299.69 km^2 (minimum bounding polygon) (Table 9.42).

b) A total of 61 line transects were walked between 6:00 am to 8:30 am with a total effort of 343 km (Fig. 9.42, Table 9.43).

Table 9.42: *Sampling details and parameter estimates of tiger from camera trap based capture mark-recapture analysis in Pench Tiger Reserve (Madhya Pradesh), 2014.*

Variables	Estimates (SE)
Minimum bounding polygon (km^2)	299.69
Camera Points	234
Trap Nights (effort)	8443
Unique tigers captured	44
Model	g0(.)σ(.)
$\hat{D}$ ML SECR (SE) (per 100 km^2)	5.67 (0.87)
Sigma (SE) (km)	3.53 (0.13)
g0 (SE)	0.01 (0.001)

SE: Standard error

$\hat{D}$ML SECR: Density estimate from Maximum Likelihood based spatially explicit capture recapture

σ(Sigma): Spatial scale of detection function, g0: Magnitude (intercept) of detection function

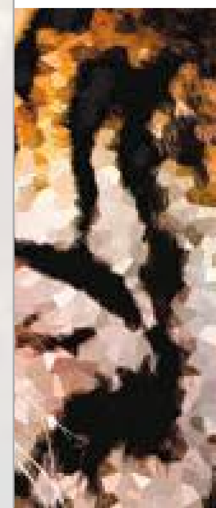


Figure 9.26: Distribution of camera traps (n=234) and line transect (n=61) in Pench Tiger Reserve (Madhya Pradesh), 2014

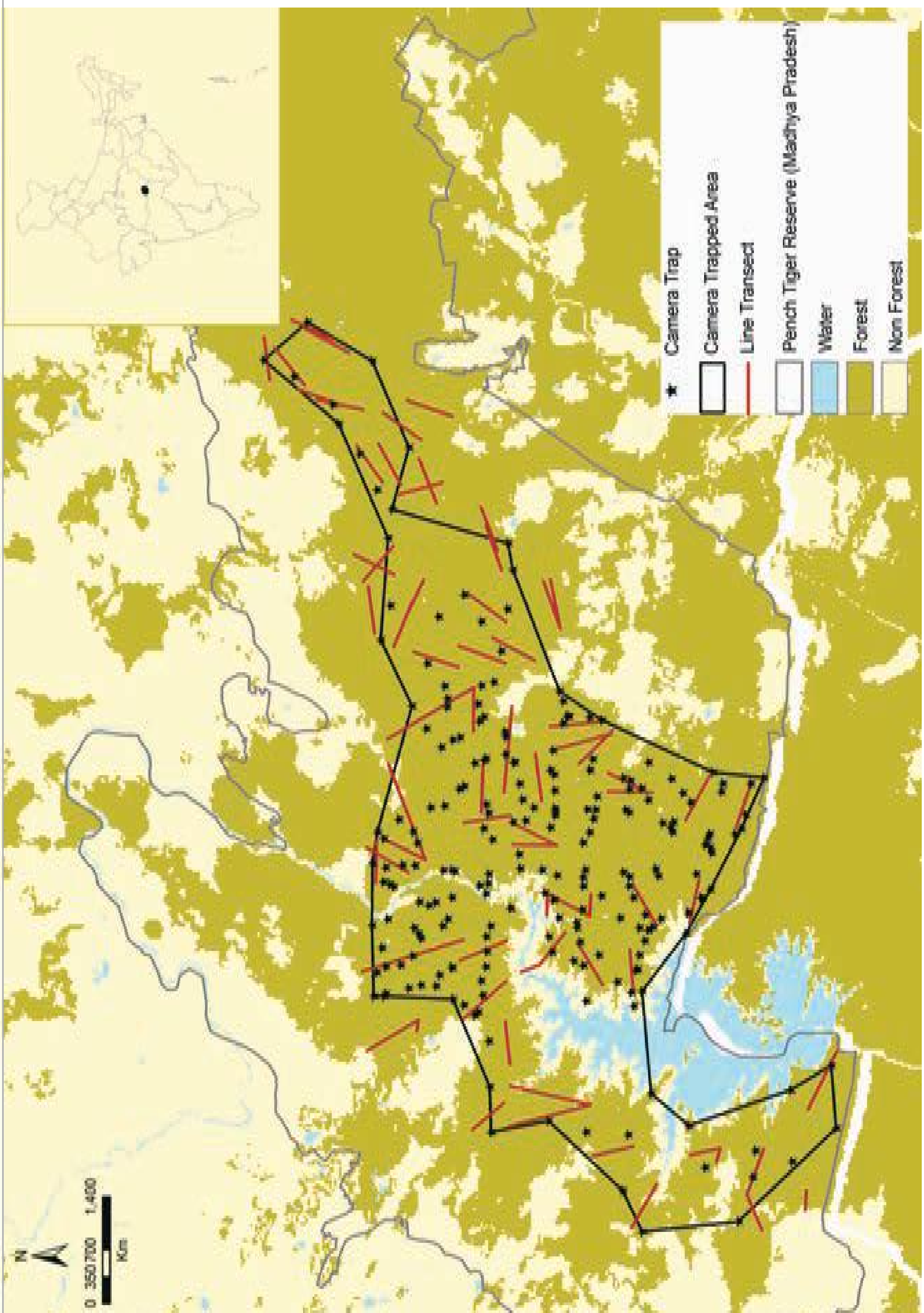
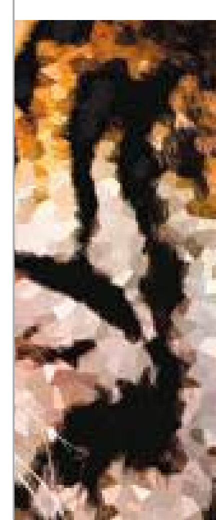


Table 9.43: *Model statistics and parameter estimates of line transect (n=61, total effort of 343 km) based distance sampling for prey species in Pench Tiger Reserve, Madhya Pradesh, 2014.*

Species	Model	Chi Sq P value	Effective Strip Width (SE)	No. Groups Detected	Mean Group size (SE)	Detection Probability (SE)	Encounter Rate per km	Group Density (SE) per km²	Individual Density (SE) per km²
Sambar	Half normal Cosine	0.81	45.62 (4.07)	90	2.64 (0.19)	0.29 (0.03)	0.26	2.87 (0.45)	7.59 (1.3)
Chital	Hazard Cosine	0.82	56.89 (2.75)	398	6.31 (0.29)	0.33 (0.02)	1.16	10.18 (1.44)	64.29 (9.61)
Langur	Half normal Cosine	0.99	43 (1.61)	308	5.91 (0.28)	0.25 (0.0)	0.89	10.43 (1.11)	61.64 (7.15)
Nilgai	Half normal Cosine	0.95	51.95 (8.73)	21	1.71 (0.22)	0.3 (0.05)	0.06	0.59 (0.18)	1.01 (0.33)
Peafowl	Hazard Cosine	0.83	52.75 (9.84)	47	1.51 (0.14)	0.44 (0.08)	0.14	1.29 (0.34)	1.96 (0.54)
Wild pig	Hazard Hermite	0.93	23.42 (8.7)	39	5.18 (0.86)	0.31 (0.11)	0.11	2.42 (1)	12.56 (5.59)
Gaur	NA	NA	NA	13	NA	NA	0.04	NA	NA
Barking Deer	NA	NA	NA	1	NA	NA	0.003	NA	NA
Chausinga	NA	NA	NA	2	NA	NA	0.006	NA	NA
Hare	NA	NA	NA	7	NA	NA	0.02	NA	NA
Jungle Fowl	NA	NA	NA	5	NA	NA	0.01	NA	NA
Rhesus macaque	NA	NA	NA	4	NA	NA	0.01	NA	NA

Pench tiger reserve is home to an important tiger population of the Satpura-Maikal landscape. Due to its strategic location, tigers disperse westward into Satpura and Melghat, southwards into Bor and Tadoba and eastward to Kanha and Navegoan-Nagzira tiger reserves. Due to good management, Pench has a good prey and tiger population. Hence, Pench serves a source population to dispersing tigers across the landscape.



Pench Tiger Reserve (Maharashtra)

Sanjay Bhagat[1], M. S. Reddy[1], Aditya Joshi[2], Milind Pariwakam[2], Vishal Bansod[2]
[1]Maharashtra Forest Department, [2]Wildlife Conservation Trust

Pench Tiger Reserve (Maharashtra) established in 1999, constitutes a unique ecosystem, comprising a wide variety of flora and fauna, including diverse and rich aquatic life and avifauna with unique natural scenic beauty. This Tiger Reserve includes Pench National Park (257 km2) and Mansingh Deo Wildlife Sanctuary (195 km2) and is located between the longitudes 790 04' E - 79024' E and latitudes 210 04' N - 210 43' N.

The general topography of Pench Tiger Reserve is mostly undulating, with a number of seasonal streams and nullahs flowing through it. It becomes flatter close to the Pench River, which cuts the reserve into two halves from north to south (Sankar et al. 2000b). The mean altitude is around 550 m above mean sea level. National highway NH49 (NH7) passes through the eastern part of the sanctuary, and will be detrimental for the connectivity of this population with adjoining forest, thus prevention measures are needed to minimize the impact.

Pench Tiger Reserve is classified under the biotic province 6E- Central Highlands (Rodgers & Panwar) and its sub division the Satpura Maikal landscape. Therefore, it has a tropical monsoonal climate, with a distinct Monsoon (July to September), Winter (November to February) and Summer (April to June).The mean annual rainfall is around 1400mm, with the south-west monsoon accounting for most of the rainfall in the region. For the dry season (November to May), the mean rainfall is 59.5mm, and the temperature varies from a minimum of 0°C in winter to 45°C in summer (Sankar et al. 2000). The forests are Tropical Moist deciduous forest and Tropical Dry Deciduous type, dominated by teak.

Sampling Details

a) Camera trapping was done from 25th February to 5th May 2014 covering an area of 322.72 km^2 (Fig. 9.27). Camera traps were placed at 176 locations (Table 9.44).

b) Forty one line transects (Fig. 9.27) were walked thrice with an effort of 247km (Table 9.45).

Table 9.44: Sampling details and parameter estimates of tiger from camera trap based capture mark-recapture analysis in Pench Tiger Reserve (Maharashtra), 2014.

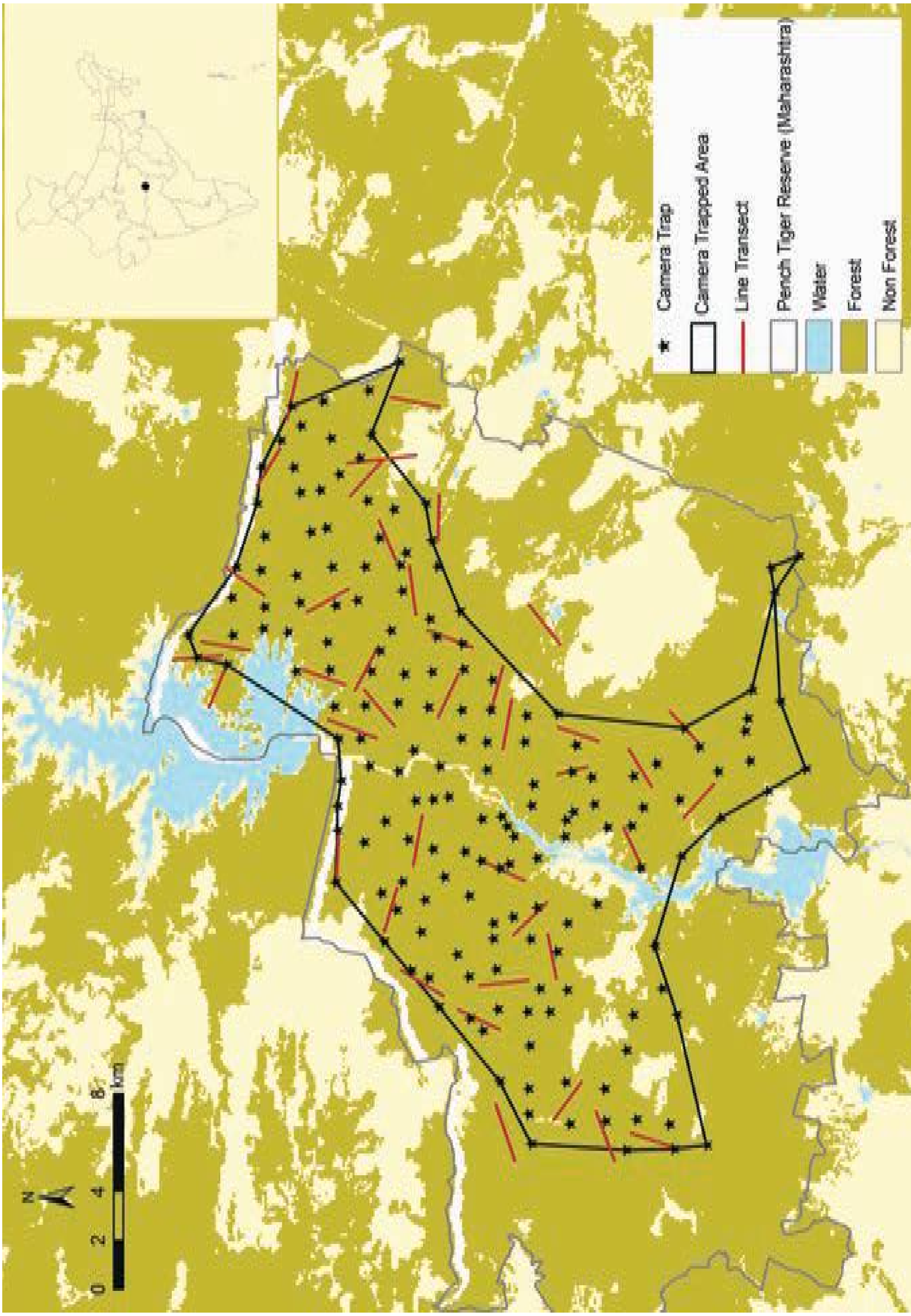
Variables	Estimates (SE)
Minimum bounding polygon (km^2)	322.72
Camera Points	176
Trap Nights (effort)	3032
Unique tigers captured	23
Model	g0(.) σ(.)
$\hat{D}$ ML SECR (SE) (per 100 km^2)	3.04 (0.62)
Sigma (SE) (km)	3.37 (0.16)
g0 (SE)	0.01 (0.001)

SE: Standard error

$\hat{D}$ ML SECR: Density estimate from Maximum Likelihood based spatially explicit capture recapture

σ(Sigma): Spatial scale of detection function, g0: Magnitude (intercept) of detection function

Figure 9.27: *Distribution of camera traps (n=176) and line transect (n=41) in Pench Tiger Reserve (Maharashtra), 2014*



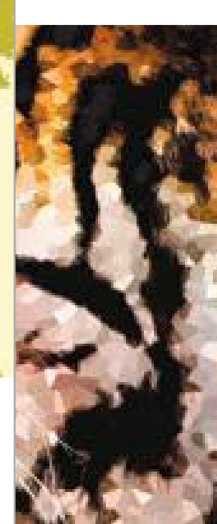


Table 4.45: Model statistics and parameter estimates of line transect (n=41, total effort of 258km) based distance sampling for prey species in Pench Tiger Reserve, Maharashtra 2014.

Species	Model	Chi Sq P value	Effective Strip Width (SE)	No. Groups Detected	Mean Group size (SE)	Detection Probability (SE)	Encounter Rate per Km	Group Density (SE) per km²	Individual Density (SE) per km²
Chital	Half normal Cosine	0.79	46.58 (3.97)	77	4.7 (0.45)	0.47 (0.04)	0.31	3.34 (1.46)	15.69 (7.14)
Sambar	Hazard Polynomial	0.72	23.25 (6.06)	27	2.81 (0.39)	0.29 (0.07)	0.11	2.34 (0.98)	6.6 (2.9)
Gaur	NA	NA	NA	4	NA	NA	0.02	NA	NA
Four-horned antelope	NA	NA	NA	2	NA	NA	0.01	NA	NA
Langur	Hazard cosine	0.76	34.42 (3.69)	70	3.64 (0.47)	0.46 (0.05)	0.28	4.11 (1.24)	14.96 (4.9)
Barking deer	Half normal cosine	0.99	40.33 (11.84)	10	1	0.75 (0.22)	0.04	0.48 (0.22)	0.48 (0.22)
Wildpig	Uniform cosine	0.97	49.18 (6.69)	19	7.84 (3.23)	0.59 (0.08)	0.07	0.78 (0.25)	6.12 (3.21)

Pench Tiger Reserve Maharashtra is on its way to recovery with appropriate management inputs. Prey and tiger populations are on the increase and the current strategy of management needs to continue. Coordination with Pench Madhya Pradesh is essential since the tiger population and management problems are shared issues.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Navegaon Nagzira Tiger Reserve (Maharashtra)

Sanjay Bhagat[1], Aditya Joshi[2], Ankur Kali[2], Milind Pariwakam[2], Vivek Tumsare[2].
[1]Maharashtra Forest Department, [2]Wildlife Conservation Trust

The Navegaon Nagzira Tiger Reserve (NNTR) is situated in the eastern most part of the state of Maharashtra. It lies between 21^{0} 12' N - 21^{0} 21' N latitudes and 79^{0} 58' E - 80^{0} 11' E longitudes. Navegaon Nagzira Tiger Reserve comprises of Navegaon National Park (129.55 km^2), Nagzira Wildlife sanctuary (152.41 km^2), Navegaon Wildlife sanctuary (122.76 km^2), New Nagzira Wildlife Sanctuary (151.33 km^2) and Kota Wildlife Sanctuary (97.62 km^2), resulting in a total area of 653.67 km^2. The Tiger Reserve lies within the tropical zone, the annual mean maximum and minimum temperature is between 33.8° C to 21.5° C, having three distinct seasons viz. summer (March-June), monsoon (July-October) and winter (November-February). The annual rain fall is 807 mm. After being declared as a Tiger Reserve the area has shown good recovery of wildlife and now has a small breeding tiger population. NNTR is strategically located between Kanha-Tadoba and Pench-Tadoba and serves to enhance the metapopulation structure of this landscape.

The forest belongs to the category of Southern Tropical Dry Deciduous. NNTR serves as a living repository of various economical, medicinal, aromatic, ornamental plant species with about 200 tree species. The major tree species are Terminalia allata, Tectona grandis, Lagerstroemia purviflora, and Anogeissus latifolia. Climbers which are of common occurrence are Combretum decandrum, Zizyphus oenoplia, and Calycopteris floribunda. Grasses include Themeda quadrivalvia, Iseilema laxum. Apluda varia, Eragrostis tennella, Cynodon dactylon, Imperata cylindrica and near the lake Vetiveria zizyniodes, Heteropogan contortus, and Schima nervosum are found.

Large mammalian fauna found here are: tiger, leopard, wolf, sloth bear, ratel, golden jackal jungle cat, gaur, sambar, chital, four horned antelope, mouse deer, and pangolin.

Sampling Details

a) Camera trap field surveys were carried out in Navegaon-Nagzira from 05/04/2014 to 08/06/2014 (Fig. 9.28). A total of 205 camera trap stations were setup and sampled for 65 occasions. Additionally, adjacent Reserved Forests (11 trap stations) were also surveyed, together accounting for a cumulative sampling effort of 13940 trap nights (Table 9.46).

Table 9.46: Sampling details and parameter estimates of tiger from camera trap based capture mark-recapture analysis in Navegaon Nagzira Tiger Reserve, 2014.

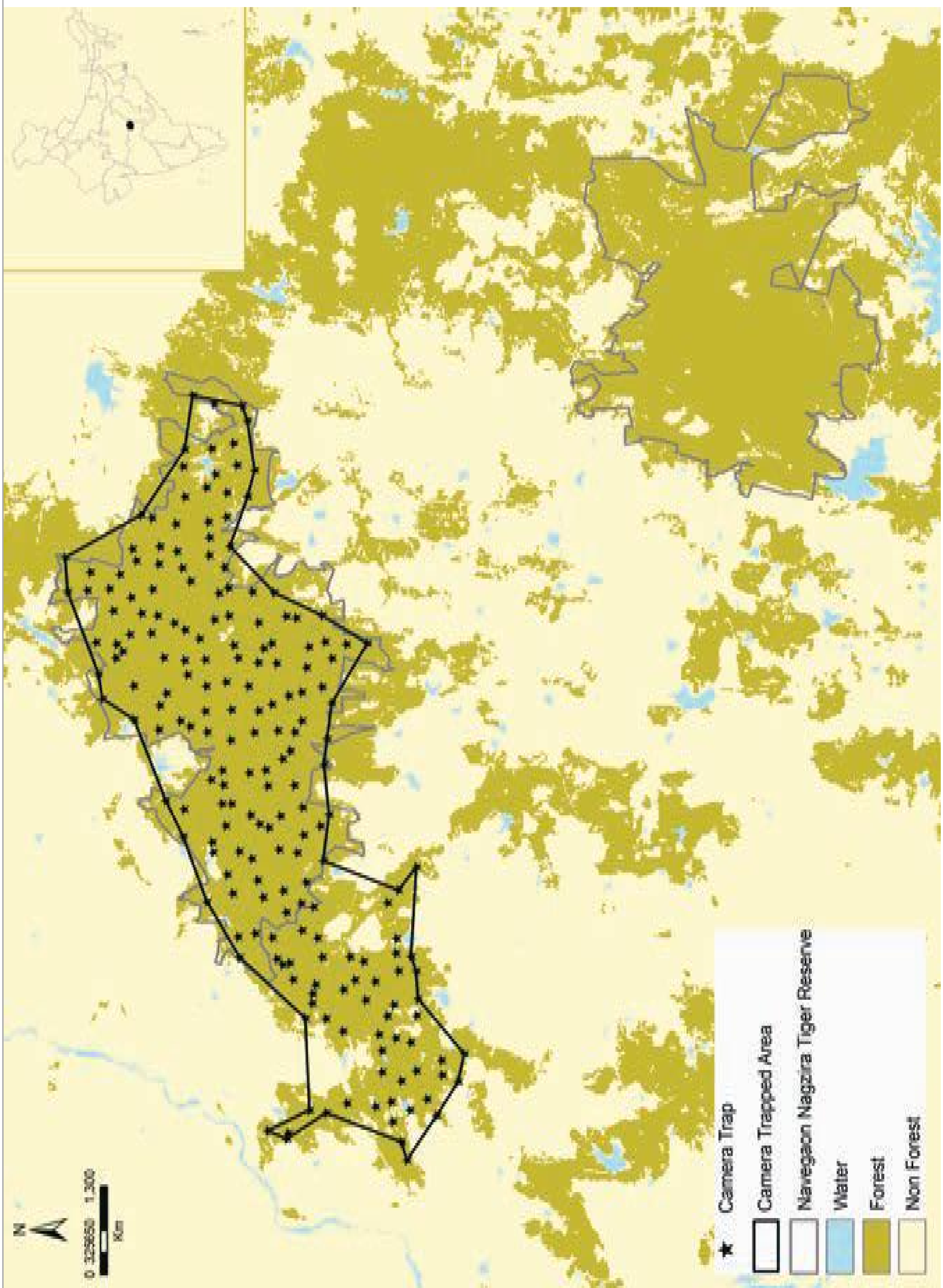
Variables	Estimates (SE)
Minimum bounding polygon (km^2)	400.35
Camera Points	205
Trap Nights (effort)	13940
Unique tigers captured	6
Model	g0(.)σ(.)
$\hat{D}$ ML SECR (SE)(per 100 km^2)	0.95 (0.41)
Sigma (SE) (km)	3.77 (0.24)
g0 (SE)	0.01 (0.001)

SE: Standard error

$\hat{D}$ ML SECR: Density estimate from Maximum Likelihood based spatially explicit capture recapture

σ(Sigma): Spatial scale of detection function, g0: Magnitude (intercept) of detection function

Figure 9.28: *Distribution of camera traps (n=205) in Navegaon Nagzira Tiger Reserve, 2014*



Bor Tiger Reserve (Maharashtra)

Sanjay Bhagat[1], M. S. Reddy[1], Aftab A. Usmani[3], Aditya Joshi[2], Milind Pariwakam[2], Vishal Bansod[2].
[1]Maharashtra Forest Department, [2]Wildlife Conservation Trust, [3]Wildlife Institute of India

Bor Wildlife Sanctuary was declared as a tiger reserve in July 2014 and is located near Hingi in Wardha District of Maharashtra. The sanctuary covers an area of 121.1 km^2 which includes the Bor Dam. The sanctuary is located at latitude 20° 58' N and longitude 78° 40' E. It includes two ranges having a total of 15 beats. The Bor sanctuary is an important 'satellite' area which has the potential to serve as a 'stepping stone' for tigers dispersing between Pench, Melghat and Tadoba. The sanctuary needs enhanced protection and habitat management, especially in the adjacent forest areas. Forest fire is a major concern in Bor.

Sampling Details

a) Camera trapping was carried out from 01.01.2014 to 19.02.2014 (Fig. 9.29). A total of 135 camera trap stations were setup and sampled for 52 occasions resulting in an effort of 7020 trap nights. The minimum bounding polygon was 95.50 km^2 (Table 9.47).

Table 9.47: Sampling details and parameter estimates of tiger from camera trap based capture mark-recapture analysis in Bor Wildlife Sanctuary, 2014.

Variables	Estimates (SE)
Minimum bounding polygon (km^2)	95.50
Camera Points	135
Trap Nights (effort)	7020
Unique tigers captured	5
Model	g0(.)σ(.)
$\hat{D}$ ML SECR (SE) (per 100 km^2)	1.31 (0.62)
Sigma (SE) (km)	6.08 (1.11)
g0 (SE)	0.01 (0.001)

SE: Standard error

$\hat{D}$ ML SECR: Density estimate from Maximum Likelihood based spatially explicit capture recapture

σ(Sigma): Spatial scale of detection function, g0: Magnitude (intercept) of detection function

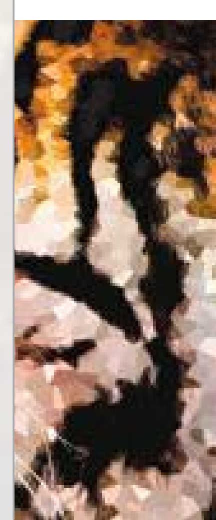
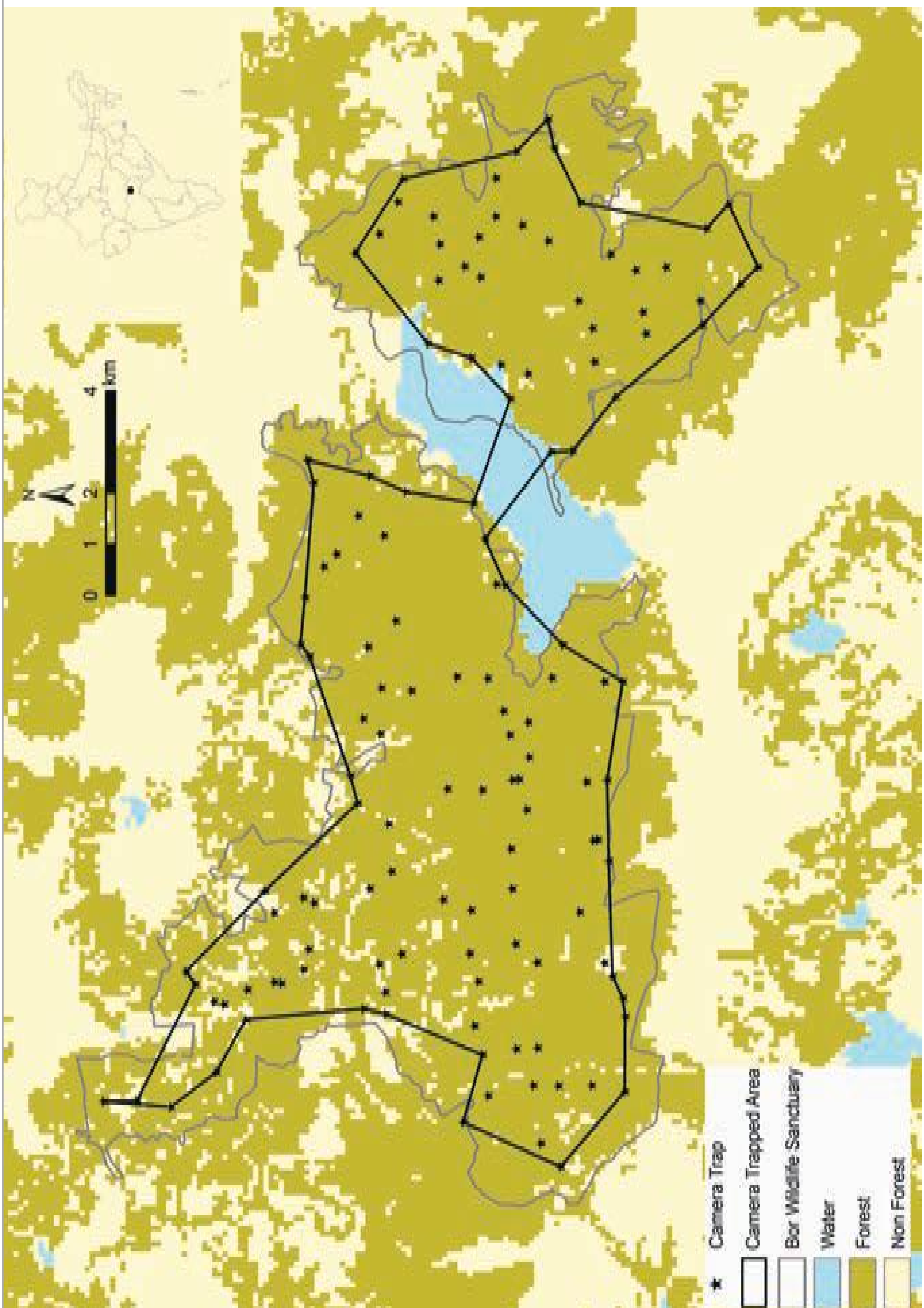


Figure 9.29: Distribution of camera traps (n=135) in Bor Tiger Reserve, 2014.



Umred Karhandla Wildlife Sanctuary (Maharashtra)

Sanjay Bhagat[1], M. S. Reddy[1], Aditya Joshi[2], Milind Pariwakam[2], Vishal Bansod[2].
[1]Maharashtra Forest Department, [2]Wildlife Conservation Trust

Umred Karhandla Wildlife Sanctuary is situated in Nagpur district of Maharashtra covering a total area of 189 km^2. It is located at 20° 50' 08" N latitude and 79° 30' 40" E longitude. The sanctuary covers two divisions, Nagpur Division (Kuhi and Bhiwapur Range) and Bhandara Division (Pauni Range), which are divided along the Maru River that flows close to Bhiwapur and joins the Vainganga River. The reserve is roughly bounded by the Wainganga River and the Gosikhurd Dam on the northeast, State Highway 9 and Bhiwapur Town on the south, Umred on the west and a narrow 10 km long range of 600 – 800 m hills to the northwest. It is located 40 km north of Tadoba-Andhari Tiger Reserve and 50 km southwest of Nagzira Wildlife Sanctury and Pench Tiger Reserve is 80 km to the northwest.

The sanctuary is home to gaur, chital, barking deer, nilgai, wild pig, sambar, and blackbuck, and carnivores

Sampling Details

a) Camera trapping operation was carried out from 09.05.2014 to 11.06.2014 (Fig. 9.30). A total of 141 camera trap stations were setup resulting in an effort of 4794 trap nights. The minimum bounding polygon was 103 km^2 (Table 9.48). Only two individual tigers were photo-captured during the camera trapping session, hence density estimates in SECR framework couldn't be done.

b) A total of 24 spatial transects were sampled (Fig. 9.35) with a walk effort of 151.14 km (Table 9.49). Density estimation was not done as number of sightings were too low.

Table 9.48: Sampling details and parameter estimates of leopard from camera trap based capture mark-recapture analysis in Umred Karhandla Wildlife Sanctuary, 2014.

Variables	Estimates (SE)
Minimum bounding polygon (km^2)	102.63
Camera Points	141
Trap Nights (effort)	4794
Unique leopards captured	13
Model	g0(.) σ(.)
$\hat{D}$ ML SECR (SE)(per 100 km^2)	6.32 (1.790
Sigma (SE) (km)	1.95 (0.17)
g0 (SE)	0.01 (0.003)

SE: Standard error

$\hat{D}$ ML SECR: Density estimate from Maximum Likelihood based spatially explicit capture recapture

σ(Sigma): Spatial scale of detection function, g0: Magnitude (intercept) of detection function

Table 9.49: Encounter rates of prey species seen on line transects (n=24, total effort of 151.14 km) in Umred Karhandla Wildlife Sanctuary, 2014.

Species	No. Groups Detected	Encounter Rate per Km
Chital	8	0.05
Sambar	1	0.007
Langur	8	0.05
Wild pig	9	0.06
Chousingha	2	0.01

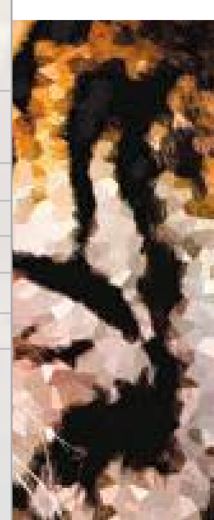
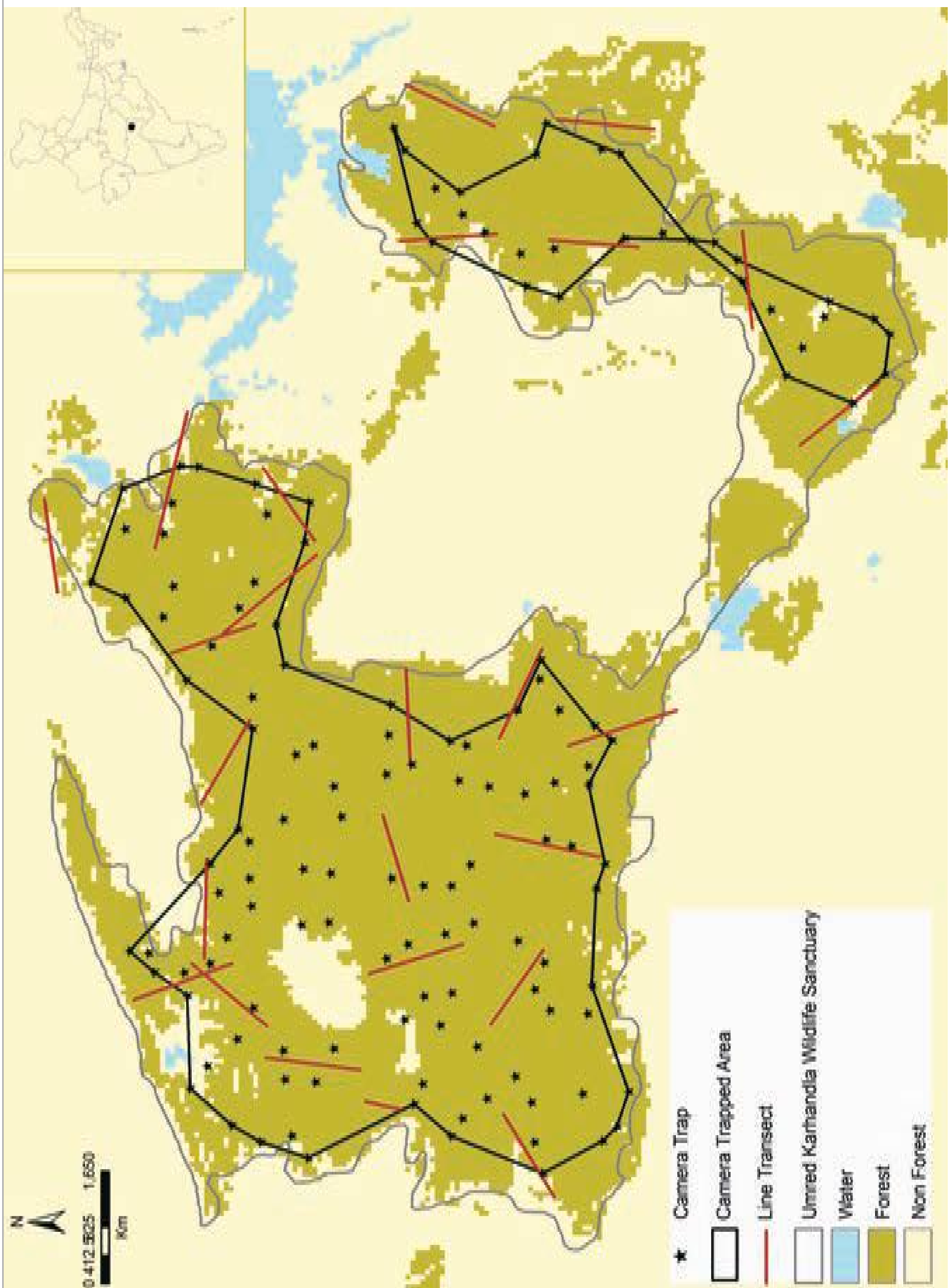


Figure 9.30: *Distribution of camera traps (n=141) and line transects (n=24) in Umred Karhandla Wildlife Sanctuary, 2014.*



Tadoba Andhari Tiger Reserve (Maharashtra)

Bilal Habib, Aftab A. Usmani, Kainat Latafat, Madhura Davate, Anil Dashare, Nilanjan Chatterjee, Rutu Prajapati, Urjit Mahesh Bhatt, Y.V. Jhala, Qamar Qureshi.
Wildlife Institute of India

The Tadoba Andhari Tiger Reserve (TATR) is situated in Chandrapur district in the eastern part of Maharashtra state between 20°04' N - 20°25' N latitudes and 79°13' E - 79°33' E longitudes, comprising of a core area of 625 km² and a buffer of 1101 km². It is situated at a distance 45 km from Chandrapur and is about 208 km from Nagpur. TATR covers a landscape that is an interspersion of grasslands, water bodies and dry tropical deciduous forests, along with patches of riparian forest alongside streams (Champion and Seth 1968). Tadoba is the most important tiger source population in this landscape, and is responsible for maintaining a large metapopulation in Maharashtra.

Teak is the predominant tree species. Patches of grasses are found throughout the reserve. Bamboo is spread over 40% of the habitat. Tadoba Lake acts as a buffer between the park's forest and the extensive farmland which extends up to Irai water reservoir. Other wetland areas within the reserve include the Kolsa Lake and Andhari River. Most of the annual rainfall (1175 mm) is received between June and September, with a minimum temperature of about 21° C in December, rising to a maximum of about 48° C in May.

A rich variety of animal species inhabit this region, including 41 species of mammals, 195 species of birds, 74 species of butterflies and 30 species of reptiles (Khawarey & Karnat, 1997; Marathe et al. 2002; Nagendra et al. 2006). Large mammals include tiger, leopard, dhole, wolf, jackal, jungle cat, gaur, chital, sambar, nilgai, wild pig, and barking deer.

Sampling Details

a) Camera trap sampling was carried out in two blocks, with 170 and 117 trap locations in each block, covering an area of 529.36 km² (Fig. 9.31). Camera traps were operated from February to April, 2014. (Table 9.50).

b) There were 57 spatial transects (Fig. 9.31) walked with 4 replicates, resulting in a total walk effort of 570 km (Table 9.51).

Table 9.50: Sampling details and parameter estimates of tiger from camera trap based capture mark-recapture analysis in Tadoba Andhari Tiger Reserve, 2014.

Variables	Estimates (SE)
Minimum bounding polygon (km^2)	529.37
Camera Points	322
Trap Nights (effort)	14656
Unique tigers captured	47
Model	g0(.) σ(.)
$\hat{D}$ ML SECR (SE) (per 100 km^2)	4.85 (0.72)
Sigma (SE) (km)	3.31 (0.11)
g0 (SE)	0.01 (0.001)

SE: Standard error

$\hat{D}$ ML SECR: Density estimate from Maximum Likelihood based spatially explicit capture recapture

σ(Sigma): Spatial scale of detection function, g0: Magnitude (intercept) of detection function

Figure 9.31: Distribution of camera traps (n=322) and line transects (n=57) in Tadoba Andhari Tiger Reserve, 2014.

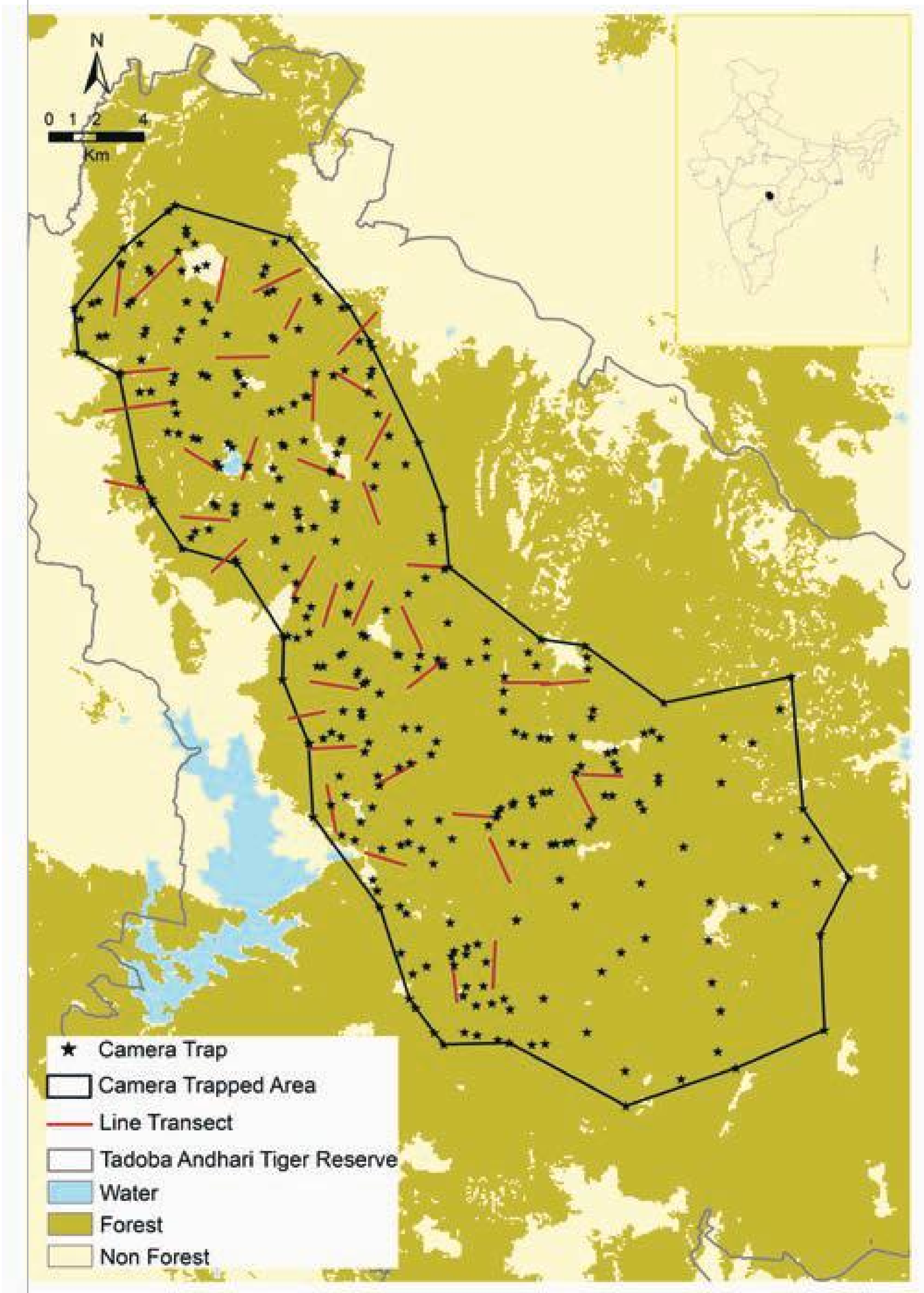
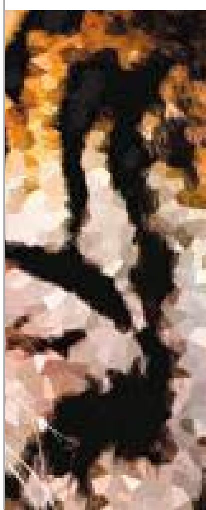


Table 9.51: Model statistics and parameter estimates of line transect (n=57, Total effort 570 km) based distance sampling for prey species in Tadoba Andhari Tiger Reserve, 2014.

Species	Model	Chi Sq P Value	Effective Strip Width (SE)	No. Groups Detected	Mean Group size (SE)	Detection Probability (SE)	Encounter Rate per Km	Group Density (SE) per km^2	Individual Density (SE) per km^2
Barking Deer	Half normal Cosine	0.83	44.82 (6.28)	32	1.15 (0.07)	0.47 (0.06)	0.06	0.62 (0.15)	0.75 (0.19)
Chital	Half normal Cosine	0.63	45.3 (5.6)	51	5.07 (0.55)	0.56 (0.07)	0.08	0.98 (0.33)	4.87 (1.74)
Gaur	Hazard rate Cosine	0.5	53.18 (8.67)	37	3.43 (0.41)	0.35 (0.05)	0.06	0.61 (0.16)	1.92 (0.59)
Wild pig	Hazard Cosine	0.66	29.64 (7.3)	22	5.5 (1.17)	0.59 (0.14)	0.038	0.65 (0.25)	2.76 (1.34)
Hare	Hazard Cosine	0.81	24.09 (3.26)	30	1.13 (0.06)	0.68 (0.09)	0.05	1.09 (0.27)	1.17 (0.3)
Langur	Half normal Cosine	0.56	43.13 (6.28)	47	10.17 (1.01)	0.77 (0.11)	0.08	0.95 (0.23)	6.85 (1.81)
Peafowl	Uniform Cosine	0.92	25.92 (1.63)	47	2.27 (0.18)	0.51 (0.03)	0.08	1.5 (0.3)	3.49 (0.79)
Nilgai	Uniform Cosine	0.64	57.82 (5.88)	21	3.14 (0.6)	0.52 (0.05)	0.04	0.31 (0.11)	1.16 (0.49)
Sambar	Hazard Cosine	0.59	39.91 (4.69)	81	2.30 (0.15)	0.23 (0.02)	0.14	1.8 (0.44)	4.10 (1.03)

Tadoba Tiger Reserve is home to the largest tiger population in Maharashtra. It is connected to the north and east to Bor and Navegoan-Nagzira tiger reserves through patchy forest fragments and agriculture mosaic. This is a landscape of conflict as tigers have established populations in this habitat matrix and predate on livestock and sometimes on humans. Habitat connectivity to the south is threatened by development projects and mining activity. This southward connectivity to Tipeshwar and Indravati is important for metapopulation dynamics.



Similipal Tiger Reserve (Odisha)

Ashok Kumar, Aftab Usmani, Deb Ranjan Laha, Narendra Mohan Katara, Roshan Puranik, Sudip Banerjee, Urjit Mahesh Bhatt, Vineet Dubey, S. P. Yadav, Y.V. Jhala, Qamar Qureshi.
Wildlife Institute of India.

The Similipal Tiger Reserve is a compact block of elevated plateau located in the central portion of the Mayurbhanj district, in the northern most part of Odisha, and lies between 20° 17' and 22° 34' north latitudes and 85° 40' and 87° 10' east longitudes. The core and buffer encompasses an area of 1194.75 km^2 and 1555.25 km^2 respectively, with the total area of the tiger reserve being 2750 km^2.

The terrain is mostly undulating and hilly, interspersed with open grasslands and wooded areas. Similipal is located in the Deccan Peninsular Bio-geographic Zone, Chhotanagpur Province and Mahanadian biogeographic region. An astounding 1078 species of plants, including 94 species of orchids, are reported from the park. The vegetation is a mix of different forest types and habitats, with northern tropical moist deciduous dominating some semi-evergreen patches. Similipal harbours a unique blend of Eastern Ghats with elements from Western Ghats and Sub-Himalayan plant species. Sal is the dominant tree species here.

There are 55 species of mammals, 361 species of birds, 62 species of reptiles, 21 species of amphibians, 38 species of fishes and 164 species of butterflies recorded from the Park. Similipal harbours the largest population of elephants in Odisha. Gaur is found in few localised pockets and in small herds. The major ungulate species found in Similipal are sambar, chital, barking deer and mouse deer. Poaching of prey animals is rampant and urgent mitigation measures are required. The major carnivores here include tiger and leopard. Other carnivores are leopard cat, fishing cat, jungle cat, and wolf. This is the only Protected Area in the world where the melanistic form of tiger is found. This tiger population is showing signs of decline and urgent mitigation measures are required to ensure the safety of this population.

Sampling Details

a) The camera trapping session was carried out from 24.11.2014 to 28.12.2014 for block 1 and 28.12.2014 to 27.01.2015 for block 2 (Fig. 9.32). The minimum bounding polygon was 369 km^2 (Table 9.52).

b) A total of 30 line transects (Fig. 9.32) were surveyed each with a temporal replicate of three with total walk effort of 182.24 km (Table 9.53).

Variables	Estimates (SE)
Minimum bounding polygon (km^2)	369
Camera Points	298
Trap Nights (effort)	4990
Model	g0(.)σ(.)
Unique tigers captured	5
$\hat{D}$ ML SECR (SE) (per 100 km^2)	0.48 (0.20)
Sigma (SE) (km)	3.90 (0.28)
g0 (SE)	0.03 (0.01)

Table 9.52: Sampling details and parameter estimates of tiger from camera trap based capture mark-recapture analysis in Simlipal Tiger Reserve, 2014.

SE: Standard error

$\hat{D}$ ML SECR: Density estimate from Maximum Likelihood based spatially explicit capture recapture

σ(Sigma): Spatial scale of detection function, g0: Magnitude (intercept) of detection function

Figure 9.32: *Distribution of camera traps (n=298) and line transects (n=30) in Simlipal Tiger Reserve, 2014*

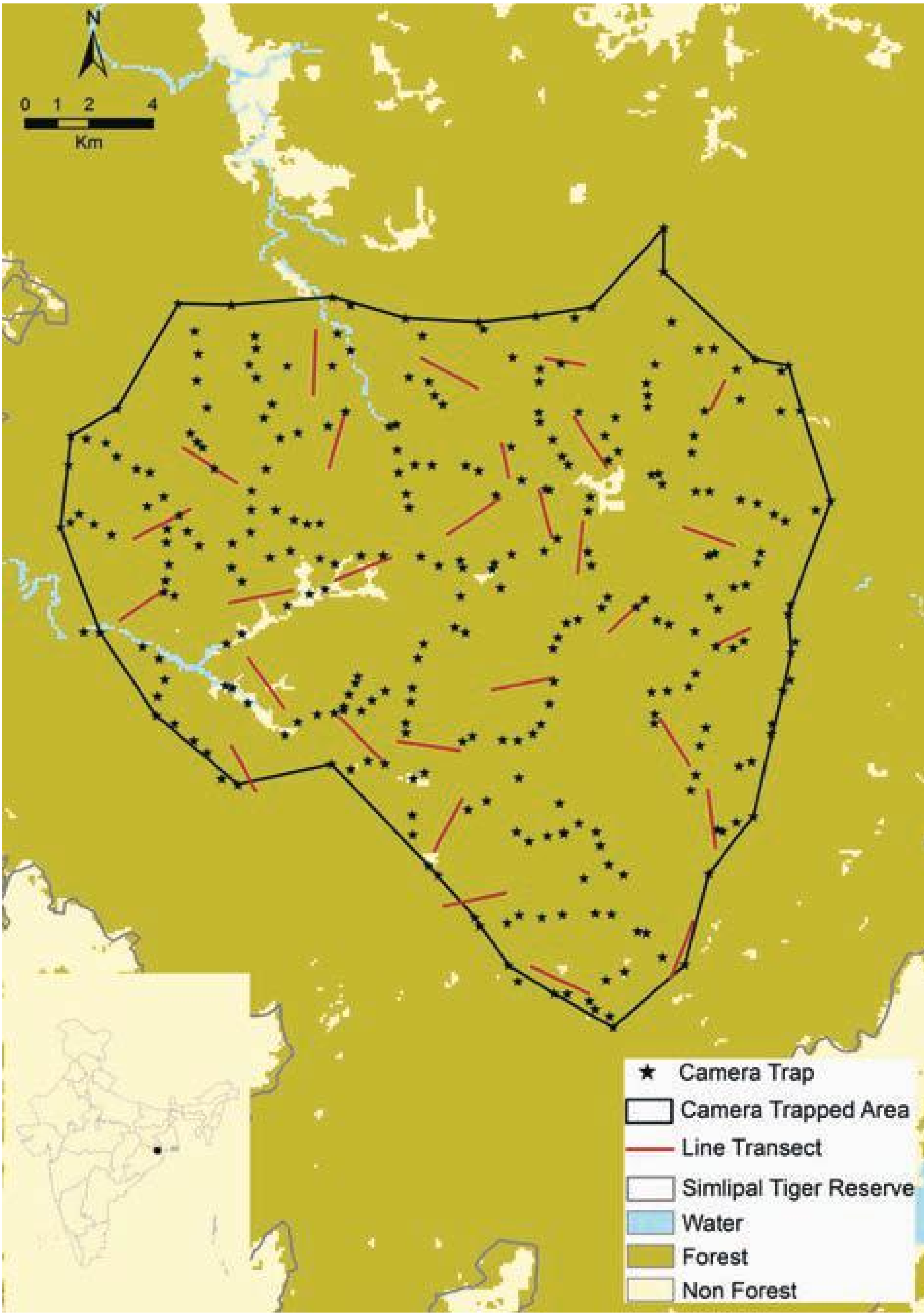


Table 9.53: Model statistics and parameter estimates of line transects (n=30, total effort of 182.24 km) based distance sampling for prey species in Simlipal Tiger Reserve, 2014.

Species	Model	Chi Sq P Value	Effective Strip Width (SE)	No. Groups Detected	Mean Group size (SE)	Detection Probability (SE)	Encounter Rate per Km	Group Density (SE) per km^2	Individual Density (SE) per km^2
Barking Deer	Half normal Hermite polynomial	0.91	28.47 (6.02)	22	1.05 (0.05)	0.71 (0.15)	0.12	2.12 (0.82)	2.22 (0.86)
Langur	Half normal Cosine	0.72	49.02 (11.13)	16	3.81 (0.66)	0.65 (0.15)	0.09	0.90 (0.35)	3.41 (1.45)
Chital	NA	NA	NA	3	NA	NA	0.02	NA	NA
Mouse deer	NA	NA	NA	4	NA	NA	0.02	NA	NA
Wildpig	NA	NA	NA	5	NA	NA	0.03	NA	NA
Sambar	Half normal Cosine	0.86	27.78 (4.64)	25	2.2 (0.33)	0.56 (0.09)	0.14	2.47 (0.69)	3.79 (1.16)

Kawal Tiger Reserve (Telangana)

Ahana Dutt, Naitik Patel, Ridhima Solanki, Vineet Dubey, Y.V Jhala, Qamar Qureshi
Wildlife Institute of India

Kawal Tiger Reserve declared in April 2012, is situated in Adilabad district Telangana (formerly Andhra Pradesh). It lies between 19° 50' - 19° 20' North longitudes and 79°32' – 79°12' East latitudes. It has a core area of 892.23 km^2 and a buffer of 1123.21 km^2. This area is drained by the Kadam River, which empties into the Godavari; apart from that, the area has a very good network of rain-fed seasonal small streams flowing through it. Summer starts from February and lasts till the end of June, with temperature peaking upto 45°C. The average annual rainfall ranges from 900mm-1100mm, receiving both south-west and north-east monsoons. The cold weather commences towards the end of November, with a minimum temperature upto 8°C. Winter lasts upto the second week of February. The open forest is of southern tropical dry deciduous type, dominated by teak and bamboo. The terrain is mostly undulating, with the altitude ranging between 152 meter to 610 meter above mean sea level.

State highway runs through the core. Both the core and buffer area are inhabited by tribals and often encroached by local people. Poaching of wildlife, hunting, tree smuggling, bamboo-cutting, sand-mining, grazing, land transformation (fast conversion into agriculture fields), hunting by feral dogs and mahua and bidi leaf collection have been observed to be severe problems in the area.

Sampling Details

a) Camera trapping was done from 7th May 2014 to 14th June 2014, in an area of 135.42 km^2 (Fig. 9.33) as there was no bigger undisturbed block of forest available. Camera traps were placed at 56 locations, the sampling effort being 2184 trap nights (Table 9.54).

b) Line transects (n=24) were walked from 3rd to 13th June 2014 with a total effort of 47.6 km (Fig. 9.33). The number of observations for prey was too low to carry out analysis, hence only encounter rate has been provided (Table 9.55).

Table 9.54: Sampling details and parameter estimates of leopard from camera trap based capture mark-recapture analysis in Kawal Tiger Reserve, 2014.

Variables	Estimates (SE)
Minimum bounding polygon (km^2)	135.42
Camera Points	56
Trap Nights (effort)	2184
Model	g0(.)σ(.)
Unique leopards captured	8
$\hat{D}$ ML SECR (SE) (per 100 km^2)	2.23 (0.84)
Sigma (SE) (km)	2.93 (0.38)
g0 (SE)	0.01 (0.004)

SE: Standard error

$\hat{D}$ ML SECR: Density estimate from Maximum Likelihood based spatially explicit capture recapture

σ(Sigma): Spatial scale of detection function, g0: Magnitude (intercept) of detection function

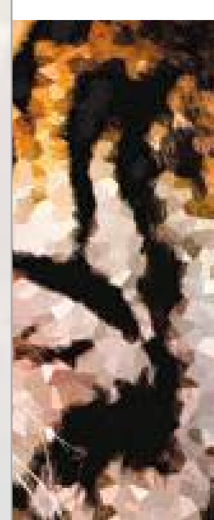
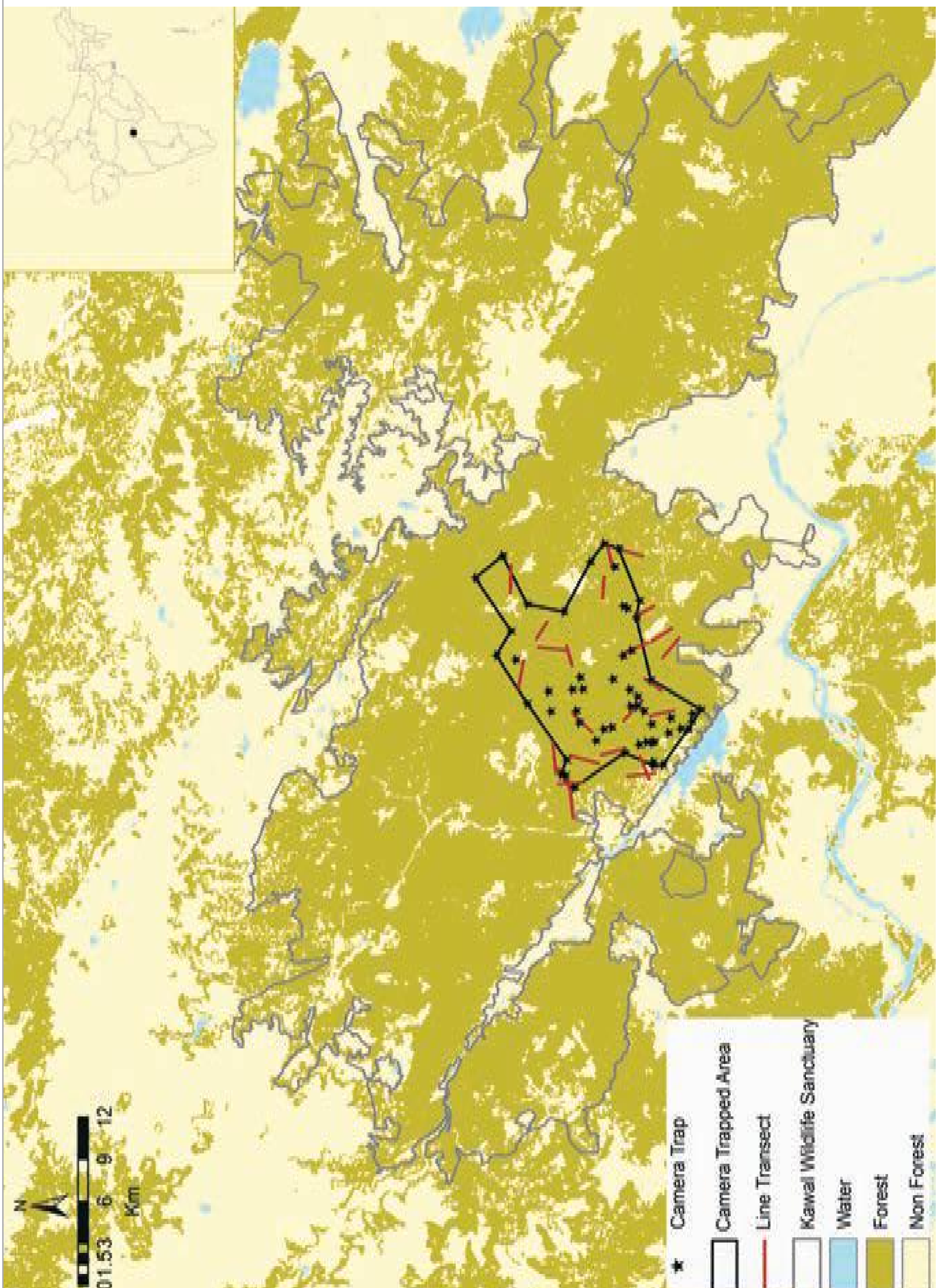


Figure 9.33: *Distribution of camera traps (n=56) and line transects (n=24) in Kawal Tiger Reserve, 2014.*



No tiger has been photo captured during camera trapping session, but there are reports of tiger presence in the region. Ungulate sightings were too few for density estimation.

Table 9.55: Encounter rates of prey species seen on line transects (n=24, total effort of 47.6km) in Kawal Tiger Reserve, 2014.

Species	No. of groups detected	Encounter Rate per Km
Nilgai	5	0.11
Chital	4	0.08
Wildpig	4	0.08
Four-horned antelope	4	0.08
Rhesus macaque	1	0.02
Langur	1	0.02

The Kawal Tiger Reserve covers a vast stretch of forest, which if managed well would act as a suitable habitat for tigers and other wildlife. Currently the reserve does not have a resident tiger population, but due to its strategic location in Northern Telengana (part of former Andhra Pradesh), with connectivity to Indravati Tiger Reserve in Chhattisgarh and Tadoba-Andhari Tiger Reserve in Maharashtra, there is potential for Kawal Tiger Reserve to be repopulated by tigers with restorative management inputs primarily through reduction of human use and pressures.

Nagarjunasagar Srisailam Tiger Reserve (Andhra Pradesh)

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[1]Wildlife Institute of India, [2]Nagarjunsagar Srisailam Tiger Reserve

Nagarjunasagar Srisailam Tiger Reserve (NSTR) is the largest Tiger Reserve in India, which lies in the Eastern Ghats of Andhra Pradesh. NSTR spreads over an area of 5938.09 km^2, which includes an area of 1194 km^2 of Gundla Brahmeswaram Wildlife sanctuary (GBM) that is notified as an extended core to NSTR. The reserve spreads in the Deccan plateau, lies in between latitudes 15^{0}45' N - 16^{0}45' N and longitudes 78^{0}15' E - 79^{0}45' E. The altitude of the park varies from 200m to 900m. Major portion of rainfall is received from the southwest monsoon, which generally sets in the second half of June and till the upto first week of October.

Here, the southern dry mixed deciduous forest overlaps with teak bearing forest. Tectona grandis and Terminalia tomentosa are common throughout. Boswellia serata and Hardwickia binnata are found at dry hilly places. Wild herbivores found are, chital, sambar, barking deer, mouse deer, nilgai, chowsingha and wild pig. Among the large carnivores, tiger, leopard, wild dog, hyaena, and sloth bear are present.

There are 24 villages situated in the core area of NSTR. There are two tribal communities in the park, the Chenchus and Lambadas, who along with their livestock, are dependent on the park resources.

Sampling Details

a) Camera trap field surveys were carried out in NSTR in 2 blocks from December 2013 to July 2014. A total of 225 camera trap stations were setup, with a grid size of 1 km^2. Camera trapping sessions were also carried out in G.V. Palli and GBM from May 2013 to July 2014 (Fig. 9.34), and sampled over 48 occasions (Table 9.56).

b) Line transect surveys were carried out from March to July 2014, where 107 spatial transects were walked with an overall effort of 226.57 km during morning hours from 0600 to 0800 hour (Fig. 9.34) The number of observations for prey was too low to carry out analysis, hence only encounter rate has been provided (Table 9.57).

Varibles	Estimates (SE)
Minimum bounding polygon (km^2)	1233.64
Camera Points	225
Trap Nights (effort)	20777
Unique tigers captured	29
Model	g0(.) σ(.)
$\hat{D}$ ML SECR (SE) per 100 km^2	0.85 (0.16)
Sigma (SE) (km)	7.66 (0.34)
g0 (SE)	0.005 (0.0006)

Table 9.56: Sampling details and parameter estimates of tiger from camera trap based capture mark-recapture analysis in NSTR, 2014.

SE: Standard error

$\hat{D}$ ML SECR: Density estimate from Maximum Likelihood based spatially explicit capture recapture

σ(Sigma): Spatial scale of detection function, g0: Magnitude (intercept) of detection function

Figure 9.34: Distribution of camera traps (n=449) and line transects (n=107) in Nagarjunsagar Srisailam Tiger Reserve, 2014.

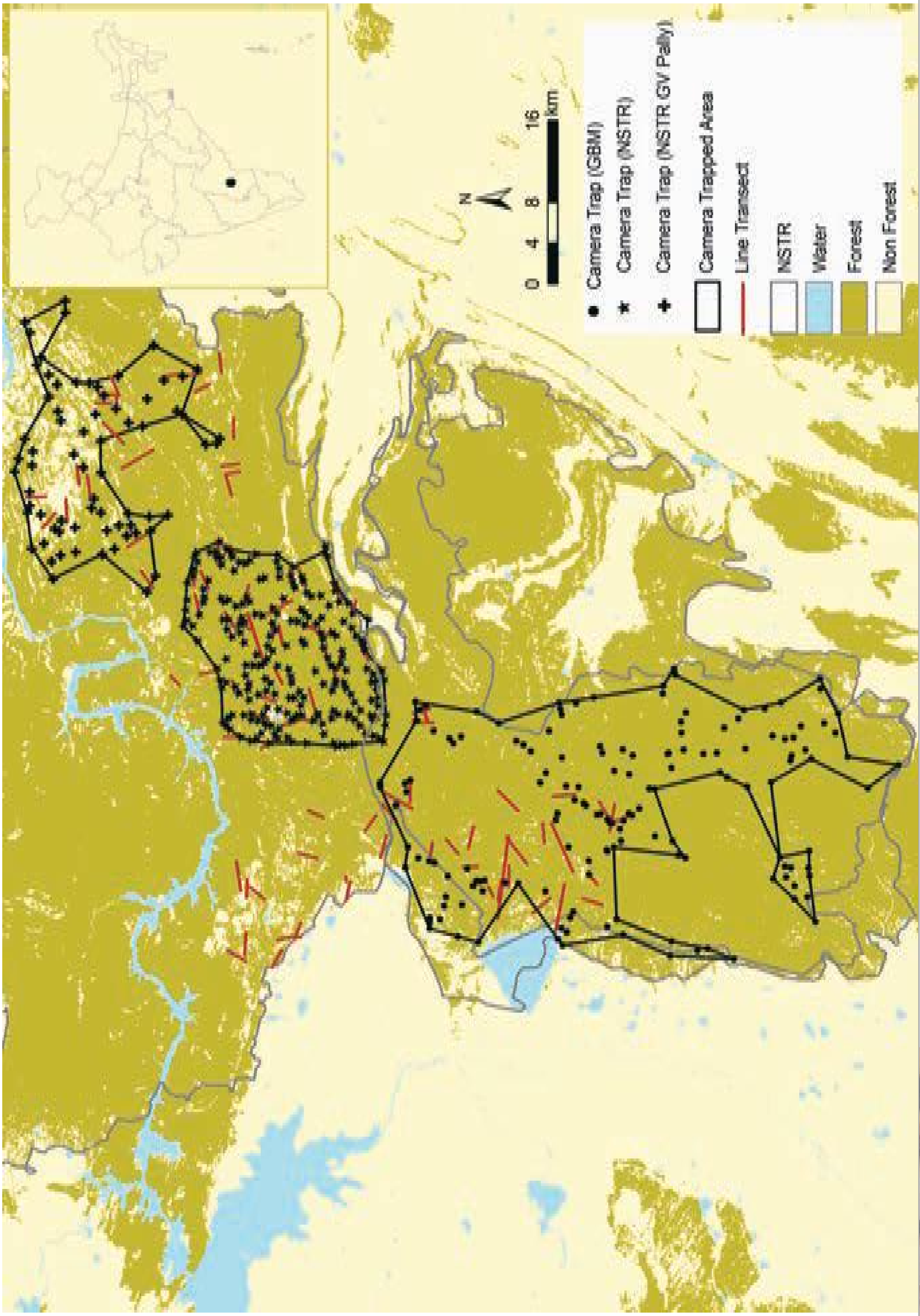

Table 9.57: Encounter rates of prey species seen on line transects (n=107, total effort of 226.57 km) in Nagarjunasagar Srisailam Tiger Reserve, 2014.

Species	No. of groups detected	Encounter Rate per Km
Chital	10	0.0441
Wildpig	9	0.039
Sambar	5	0.022
Four-horned antelope	3	0.013

Control of extremism within Srisailam has assisted in recovery of tigers. However a lot needs to be done to control anthropogenic pressure, especially livestock grazing which competes with wild prey, and subsistence level hunting, which are major impediments to the recovery of prey population and subsequently those of tigers in the reserve. Relocation of human settlements from the core area would help recovery of wildlife populations, including tigers.

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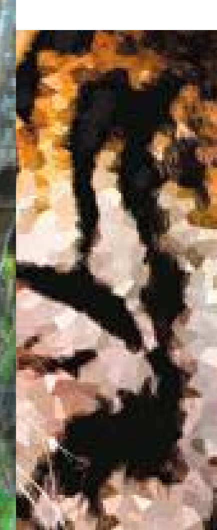


Western Ghats Landscape

Nagarahole National Park (Karnataka)

K. Ullas Karanth, N. Samba Kumar, Ravishankar Parameshwaran, Arjun Srivathsa, Sushma Sharma,
Wildlife Conservation Society – India and Centre for Wildlife Studies

Nagarahole, spreading over an area of 644 km², was constituted as a National Park in 1955. The protected area is at an altitude of 700–960 m, with monthly mean temperatures of 20–27 °C, and an annual rainfall ranging between 1000 mm in the eastern parts and 1500 mm in the western parts. It is located at 76º 05' E and 12º 04' N. The vegetation mostly consists of tropical moist-deciduous and tropical dry deciduous forests, with anthropogenic habitat modifications creating a heterogeneous vegetation matrix. The land cover around the protected area includes large tracts of forests, coffee plantations towards the western parts (Kodagu District) and crop mosaic towards the eastern parts. Over 600 families have been relocated to outside Nagarahole and a few are still living inside the reserve. The park has prolific presence of streams and rivulets. The Kabini and Taraka reservoirs are large water bodies located towards the west and southeastern parts of the park respectively. It is contiguous with Wayanad Wildlife Sanctuary (Kerala) to its south and Bandipur National Park to its southeastern parts. The forests of Malenad landscape in the Western Ghats supports large assemblages of carnivores and herbivores: tiger, leopard, Asiatic wild dog and sloth bear, Asiatic elephant, gaur, sambar, chital, muntjac, four-horned antelope, wild pig , Indian chevrotain and hanuman langur.

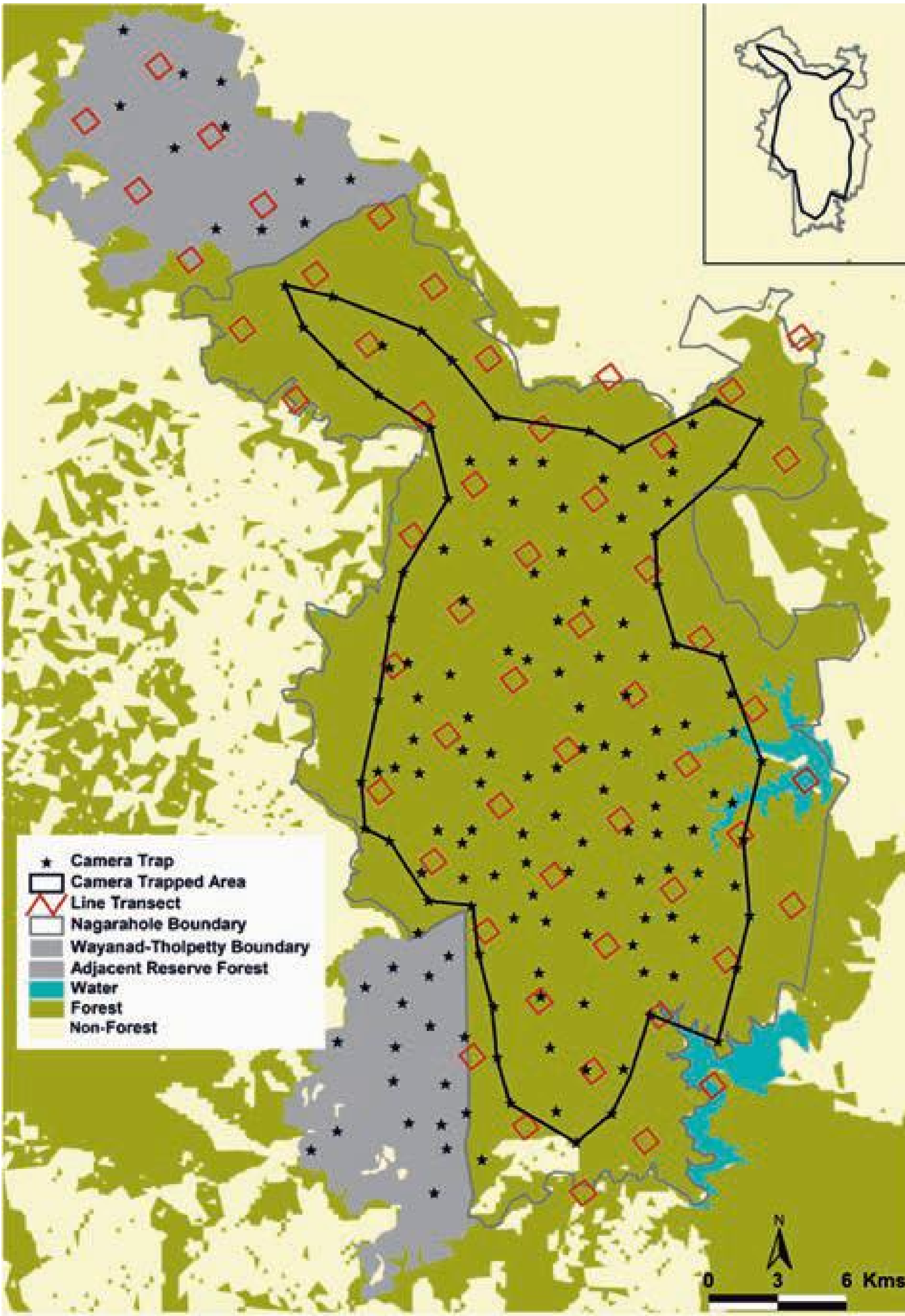
Sampling Details

Camera trap field surveys were carried out in Nagarahole from 8th March 2013 to 7th April 2013. A total of 130 camera trap stations were setup and sampled simultaneously over 30 sampling occasions in Nagarahole. Additionally, adjacent Reserved Forests (11 trap stations) were also surveyed, together accounting for cumulative sampling effort of 4220 trap nights (Karanth 2014). Surveys were also concurrently carried out in Tholpetty range of Wayanad Wildlife Sanctuary adjacent to Nagarahole, along 20 trap locations (Fig. 9.35). The camera trap area for Nagarahole National Park is 395.81 km² (Table 9.58).

Since the forests of Nagarahole are contiguous with that of Tholpetty range of Wayanad Wildlife Sanctuary, the analysis was done together.

Line transect surveys were carried out in Nagarahole between 5th May to 26th May 2013. The surveys were conducted along 48 square samplers in the National Park (Fig 9.35). Each transect was walked twice a day for a two-hour duration (Morning walk was from 0600 to 0800 hours; Evening walk was from 1600 to 1800 hours) to obtain six temporal replicates which resulted in a total walk effort of 957.4 km (Karanth 2014) (Table 9.59).

Figure 9.35: Distribution of camera traps (n=130) and line transects (n=48) in Nagarhole National Park, 2014.



Analytical Details

Table 9.58: Sampling details and parameter estimates fromspatially explicit capture mark-recapture analysis in SPACECAP in Nagarahole between 8th March 2013 to 7th April 2013.

Sampling details	Estimates	Standard Errors
Camera Trapped Area(km^2)	395.81	NA
Camera Points	130	NA
Trap Nights (effort)	3898	NA
Unique tigers captured	72	NA
Initial Encounter Frequency (λ_o)	0.025	0.002
Scale parameter (σ in meters)	1875	72
No. of tigers / 100 km^2 ($\hat{D}$) for the Effective Sampled Area	11.09	0.91
Population Estimate ($\hat{N}$) for the Protected Area	77	9

Table 9.59: Model statistics and parameter estimates of line transect (n=48, Total effort 954.4 km) based distance sampling for prey species in Nagarahole National Park, 2014.

Species	Model	Chi Sq P Value	Effective Strip Width (SE)	No. Groups Detected	Mean Group size (SE)	Median Group size	Detection Probability (SE)	Encounter Rate per Km (SE)	Group Density (SE) per km^2	Individual Density (SE) per km^2
Sambar	Half normal Cosine	0.90	23.30 (1.71)	107	1.49 (0.08)	1	0.51 (0.04)	0.11 (0.02)	2.40 (0.36)	3.56 (0.57)
Chital	Hazard Cosine	0.18	35.67 (2.26)	379	6.27 (0.45)	4	0.50 (0.03)	0.40 (0.05)	5.55 (0.74)	29.85 (4.36)
Gaur	Hazard Cosine	0.21	25.65 (3.39)	62	2.00 (0.26)	1	0.52 (0.07)	0.07 (0.01)	1.26 (0.27)	2.53 (0.63)
Muntjac	Half normal Cosine	0.21	15.36 (2.19)	66	1.08 (0.03)	1	0.44 (0.06)	0.07 (0.02)	2.24 (0.65)	2.41 (0.70)
Wild Pig	Half normal Cosine	0.19	24.49 (2.67)	58	1.69 (0.16)	1	0.45 (0.05)	0.06 (0.01)	1.23 (2.25)	2.09 (0.47)

Bandipur National Park (Karnataka)

K. Ullas Karanth, N. Samba Kumar, Ravishankar Parameshwaran, Arjun Srivathsa, Sushma Sharma.
Wildlife Conservation Society – India and Centre for Wildlife Studies

Bandipur National Park is a 935 km^2 protected area predominantly consisting of tropical deciduous forests and dry-deciduous scrub forests. Bandipur was declared as a national park in the year 1974. The National Park is situated at 76º 45' E and 11º 48' N. It receives an annual rainfall of 700–1200mm. Bandipur supports four habitat types: dense forest, woodland to savanna woodland, tree savanna and scrub woodland and dense thicket. The areas surrounding the park have large anthropogenic habitat modifications such as agricultural lands, plantations and pasture lands. There are over 156 villages located around the park, supporting a population of 1, 26,000 people and livestock population of 1,16,000. The forests of Malenad landscape in the Western Ghats supports large assemblages of carnivores and herbivores: tiger, leopard, Asiatic wild dog and sloth bear, Asiatic elephant, gaur, sambar, chital, muntjac, four-horned antelope, wild pig , Indian chevrotain and hanuman langur .

Sampling Details

Camera trap field surveys were carried out in Bandipur from 13th April to 13th May 2013. A total of 129 camera trap locations were sampled simultaneously over 30 sampling occasions (Karanth 2014), accounting for cumulative sampling effort of 3858 trap nights (Fig. 9.36). Surveys were also concurrently carried out in Kurichiyat, SulthanBathery and Muthanga (KSBM) ranges of Wayanad Wildlife Sanctuary adjacent to Bandipur, across 51 trap locations. The camera trap area for Bandipur is 466.92 km^2. Since, the forests of Bandipur are contiguous with that of KSBM region of Wayanad Wildlife Sanctuary the analysis was done together (Table 9.60).

Line transect surveys were carried out in Bandipur between 25th February to 7th April 2013. The surveys were conducted along 56 square samplers (Fig. 9.36). Each transect was walked twice a day for a two hour duration (Morning walk was from 0600 to 0800 hours; Evening walk was from 1600 to 1800 hours) to obtain six temporal replicates which resulted in a total walk effort of 985.4 km (Karanth 2014) (Table 9.61).

Analytical Details

Table 9.60: Sampling details and parameter estimates from spatially explicit capture mark-recapture analysis using camera traps in Bandipur National Parkfrom 13th April to 13th May 2013.

Sampling detail	Estimates	Standard Errors
Camera Trapped Area km^2	466.92	NA
Camera Points	129	NA
Trap Nights (effort)	3858	NA
Unique tigers captured	79	NA
Initial Encounter Frequency ([redacted]	0.021	0.002
Scale parameter ([redacted]n meters)	2117	79
No. of tigers / 100 km^2 ($\hat{D}$)for the Effective Sampled Area	10.28	0.82
Population Estimate ($\hat{N}$) for the Protected Area	99	10

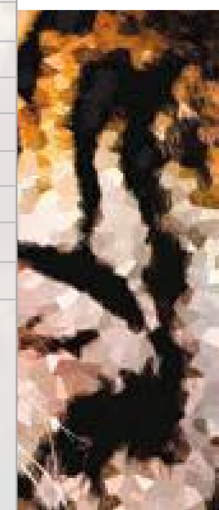


Figure 9.36: *Distribution of camera traps (n=129)and line transects samplers (n=56) in Bandipur National Park, 2013.*

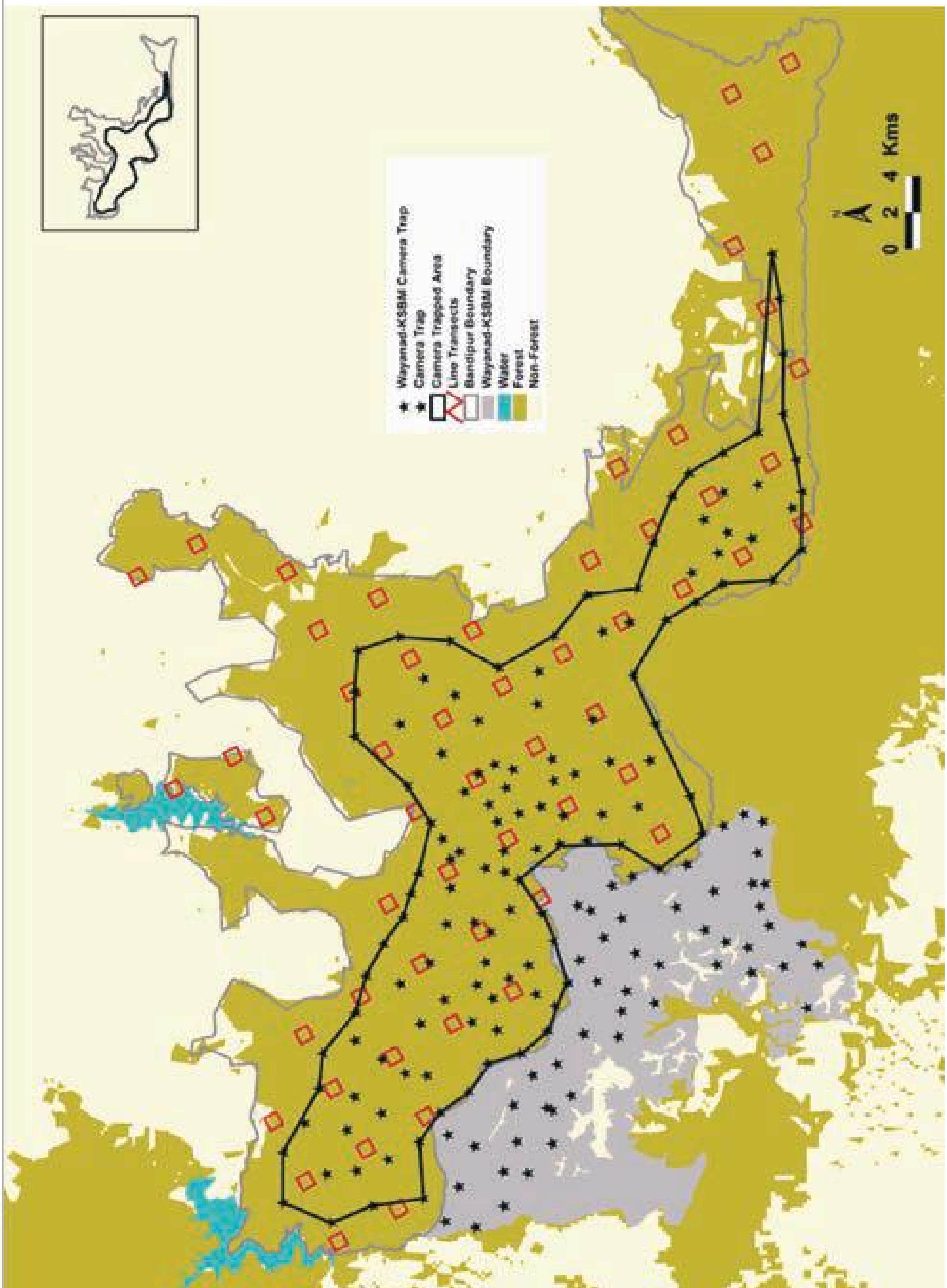
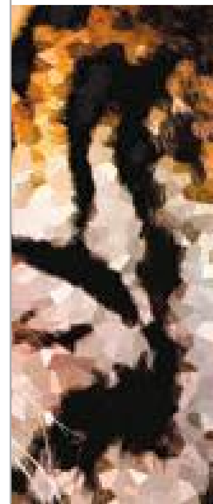


Table 9.61: Model statistics and parameter estimates of line transect (n=56, Total effort 985.4 km) based distance sampling for prey species in Bandipur National Park, 2014.

Species	Model	Chi Sq P Value	Effective Strip Width (SE)	No. Groups Detected	Mean Group size (SE)	Median Group size	Detection Probability (SE)	Encounter Rate per Km	Group Density (SE) per km^2	Individual Density (SE) per km^2
Sambar	Half normal Cosine	0.96	33.40 (1.52)	260	1.54 (0.06)	1	0.45 (0.02)	0.26 (0.03)	3.95 (0.51)	6.09 (0.82)
Chital	Half normal Cosine	0.004	38.85 (1.74)	297	4.31 (0.83)	2	0.57 (0.03)	0.30 (0.05)	3.88 (0.62)	12.32 (2.09)
Gaur	Half normal Cosine	0.62	40.59 (4.55)	44	2.30 (0.44)	1	0.47 (0.05)	0.04 (0.01)	0.55 (0.17)	0.97 (0.32)
Muntjac	Half normal Cosine	0.47	25.89 (2.86)	46	1.02 (0.02)	1	0.47 (0.05)	0.05 (0.01)	0.90 (0.21)	0.92 (0.22)
Wild Pig	Half normal Cosine	0.01	27.67 (2.57)	54	3.83 (0.53)	2	0.43 (0.04)	0.05 (0.01)	0.99 (0.21)	3.80 (0.97)



Bhadra Wildlife Sanctuary (Karnataka)

K. Ullas Karanth, N. Samba Kumar, Ravishankar Parameshwaran, Arjun Srivathsa, Sushma Sharma.
Wildlife Conservation Society – India and Centre for Wildlife Studies

Bhadra Wildlife Sanctuary is a protected area covering 492 km^2 in the Western Ghats located at 75º 38' E and 13º 34' N. It was declared as a tiger reserve in the year 1998. The protected area is at an altitude of 670–760 m, with monthly mean temperatures of 10–32 °C, and an annual rainfall ranging between 2000–2540 mm. Vegetation comprises of wet evergreen forests and moist deciduous forests that are dominated by bamboo. Low-lying valleys of the park previously consisted of swampy grasslands occupied by village settlements and rice-agriculture. Following massive relocation of large number of villages from the park in 2002, large mammal populations are on a gradual increasing trend. The forests of Malenad landscape in the Western Ghats supports large assemblages of carnivores and herbivores: tiger, leopard, Asiatic wild dog and sloth bear, Asiatic elephant, gaur, sambar, chital, muntjac, four-horned antelope, wild pig, Indian chevrotain and hanuman langur .

Sampling Details

Camera trap field surveys were carried out in Bhadra from 29th January to 28th February 2013. A total of 97 camera trap locations were simultaneously sampled over 30 sampling occasions (Karanth 2014), accounting for cumulative sampling effort of 2874 trap nights (Fig. 9.37). The total camera trap area for Bhadra is 483.03 km^2. In addition to the Wildlife Sanctuary, adjacent Reserve Forests and coffee plantations were also surveyed (Table 9.62).

Line transect surveys were carried out in Bhadra between 20th April to 9th May 2013. The surveys were conducted along 39 square samplers (Fig. 9.37). Each transect was walked twice a day for a two-hour duration (Morning walk was from 0600 to 0800 hours; Evening walk was from 1600 to 1800 hours) to obtain eight temporal replicates which resulted in a total walk effort of 912 km (Karanth 2014). (Table 9.63)

Analytical Details

Table 4.62: Sampling details and parameter estimates from spatially explicit capture mark-recapture analysis using camera traps in Bhadra Wildlife Sanctuary between 29th January to 28th February 2013.

Sampling details	Estimates	Standard Errors
Camera Trapped Area km^2	483.03	NA
Camera Points	97	NA
Trap Nights (effort)	2874	NA
Unique tigers captured	20	NA
Initial Encounter Frequency ([redacted])	0.018	0.003
Scale parameter ([redacted]n meters)	3097	294
No. of tigers / 100 km^2 ($\hat{D}$) for the Effective Sampled Area	2.34	0.41
Population Estimate ($\hat{N}$) for the Protected Area	13	4

Figure 9.37: Distribution of camera traps (n=97) and line transect samplers (n=39) in Bhadra Wildlife Sanctuary, 2013.

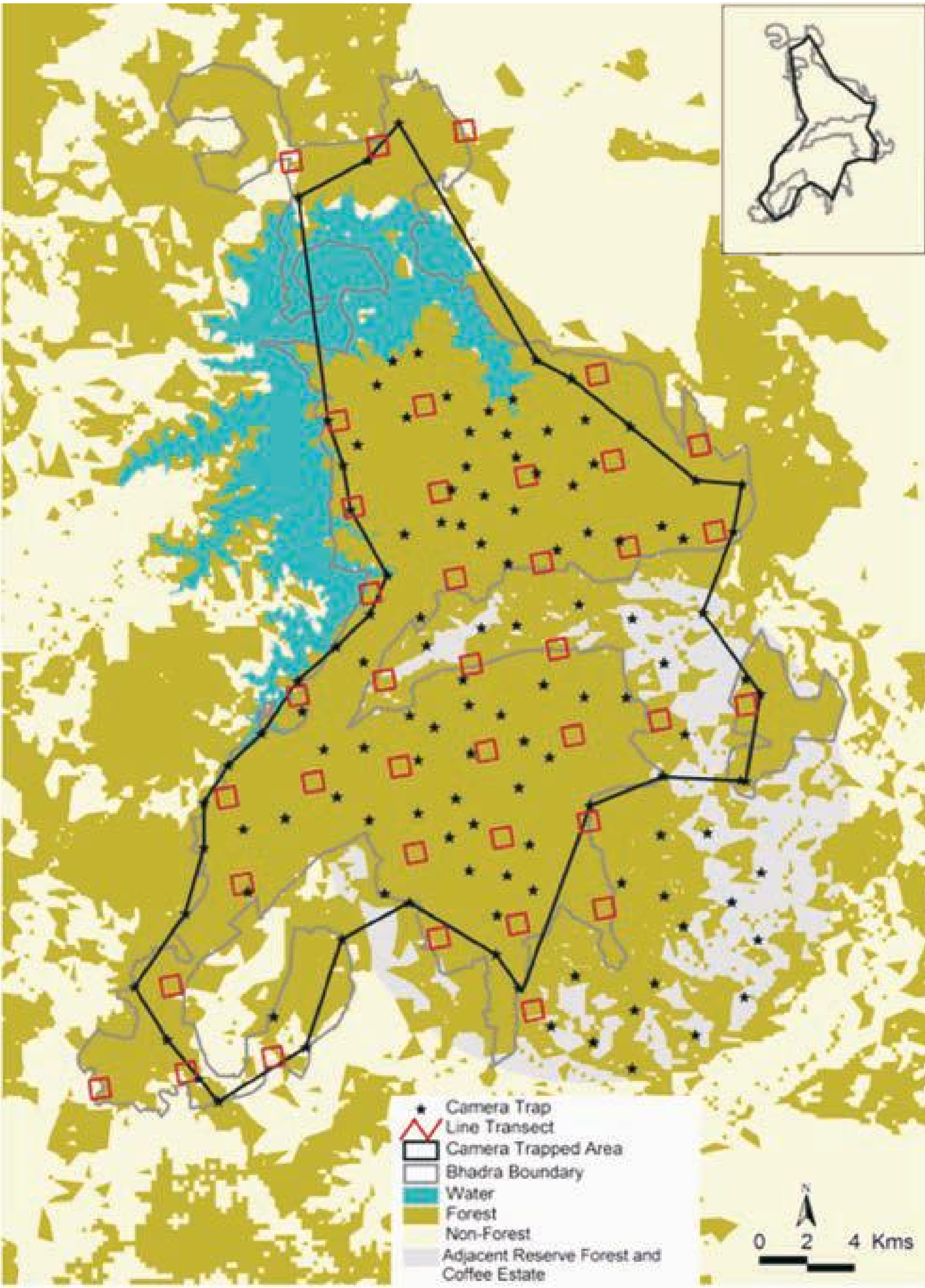


Table 9.63: Sample and parameter estimates from distance sampling analysis in Bhadra Wildlife Sanctuary obtained from 39 spatial transects with 8 temporal replicates with a walk effort of 912 km.

Species	Model	Chi Sq P Value	Effective Strip Width (SE)	No. Groups Detected	Mean Group size (SE)	Median Group size	Detection Probability (SE)	Encounter Rate per km	Group Density (SE) per km^2	Individual Density (SE) per km^2
Sambar	Half normal Cosine	0.48	32.35 (1.68)	197	1.41 (0.06)	1	0.44 (0.02)	0.22 (0.03)	3.34 (0.48)	4.37 (0.64)
Chital	Half normal Cosine	0.06	37.75 (2.56)	116	2.67 (0.22)	2	0.48 (0.03)	0.13 (0.03)	1.69 (0.39)	4.50 (1.09)
Gaur	Half normal Cosine	0.69	27.87 (3.32)	45	2.02 (0.31)	1	0.52 (0.06)	0.05 (0.01)	0.89 (0.26)	1.48 (0.47)
Muntjac	Half normal Cosine	0.94	24.50 (2.03)	153	1.09 (0.02)	1	0.37 (0.03)	0.17 (0.02)	3.42 (0.52)	3.74 (0.58)
Wild Pig	Half normal Cosine	0.52	26.94 (2.67)	56	1.73 (0.20)	1	0.42 (0.04)	0.06 (0.01)	1.14 (0.27)	1.52 (0.38)

Dandeli Wildlife Sanctuary-Anshi National Park (Karnataka)

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Dandeli-Anshi Tiger Reserve is constituted together with Dandeli Wildlife Sanctuary and Anshi National Park and covers a total area of 1306 km^2. It was declared as a tiger reserve in the year 2007.It lies in Uttara Kannada district of Karnataka at a location 74º 26' E and 15º 7' N. Together with seven other neighbouring protected areas in Karnataka, Goa and Maharashtra, the tiger habitats around Dandeli-Anshi extend over 5,000 km^2 of deciduous and semi-evergreen forests. The western parts of the reserve receive seasonal heavy rainfall from the South-West Monsoon to of 3000–6000 mm. A number of villages and even townships are located within the Dandeli-Anshi Tiger Reserve and the Tiger Reserve has widespread anthropogenic human modifications such as large human settlements, reservoirs and industries. The vegetation comprises of tropical evergreen, semi-evergreen and moist deciduous forests. The forests of Malenad landscape in the Western Ghats supports large assemblages of carnivores and herbivores: tiger, leopard, Asiatic wild dog and sloth bear, Asiatic elephant, gaur, sambar, chital, muntjac, four-horned antelope, wild pig, Indian chevrotain and hanuman langur .

Sampling Details

Camera trap field surveys were carried out in Dandeli-Anshi from 25th October 2012 to 14th January 2013. A total of 123 camera trap locations were sampled over 81 sampling occasions, accounting for cumulative sampling effort of 6789 trap nights (Karanth 2014). We used a block-sampling approach to set camera traps across 6 blocks (Fig. 9.38). The total camera trap area for Dandeli-Anshi is 936.01 km^2 that included Castle Rock area which was recently included within the reserve (Table 9.64).

Line transect surveys were carried out in Dandeli-Anshi between 23rd March to 2nd May 2013. The surveys were conducted along 56 square samplers (Fig. 9.38). Each transect was walked twice a day for a two-hour duration (Morning walk was from 0600 to 0800 hours; Evening walk was from 1600 to 1800 hours) to obtain eight temporal replicates which resulted in a total walk effort of 1680.8 km (Karanth 2014) (Table 9.65).

Analytical Details

Table 9.64: *Sampling details and parameter estimates from spatially explicit capture mark-recapture analysis using camera traps in Dandeli-Anshi from 25th October 2012 to 14th January 2013.*

Sampling details	Estimates	Standard Errors
Camera Trapped Area km^2	936.01	NA
Camera Points	123	NA
Trap Nights (effort)	6789	NA
Unique tigers captured	3	NA
Initial Encounter Frequency ([redacted])	0.010	0.005
Scale parameter ([redacted]n meters)	4025	1218
No. of tigers / 100 km^2 ($\hat{D}$)for the Effective Sampled Area	0.20	0.08
Population Estimate ($\hat{N}$) for the Protected Area	3	2

Figure 9.38: Distribution of camera traps (n=123) and line transects (n=56) samplers in Dandeli-Anshi, 2013.

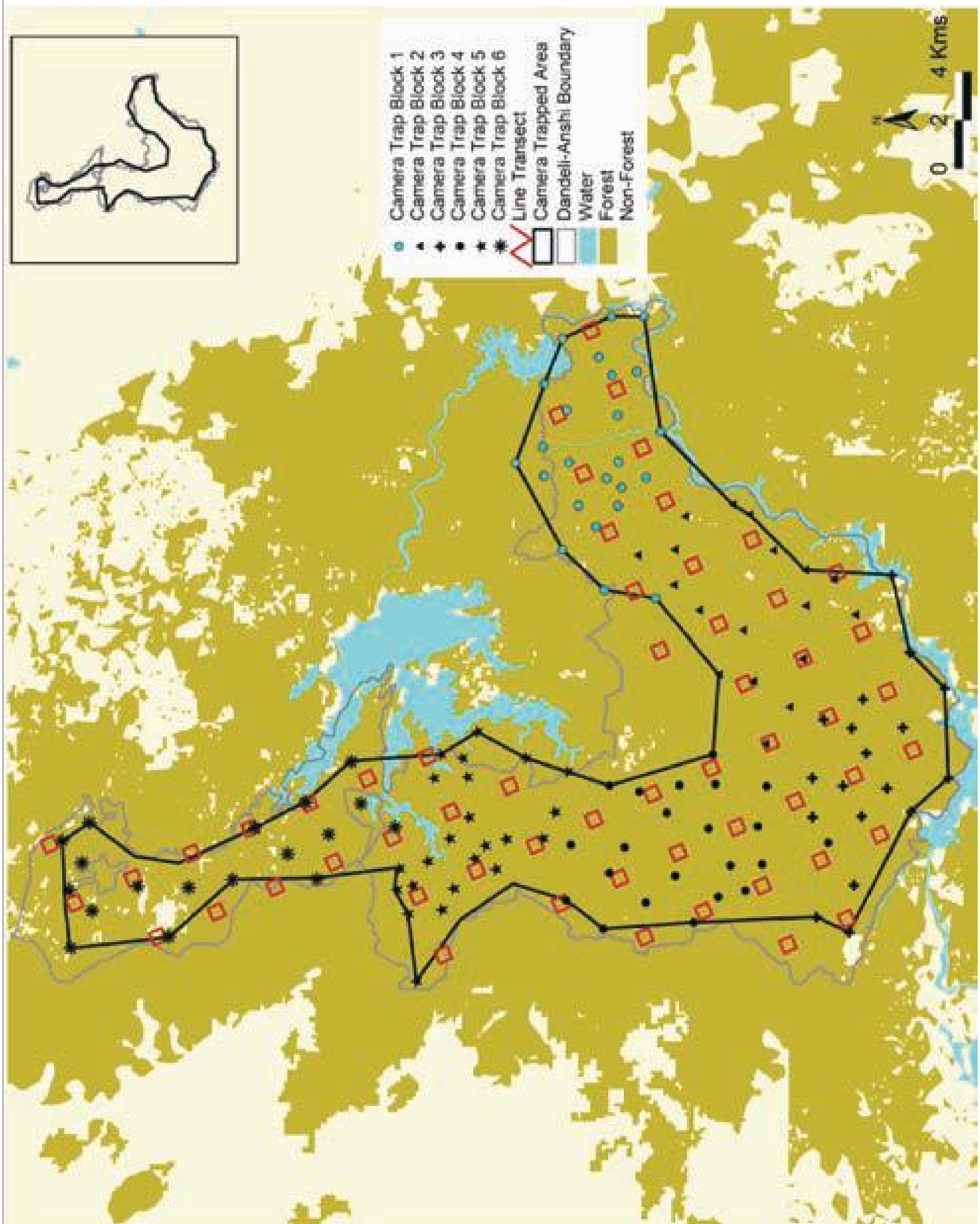
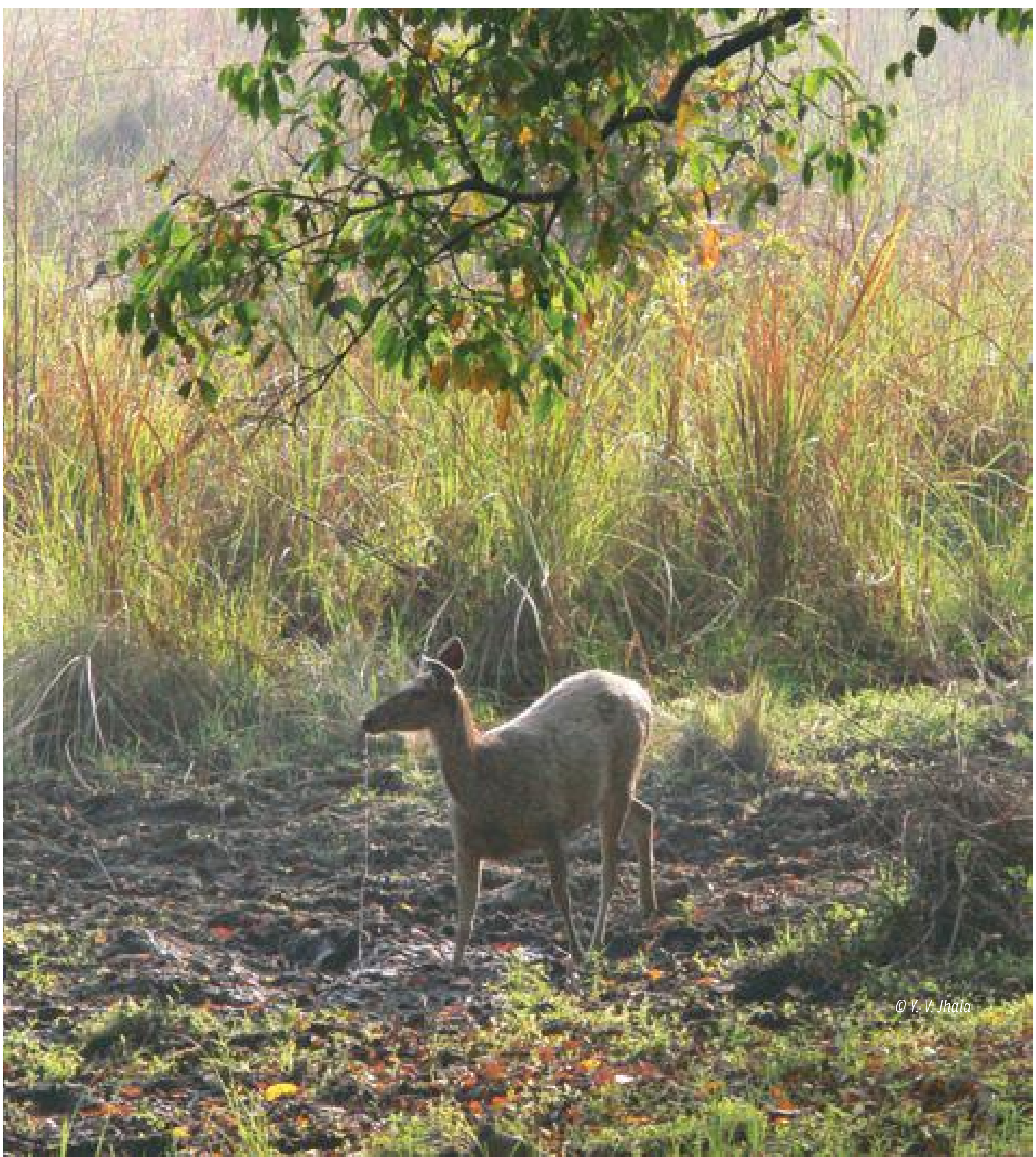


Table 9.65: Model statistics and parameter estimates of line transect (n=56, Total effort 1680.8 km) based distance sampling for prey species in Dandeli - Anshi, 2014.

Species	Model	Chi Sq P Value	Effective Strip Width (SE)	No. Groups Detected	Mean Group size (SE)	Median Group size	Detection Probability (SE)	Encounter Rate per km (SE)	Group Density (SE) per km^2	Individual Density (SE) per km^2
Sambar	Uniform Cosine	0.17	29.38 (3.11)	71	1.47 (0.08)	1	0.44 (0.05)	0.04 (0.01)	0.72 (0.20)	1.05 (0.29)
Chital	Uniform Cosine	0.15	52.50 (4.54)	34	3.65 (0.74)	2	0.50 (0.04)	0.02 (0.01)	0.19 (0.10)	0.70 (0.39)
Gaur	Half normal Cosine	0.75	35.88 (3.73)	53	1.83 (0.14)	1	0.45 (0.05)	0.03 (0.01)	0.44 (0.11)	0.69 (0.18)
Muntjac	Half normal Cosine	0.85	25.25 (2.39)	62	1.21 (0.06)	1	0.44 (0.04)	0.04 (0.01)	0.73 (0.14)	0.88 (0.17)
Wild Pig	Half normal Cosine	0.37	28.14 (3.02)	41	3.07 (0.54)	1	0.45 (0.05)	0.02 (0.01)	0.43 (0.11)	1.33 (0.42)



Biligiri Rangaswamy Temple Wildlife Sanctuary (Karnataka)

K. Ullas Karanth, N. Samba Kumar, Ravishankar Parameshwaran, Arjun Srivathsa, Sushma Sharma,
Wildlife Conservation Society – India and Centre for Wildlife Studies

The Biligiri Rangaswamy Temple (BRT) Wildlife Sanctuary (area 540 km^2) is situated at 77º 10' E and 11º 55' N. BRT was declared a Tiger Reserve in the year 2010. It forms an interesting link between the Eastern and Western Ghats, with an altitudinal range of 660–1807 m above sea level and the annual rainfall varying between 500–1800 mm. Both these factors combine to support highly diverse vegetation that ranges between scrub, dry and moist deciduous forests, to evergreen forests, sholas and montane grasslands. However, a variety of anthropogenic pressures is exerted from the 57 human settlements in and around the sanctuary. The forests of Malenad landscape in the Western Ghats supports large assemblages of carnivores and herbivores: tiger, leopard, Asiatic wild dog and sloth bear, Asiatic elephant, gaur, sambar, chital, muntjac, four-horned antelope, wild pig , Indian chevrotain and hanuman langur .

Sampling Details

Camera trap field surveys were carried out in BRT from 18th May to 17th June 2013. A total of 99 camera trap locations were sampled simultaneously over 30 sampling occasions (Karanth 2014), accounting for cumulative sampling effort of 2966 trap nights (Fig. 9.39). The total camera trap area for BRT is 351.70 km^2 (Table 9.66) .

Line transect surveys were carried out in BRT between 20th January to 26th February 2013. The surveys were conducted along 24 square samplers (Fig. 9.39). Each transect was walked twice a day for a two-hour duration (Morning walk was from 0600 to 0800 hours; Evening walk was from 1600 to 1800 hours) to obtain eight temporal replicates which resulted in a total walk effort of 597.5 km (Karanth 2014) (Table 9.67).

Analytical Details

Table 9.66: Sampling details and parameter estimates from spatially explicit capture mark-recapture analysis using camera traps in BRT from 18th May to 17th June 2013.

Sampling details	Estimates	Standard Errors
Camera Trapped Area km^2	351.70	NA
Camera Points	99	NA
Trap Nights (effort)	2966	NA
Unique tigers captured	52	NA
Initial Encounter Frequency ([redacted])	0.024	0.003
Scale parameter ([redacted]n meters)	1762	95
No. of tigers / 100 km^2 ($\hat{D}$) for the Effective Sampled Area	11.29	1.32
Population Estimate ($\hat{N}$) for the Protected Area	69	8

Figure 9.39: Distribution of camera traps (n=99) and line transect samplers (n=24) in Biligri Rangaswamy Temple Wildlife Sanctuary, 2013

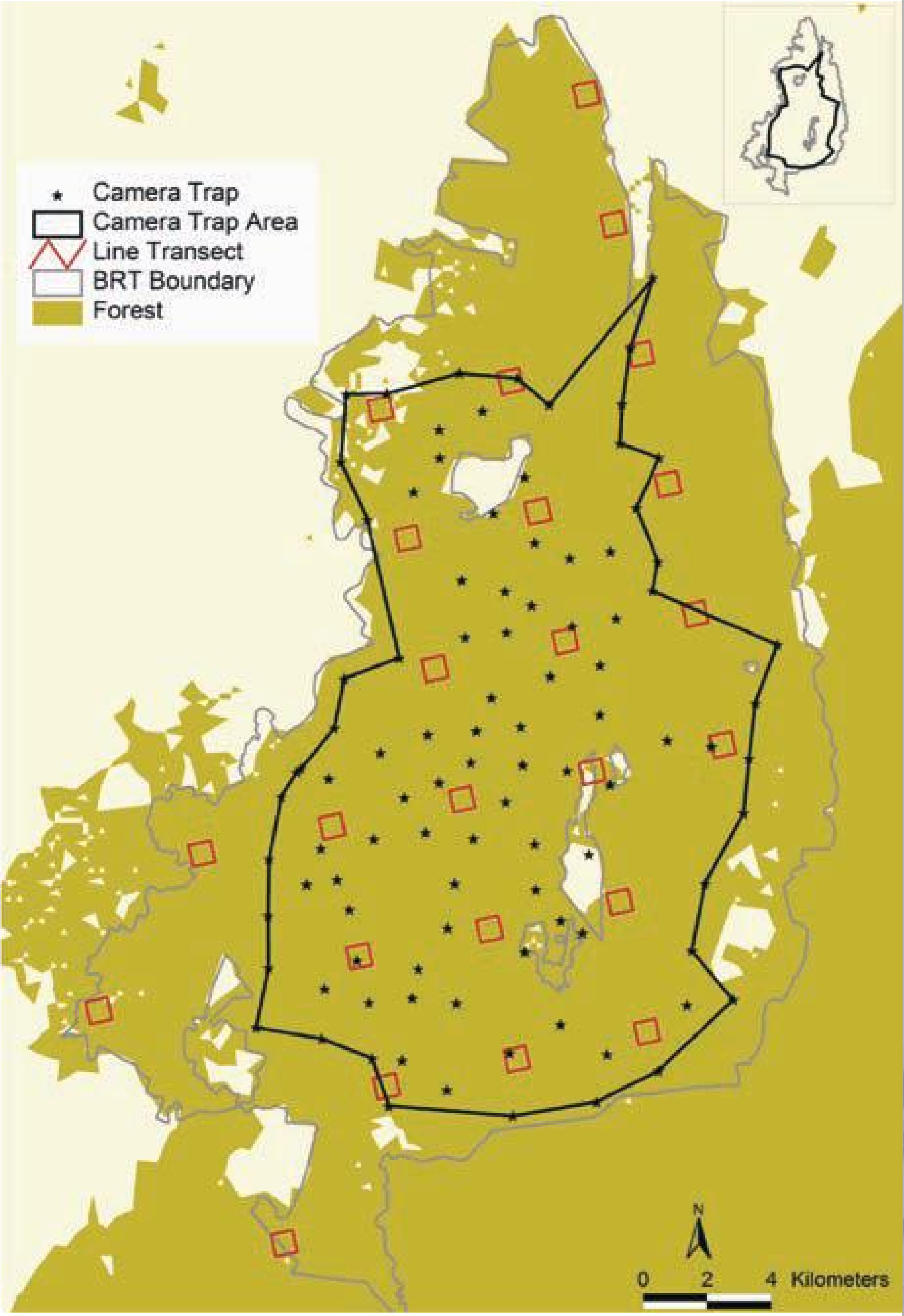


Table 9.67: Model statistics and parameter estimates of line transect (n=24, Total effort 597.5 km) based distance sampling for prey species in Biligiri Rangaswamy Temple Wildlife Sanctuary, 2013.

Species	Model	Chi Sq P Value	Effective Strip Width (SE)	No. Groups Detected	Mean Group size (SE)	Median Group size	Detection Probability (SE)	Encounter Rate per km (SE)	Group Density (SE) per km²	Individual Density (SE) per km²
Sambar	Hermite Cosine	0.88	42.22 (3.63)	168	1.65 (0.10)	2	0.51 (0.04)	0.28 (0.04)	3.33 (0.54)	5.12 (0.85)
Chital	Uniform Cosine	0.54	34.47 (1.64)	76	2.78 (0.36)	1	0.52 (0.03)	0.13 (0.03)	1.85 (0.49)	4.43 (1.25)
Gaur	Half normal Cosine	0.48	39.34 (5.70)	36	3.69 (0.62)	2	0.56 (0.08)	0.06 (0.02)	0.77 (0.24)	2.83 (1.02)
Muntjac	Half normal Cosine	0.56	30.55 (2.82)	62	1.10 (0.04)	1	0.41 (0.04)	0.10 (0.02)	1.70 (0.30)	1.75 (0.31)
Wild Pig	Hermite Cosine	0.31	34.09 (8.81)	17	3.24 (0.63)	3	0.36 (0.09)	0.03 (0.01)	0.42 (0.19)	1.35 (0.66)

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Wayanad Wildlife Sanctuary - 1 (Kerala)

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Wayanad Wildlife Sanctuary was declared a sanctuary with an area of 344 km^2 in the year 1973. The park is located in the Wayanad district between 76º 02'and 76º 27'E, 11º 35' and 11º51'N. The altitude ranges from 650 m to 1150 m above mean sea level. The Wayanad Wildlife Sanctuary has two distinct blocks of forests separated by completely human-dominated areas. The northern block of forests comprises of Tholpetty range (78 km^2), which is adjacent to Nagarahole Tiger Reserve in Karnataka. The southern block of forests comprises of Kurichiyat, SulthanBathery and Muthanga (KSBM) ranges, and, this block (266 km^2) is contiguous with Bandipur Tiger Reserve in Karnataka and Mudumalai Tiger Reserve in Tamil Nadu. The Sanctuary receives an average annual rainfall of about 2000 mm. The terrain is gently undulating with small hills interspersed with many swampy valleys. It is drained by several perennial and seasonal streams and rivers: Cherupuzha, Bavalipuzha, Kabini, Kannarampuzha, Kurichiatpuzha and Chedalathupuzha. Two types of forests are typically found in Wayanad: Moist Deciduous and Semi-evergreen forest. Several grassy swamps locally called vayals exist, where soil is clayey, perennially moist and supports the luxuriant growth of sedges and grasses. The forests of Malenad landscape in the Western Ghats supports large assemblages of carnivores and herbivores: tiger, leopard, Asiatic wild dog and sloth bear, Asiatic elephant, gaur, sambar, chital, muntjac, four-horned antelope, wild pig , Indian chevrotain and hanuman langur .

Sampling Details

Camera trap field surveys were carried out in Tholpetty region in the Northern part of Wayanad Wildlife Sanctuary from 08th March to 12th May 2014 along with Nagarahole National Park; and in KSBM region in the Southern part of Wayanad Wildlife Sanctuary from 11th March to 13th May 2014 together with Bandipur National Park (Karanth & Kumar 2013). A total of 20 camera trap locations were sampled over 30 sampling occasions, accounting for cumulative sampling effort of 540 trap nights in the Tholpetty region (Figure 9.40) in a trap area of 52.41 km^2. Similarly in the KSBM region, A total of 51 camera trap locations were sampled over 30 sampling occasions, accounting for cumulative sampling effort of 1530 trap nights (Figure 9.40) in a trap area of 143.78 km^2. As the north and south parts of Wayanad were contiguous with Nagarahole and Bandipur respectively, data from Wayanad-Tholpetty were analyzed together with Nagarahole data and data from Wayanad-KSBM were analyzed along with Bandipur data (Table 9.68 & 9.69).

Analytical Details

Table 9.68: Sampling details and parameter estimates from spatially explicit capture mark-recapture analysis using camera traps in Tholpetty region of Wayanad Wildlife Sanctuary from 8th March 2013 to 12th May 2013.

Sampling details	Estimates	Standard Errors
Camera Trapped Area km^2	52.41	NA
Camera Points	20	NA
Trap Nights (effort)	540	NA
Unique tigers captured	12	NA
Initial Encounter Frequency ([redacted]	0.025	0.002
Scale parameter ([redacted]n meters)	1875	72
No. of tigers / 100 km^2 ($\hat{D}$) for the Effective Sampled Area	11.09	0.91
Population Estimate ($\hat{N}$) for the Protected Area	10	3

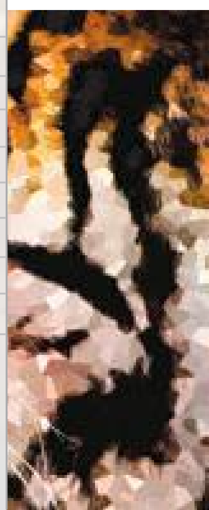

Figure 9.40: *Distribution of camera traps (n=20 & 51) in Wayanad Wildlife Sanctuary, 2013.*

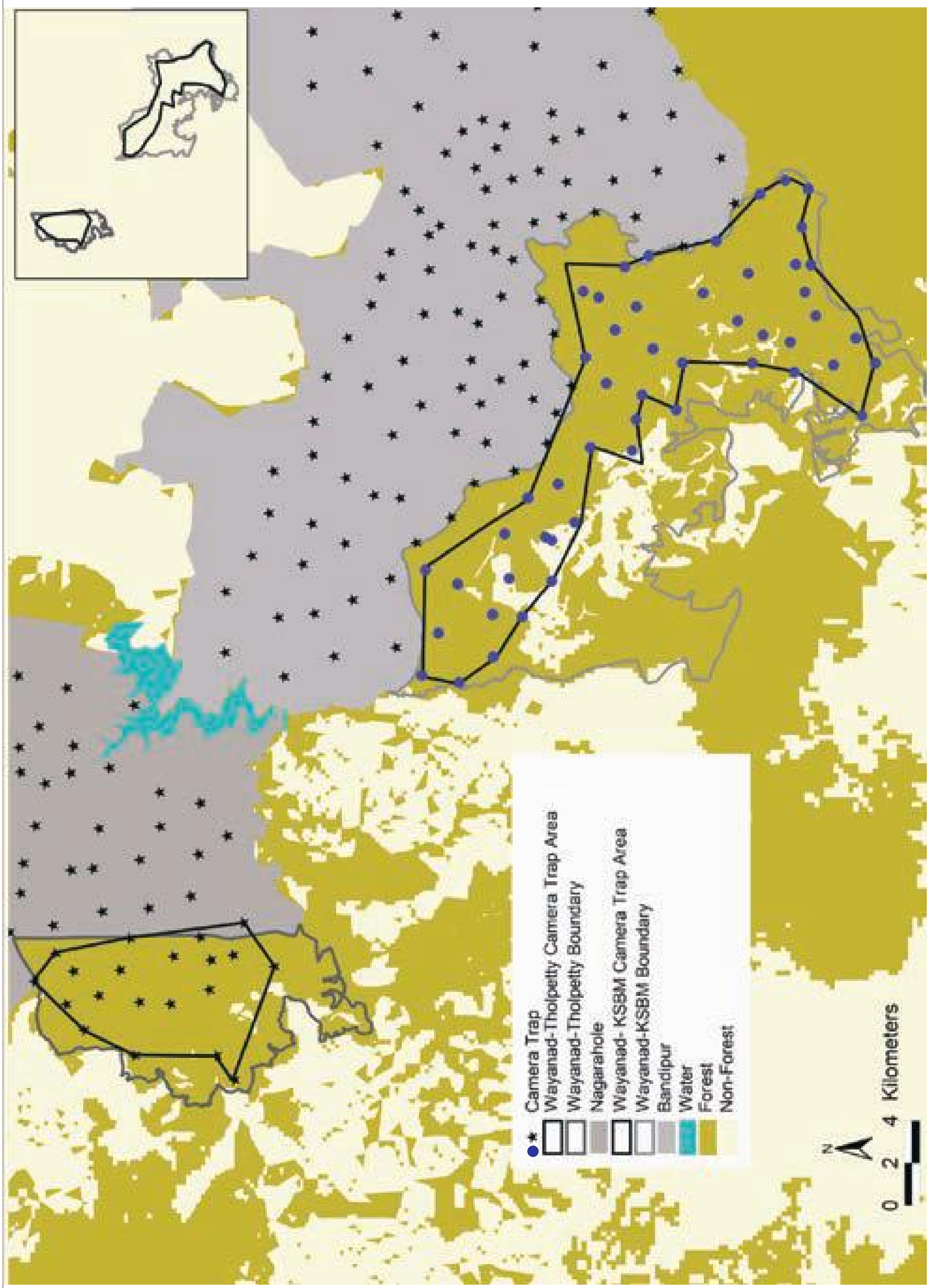

Table 9.69: *Sampling details and parameter estimates from spatially explicit capture mark-recapture analysis using camera traps in Kurichiyat-Sulthan Bathery-Muthanga (KSBM) region of Wayanad Wildlife Sanctuary between 11th March to 13th May 2013.*

Sampling details	Estimates	Standard Errors
Camera Trapped Area km^2	143.8	NA
Camera Points	51	NA
Trap Nights (effort)	1523	NA
Unique tigers captured	33	NA
Initial Encounter Frequency ([redacted]	0.021	0.002
Scale parameter ([redacted]n meters)	2117	79
No. of tigers / 100 km^2 ($\hat{D}$) for the Effective Sampled Area	10.28	0.82
Population Estimate ($\hat{N}$) for the Protected Area	32	6

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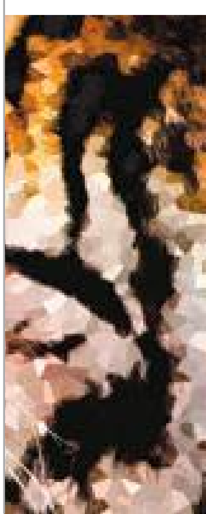


Wayanad Wildlife Sanctuary - 2 (Kerala)

Yogesh J.[1], Meraj Anwar[1], Dimpi Patel[2], Narendr Mohan Katara[2], Paul P. Predit[2], Rajal Pathak[2], Shameer T. T.[2], Peter Prem Chakravarthi J[1].
[1]World Wide Fund for Nature, India. [2]Wildlife Institute of India,

Wayanad Wildlife Sanctuary (WWLS) is a part of Western Ghats landscape with an area of 344.4 km^2 and is situated between 11° 35` to 11° 51` N latitude and 76° 02` to 76° 27` E longitude. WWLS has two distinct blocks of forests separated by completely human-dominated areas. The southern block has three ranges (266 km^2), Muthanga, Sulthan Bathery and Kurichiyard, while the northern block consist of the Tholpetty range (78 km^2). The southern block of forests is contiguous with Bandipur Tiger Reserve in Karnataka and Mudumalai Tiger Reserve in Tamil Nadu while the northern block of forests is adjacent to Nagarahole Tiger Reserve in Karnataka. WWLS habitat types can be categorized into three major types: South Indian Tropical Moist deciduous forest, Semi-evergreen forest and Tropical dry deciduous forest.

Wayanad district experience climate with mean rainfall of 2786 mm. Eastern and northern area receive lesser rainfall of about 1500 mm compared with other region of Wayanad district. It is classified as 'high-rainfall dry and moist deciduous forest. The region receives 80% of its rainfall from South West monsoon (Vinayachanran and Joji 2007). Winter season starts from November end to until February, the temperature as low as 10°C have been recorded, followed by a dry summer when maximum temperature often exceeds 36°C.

Wayanad has a good diversity of fauna. Major carnivores include tiger, leopard, and wild dog while prey species includes chital, sambar, muntjac, wild pig, and gaur. Elephant population is also very high in this region. Domestic livestock (cattle, buffalo and goat) occur in places where the villages are present inside the Sanctuary.

Sampling Details

a) *Camera Trap field survey was carried out in only three ranges of WWLS from 8/3/2014 to 12/5/2014. A total of 71 camera trap stations were set up and sampled simultaneously over 32 occasions accounting for cumulative sampling effort of 2272 trap nights. The minimum bounding polygon for WWLS was 180 km^2 (Table 9.70) and (Fig. 9.41).*

b) *Distance sampling was carried out in between the month of April and May2014. Total 19 random line transects were sampled across the WWLS (only in southern part) as per NTCA protocols. Lengths of line transect varied from 1.6 km to 2.1 km. All transects were walked during early morning between 6:30 am and 8:30 am and in the evening between 3:40 pm to 5:40 pm. Each transect was walked with six temporal replicates. The total length of 19 transects was 37.86 km and total effort of transect walk was 228.1 km.*

Variables	Estimates
Minimum bounding polygon (km^2)	180
Camera Points	71
Trap Nights (effort)	2272
Unique tigers captured	50
$\hat{D}$ ML SECR (per 100 km^2)	10.33(1.5)
Best Model	g0(.)[redacted])
Sigma (SE) (km)	1.27(0.053)
g0 (SE)	0.1106 (0.0107)

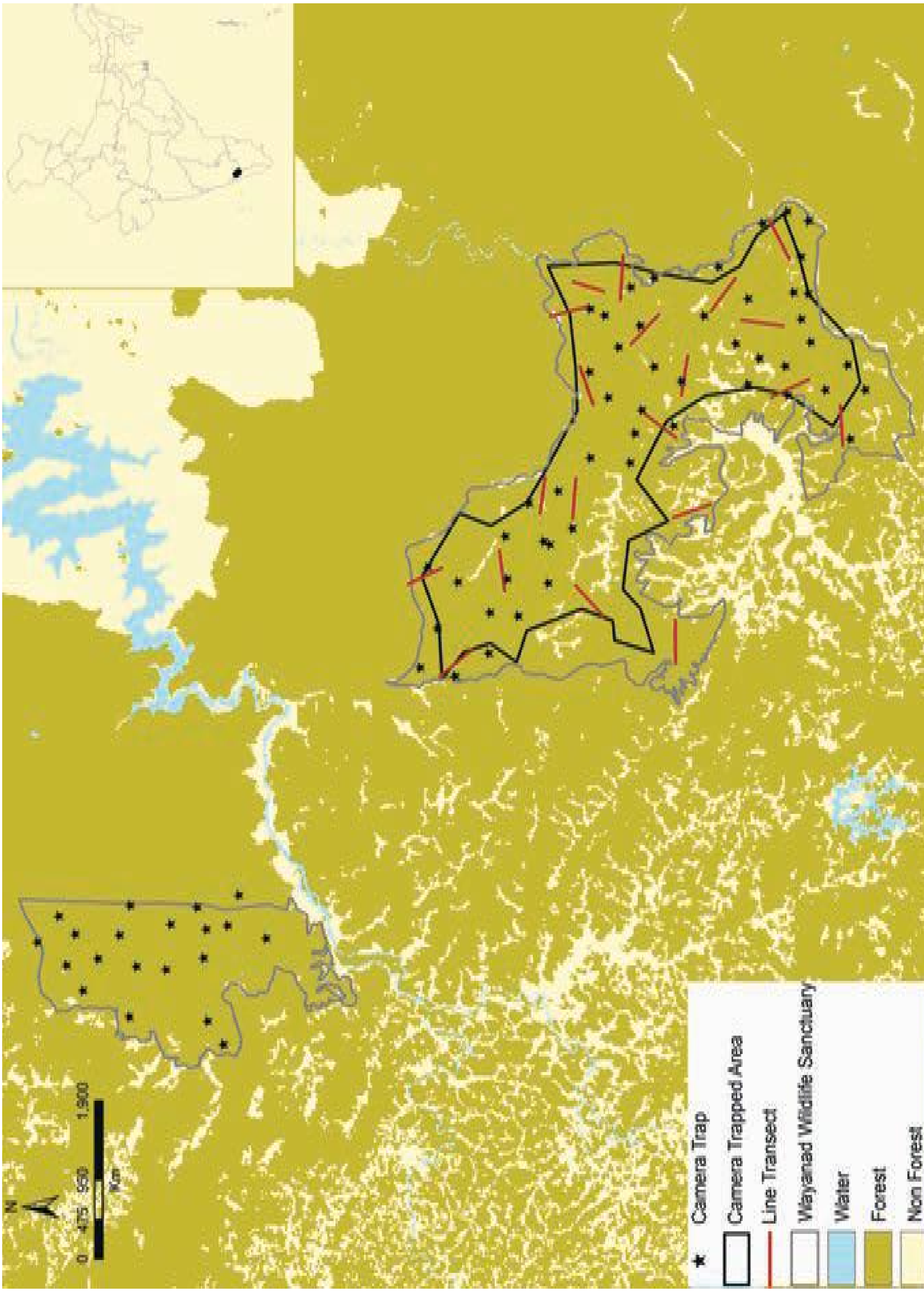
Table 9.70: *Sampling details and tiger density parameter estimates using spatially explicit capture mark-recapture analysis in a likelihood framework for Wayanad Wildlife Sanctuary, 2014.*

SE: Standard error

$\hat{D}$ ML SECR: Density estimate from Maximum Likelihood based spatially explicit capture recapture

σ(Sigma): Spatial scale of detection function, g0: Magnitude (intercept) of detection function

Figure 9.41: Distribution of Camera traps (n=19)in Wayanad Wildlife Sanctuary, 2014.



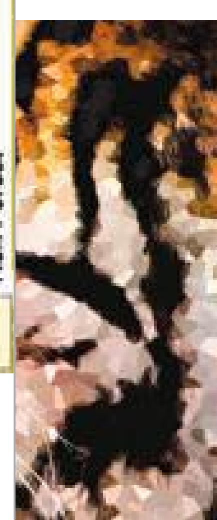


Table 9.71: *Model statistics and parameter estimates of line transect (n=19, Total effort 228.10 km) based distance sampling for prey species in Wayanad Wildlife Sanctuary, 2014.*

Species	Model	Chi Sq P Value	Effective Strip Width (SE)	No. Groups Detected	Mean Group size (SE)	Detection Probability (SE)	Encounter Rate per km	Group Density (SE) per km^2	Individual Density (SE) per km^2
Chital	Half normal Cosine	0.77	31.54 (2.36)	104	6.28 (0.81)	0.28 (0.02)	0.45	7.22 (1.3)	45.44 (10.1)
Sambar	Hazard Cosine	0.7	33.16 (6.56)	48	1.75 (0.18)	0.16 (0.03)	0.21	3.17 (1.02)	5.56 (1.89)
Barking Deer	Hazard Polynomial	0.55	31.17 (6.56)	39	1.09 (0.03)	0.27 (0.05)	0.17	2.74 (0.93)	3 (1.02)
Gaur	Hazard Cosine	0.68	35.45 (9.08)	27	2.66 (0.54)	0.14 (0.03)	0.11	1.66 (0.71)	4.44 (2.11)
Wild Pig	Hazard Polynomial	0.73	21 (6.53)	18	1.51 (0.24)	0.19 (0.05)	0.07	1.87 (0.82)	2.84 (1.32)
Common Langur	Uniform Cosine	0.52	51.58 (6.9)	41	4.98 (0.55)	0.4 (0.05)	0.17	1.74 (0.48)	8.68 (2.6)
Bonnet Macaque	Uniform Cosine	0.97	46.83 (8.5)	19	5.21 (0.77)	0.8 (0.18)	0.08	0.88 (0.27)	4.63 (1.6)

Cotigao-Mhadei Forest Complex of Goa

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The Cotigao-Mhadei forest complexof Goa comprises of five protected areas, namely,Mhadei Wildlife Sanctuary (208 km^2), BhagwanMahavir Wildlife Sanctuary (133 km^2), BhagwanMahavir National Park (107 km^2), Netravali Wildlife Sanctuary (211 km^2) and Cotigao Wildlife Sanctuary (86 km^2) along the Western Ghats ridge. They cover an area of about 750 km^2, forming a contiguous belt of forest, connecting the forests of Karnataka and Maharashtra. Cotigao-Mhadei forest complex is situated at 74º 55'E and 15º 42' N. The region along the Vagheri hills in north Goa is The Mhadei Wildlife Sanctuary. Elevations among the hills of the Sanctuary range from 200–560 m. The Mhadei River, known downstream as the Mandovi River originates in Karnataka, passes through the Mhadei Wildlife Sanctuary and meets the Arabian Sea at Panaji in Goa. To the south of Mhadei is the BhagwanMahavir Wildlife Sanctuary and BhagwanMahavir National Park. A National Highway divides it into two parts and a railway line passes through the area. The Netravali Wildlife Sanctuary lies between the BhagwanMahavir National Park on the north and the Cotigao Wildlife Sanctuary to its south.This region typically contains evergreen, semi-evergreen and moist deciduous forest types. The evergreen forests are mainly seen at higher altitudes and along the river banks.

Sampling Details

Camera trap field surveys were carried out in Goa from 7th May 2013 to 11th June 2013. A total of 42 camera trap locations were sampled over 10 sampling occasions (Karanth & Kumar 2014), accounting for cumulative sampling effort of 420 trap nights (Fig. 9.42). We adopted a block-sampling approach to set camera traps across 3 blocks. The total camera trap area for Goa is 478.47 km^2 (Table 9.72).

Analytical Details

Data from Goa could not be analyzed because only one individual tiger was photo-captured during camera trap surveys.

Table 9.72: *Sampling details of camera trap efforts in Goa from7th May 2013 to 11th June 2013*

Sampling details	Estimates	Standard Errors
Camera Trapped Area km^2	478.47 km^2	NA
Camera Points	42	NA
Trap Nights (effort)	420	NA
Unique tigers captured	1	NA
Initial Encounter Frequency ([redacted]	NA	NA
Scale parameter ([redacted]n meters)	NA	NA
No. of tigers / 100 km^2 ($\hat{D}$)for the Effective Sampled Area	NA	NA
Population Estimate ($\hat{N}$) for the Protected Area	NA	NA

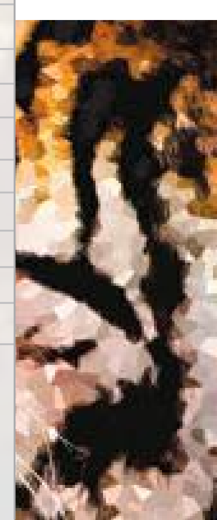
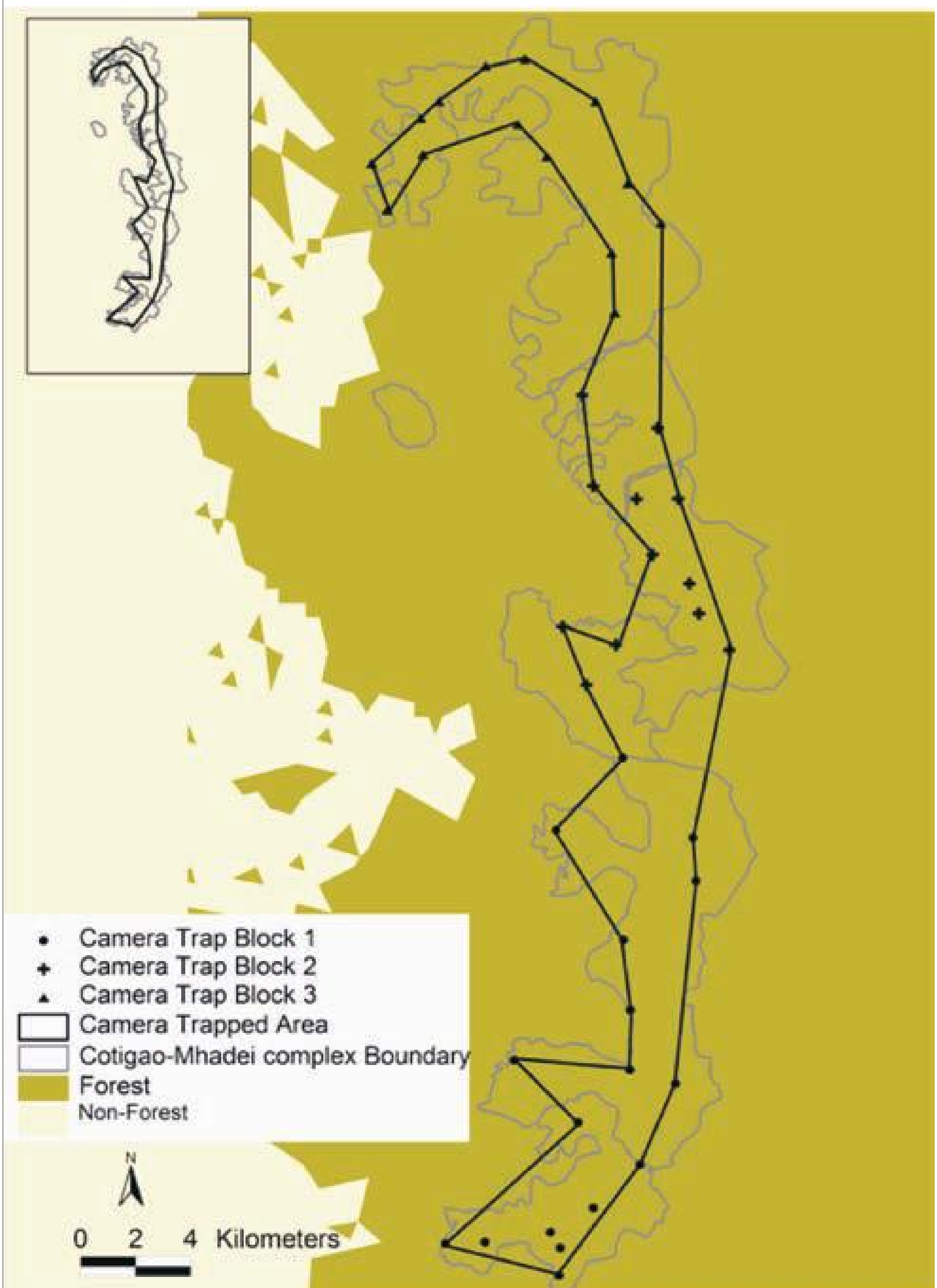


Figure 9.42: Distribution of camera traps (n=42) in Cotigao-Mhadei forest complex of Goa, 2013.



Indira Gandhi (Anamalai) Tiger Reserve (Tamil Nadu)

Krishnakumar N, Peter Prem Chakravarthi J, Ravikumar N and Arumugam K.
World Wide Fund for Nature, India.

Anamalai Tiger Reserve (ATR) located in Tamil Nadu and is one of the largest tiger reserves in India. It is situated in the Southern Side of the Palghat gap which is a part of the Southern Western Ghats landscape. It is bound between 10° 12' N to 10° 35' N and 76° 49' E to 77° 24' E. Total area of the tiger reserve comprises of 958.59 km^2 of the critical tiger habitat and buffer area of 521.28 km^2, totaling an area of 1479.87 km^2. This reserve has diverse forest types which range from dry thorn forest to shola patches, grass land, dry deciduous, moist deciduous, evergreen, semi evergreen and teak plantations. The major carnivores are tiger, leopard, wild dog, leopard cat, jungle cat, brown palm civet and small Indian civet. Major ungulates are gaur, sambar, chital, barking deer, mouse deer and nilgiri tahr.

Sampling Details

a) *Camera Trap field survey was carried out in ATR from 12-03-2013to 07-06-2013. A total of 119 camera trap stations were set up and sampled simultaneously over 88 occasions accounting for cumulative sampling effort of 6223 trap nights. The minimum bounding polygon for ATR was 349.64 km^2 (Table 9.73) and (Fig. 9.43).*

Table 9.73: *Sampling details and tiger density parameter estimates using spatially explicit capture mark-recapture analysis using likelihood framework for Annamalai Tiger Reserve, 2013*

Variables	Estimates
Minimum bounding polygon (km^2)	349.64
Camera Points	119
Trap Nights (effort)	6223
Unique tigers captured	10
Model	g0(.)[redacted])
$\hat{D}$ ML SECR (per 100 km^2)	1.18(0.46)
Sigma (SE) km	3.69(0.75)
g0 (SE)	0.004(0.001)

SE: Standard error

$\hat{D}$ ML SECR: Density estimate from Maximum Likelihood based spatially explicit capture recapture

σ(Sigma): Spatial scale of detection function, g0: Magnitude (intercept) of detection function

Among the two administrative units namely Pollachi and Thirupur forest divisions, the Pollachi forest division holds a better carnivore and herbivore population. The faunal diversity is lower in Thirupur forest division due to high anthropogenic pressure. There is a need for more intervention to work on community related issues in the Thirupur forest division. The camera trap data shows that almost 95% of the camera traps locations have presence of local people. Proper management interventions and protection can ensure that the region can sustain good tiger population.

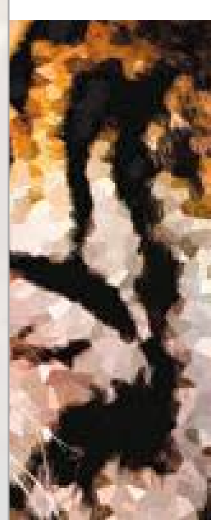
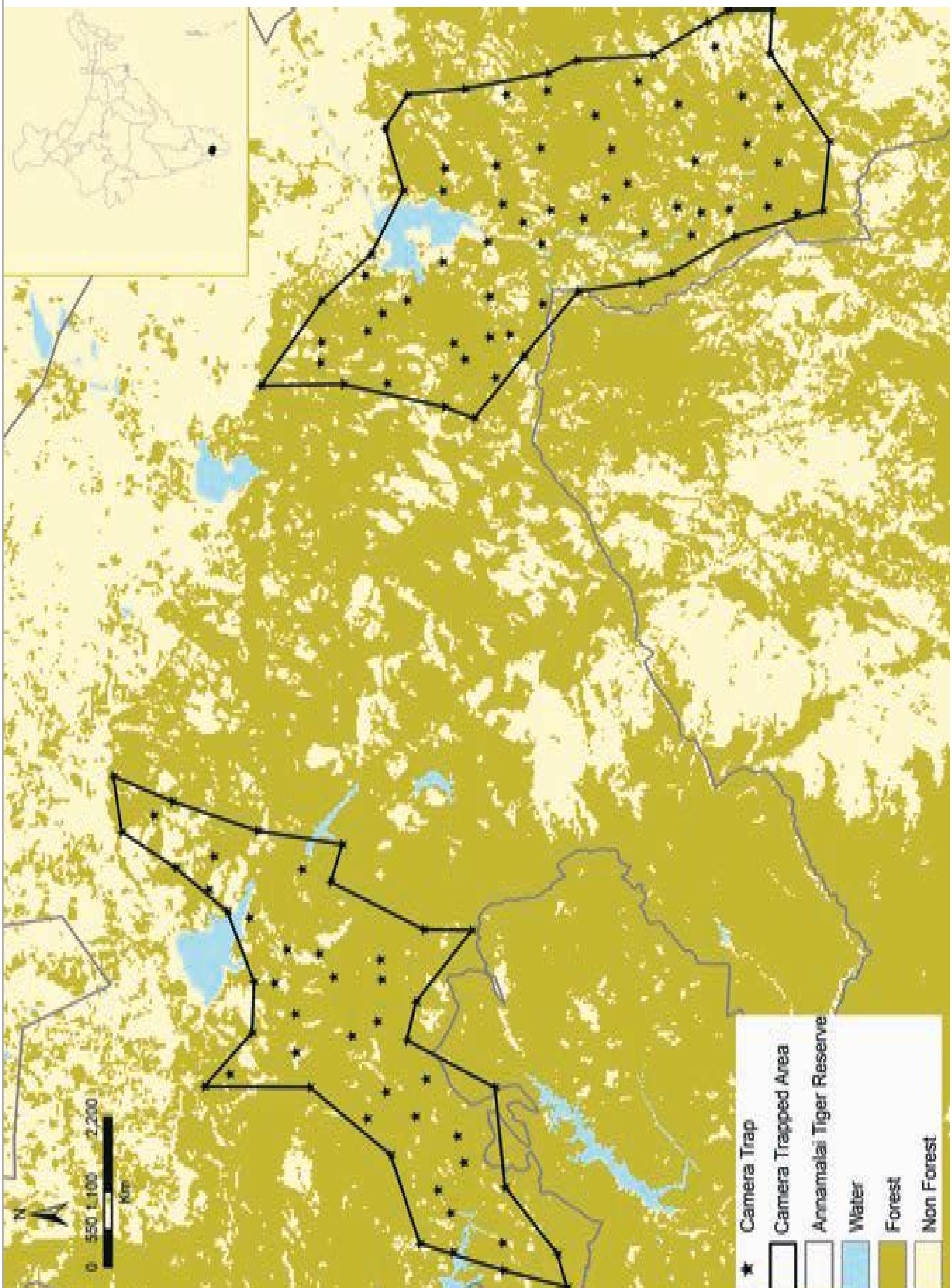


Figure 9.43: Distribution of camera traps (n=119) in Annamalai Tiger Reserve, 2013.



Kalakkad Mundanthurai Tiger Reserve (Tamil Nadu)

Meeta Banerjee[1], R. Kanchana[1], R. Pillai Vinayagam[1], Deepan Chakravarthy[2], Roshan Puranik[2], Syed Abrar[2], Parabita Basu[2], Y. V. Jhala[2] and Qamar Qureshi[2].

[1]Forest Department of Tamil Nadu, [2]Wildlife Institute of India.

Kalakkad Mundanthurai Tiger Reserve (KMTR) is situated at 8° 41′ 0′′ N, 77° 19′ 0′′ in the Southern Western Ghats. It also forms part of the interstate Agasthiyarmalai Biosphere Reserve. It was declared as Tiger Reserve in 1988. This includes two contiguous Sanctuaries namely Kalakad Sanctuary and Mundanthurai Sanctuary and a part of Kanyakumari Sanctuary. The total area of the Tiger Reserve is 895 km^2.

Major Forest types found in KMTR are southern hilltop evergreen forests, west coast tropical wet evergreen forests, tirunelveli semi evergreen forests, southern moist mixed deciduous forests, tropical riparian fringing forests, dry teak forests, southern dry mixed deciduous forests, carnatic umbrella thorn forests, ochlandra reeds and southern montane wet grassland (Champion and Seth 1968).

KMTR has 77 mammals, 33 fish, 37 amphibians, 81 reptiles and 273 bird's species. The flagship species are tiger, elephant and lion tailed macaque. The co-predators of tiger include dhole and leopard. Major ungulates are wild pig, mouse deer, barking deer, chital, sambar, gaur, nilgiri tahr and elephant.

Sampling Details

a) Camera trap field surveys were carried out in KMTR from 07-06-2014 to 15-08-2014. A total of 60 camera trap stations were setup and sampled simultaneously over 83 sampling occasions accounting for cumulative sampling effort of 4980 trap nights. The minimum Bounding Polygon for KMTR was 189.69 km^2 (Table 9.74) and (Fig. 9.43).

Table 9.74: *Sampling details and tiger density parameter estimates using spatially explicit capture mark-recapture analysis using likelihood framework for Kalakad Mundanthurai Tiger Reserve, 2014*

Variables	Estimates
Minimum Bounding Polygon (km^2)	189.69
Camera Points	60
Trap Nights (effort)	4980
Unique tigers captured	6
Model	g0(.)[redacted])
$\hat{D}$ ML SECR (per 100 km^2)	0.88 (0.39)
Sigma (SE) (km)	3.16 (0.48)
g0 (SE)	0.01 (0.008)

SE: Standard error

$\hat{D}$ ML SECR: Density estimate from Maximum Likelihood based spatially explicit capture recapture

σ(Sigma): Spatial scale of detection function, g0: Magnitude (intercept) of detection function

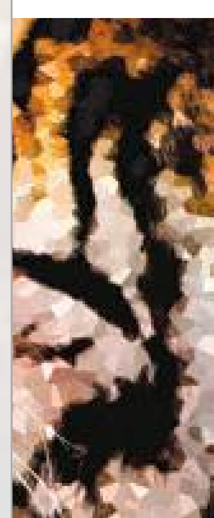
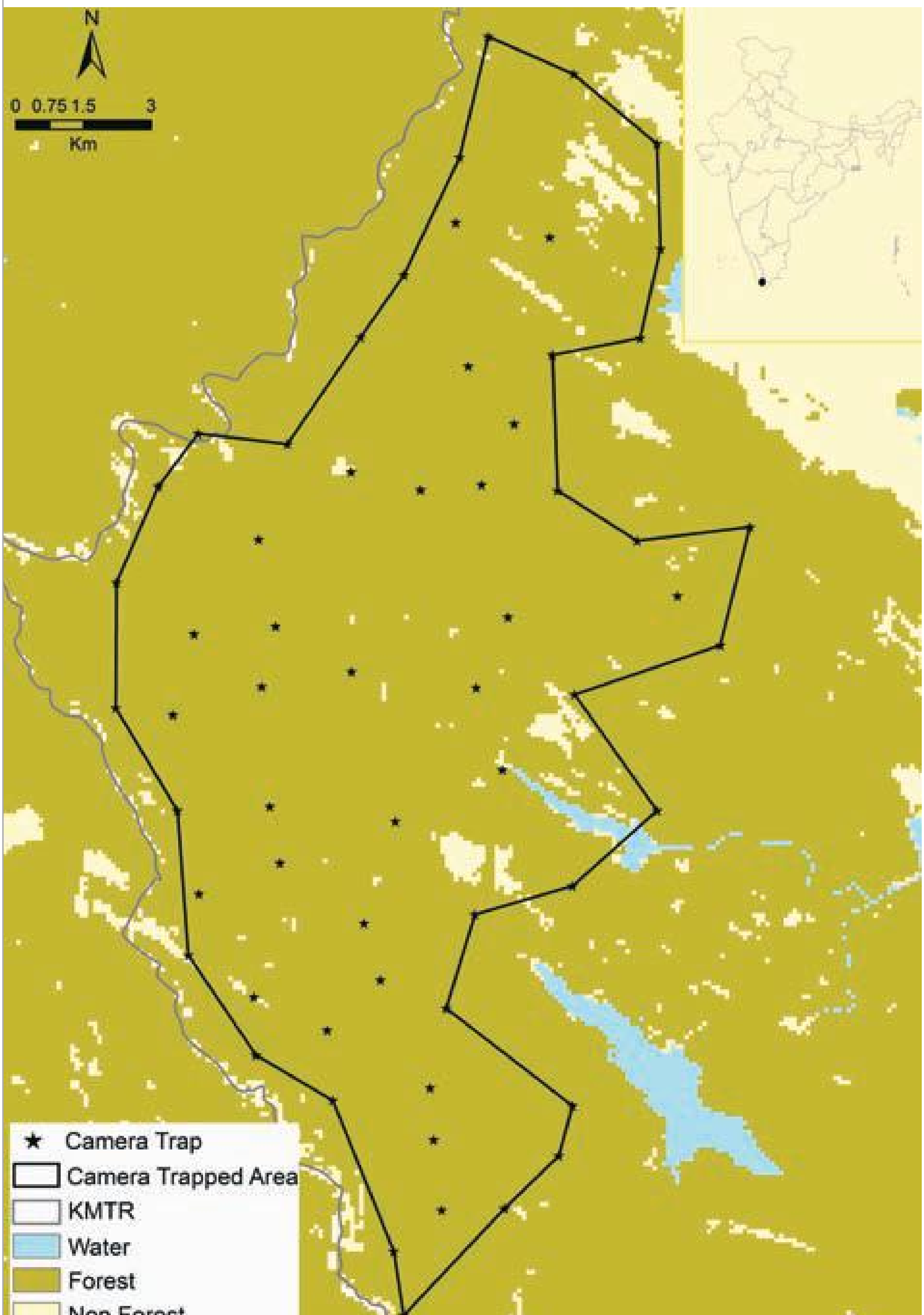


Figure 9.44: Distribution of camera traps (n=60) in Kalakkad Mundanthurai Tiger Reserve , 2014.



Nilgiri North Forest Division (Tamil Nadu)

Vijaya Kumar. K. and Vinoth. A.
World Wide Fund for Nature, India.

The Nilgiri North Division (NND) covers an area of 482 km^2. This division comprises of seven ranges i.e. Sigur, Singara, North Eastern Slopes (NES), Kothagiri, Coonoor, Kattabettu and Ooty North Range. Sigur Plateau is located adjoining the Bandipur National Park to the northwest, Wayanad Wildlife Sanctuary to the west, and Sathyamangalam Wildlife Sanctuary and Nilgiris East ranges to the east. As it is insulated by protected areas on all sides, it is less disturbed with diverse vegetation types from Evergreen to Thorn forest on the plateau and therefor this diversity of habitat supports a variety of fauna. Elevation of the plateau lies between 600m to 2600m. The average annual rainfall varies from 40cm to 200cm. Vegetation type varies in accordance with elevation and rainfall gradient in this area.

The presence of Riparian forest in Moyar River and arid Thorn forest in the hills with open grass and sparsely distributed trees supports a variety of large herbivores. Some of the mammal species found in this division includes elephant, gaur, sambar, chital, muntjac, blackbuck, four-horned antelope, giant squirrel, wild pig, black-napped hare, common langur, and bonnet macaque. The division supports carnivores like tiger, leopard, wild dog, striped hyena and sloth bear.

Sampling Details

Camera Trap field survey was carried out in NND in two blocks. Block one (Sigur) was from 1/1/2014 to 16/2/2014 and Block two (Moyar valley) from 3/3/2014 to 19/4/2014. A total of 88 camera trap stations were set up and sampled simultaneously over 48 sampling occasions accounting for cumulative sampling effort of 3969 trap nights. The minimum bounding polygon for NND was 305.19 km^2 (Table 9.75) and (Fig. 9.45).

Table 9.75: *Sampling details and tiger density parameter estimates using spatially explicit capture mark-recapture analysis in a likelihood framework for Nilgiri North Divison, 2014*

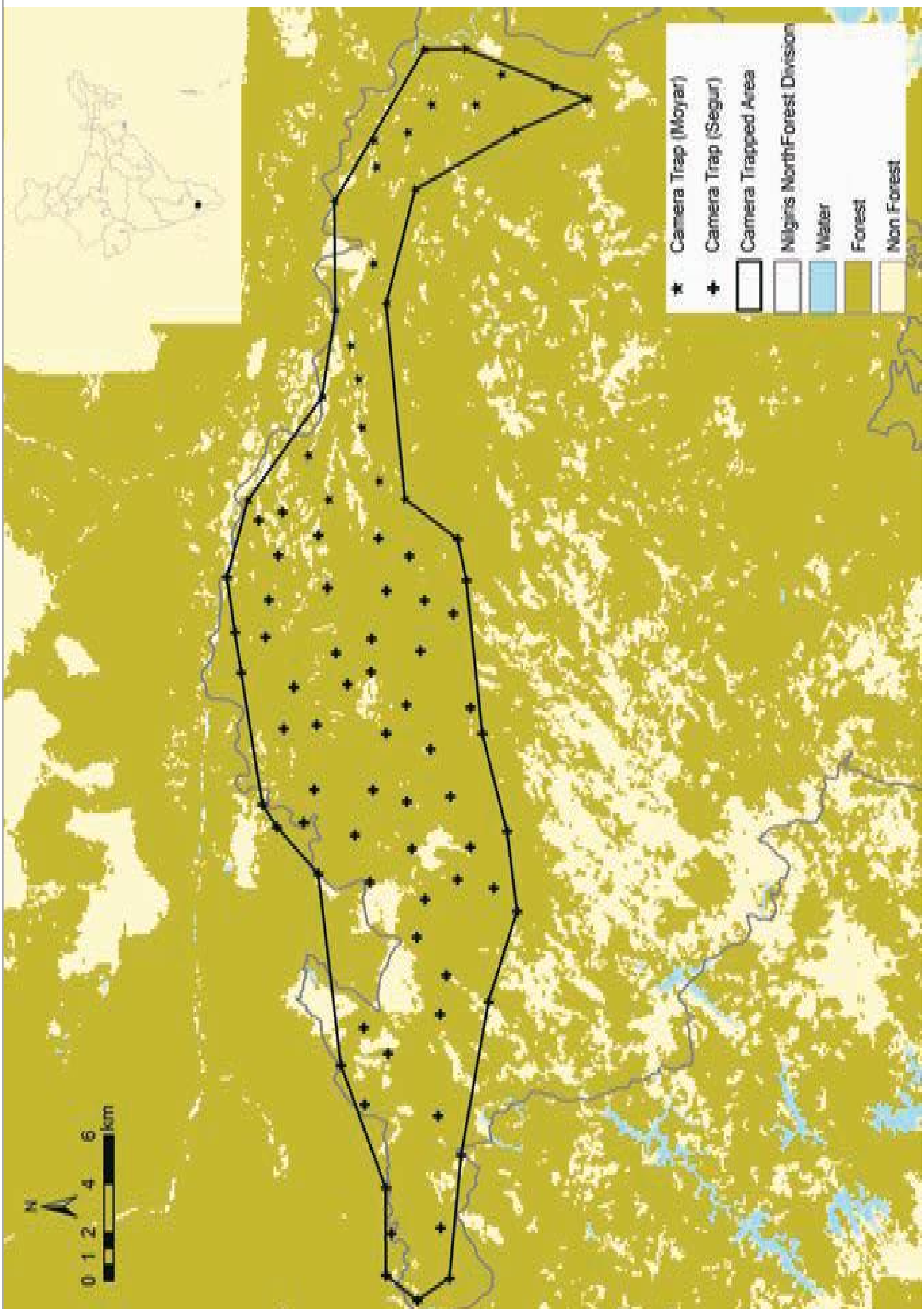
Variables	Estimates
Minimum bounding polygon (km^2)	305.19
Camera Points	88
Trap Nights (effort)	3969
Unique tigers captured	40
Model	g0(.)[redacted])
$\hat{D}$ ML SECR (per 100 km^2)	5.95(0.99)
Sigma (SE) km	1.6(0.09)
g0 (SE)	0.06(0.01)

SE: Standard error

$\hat{D}$ ML SECR: Density estimate from Maximum Likelihood based spatially explicit capture recapture

σ(Sigma): Spatial scale of detection function, g0: Magnitude (intercept) of detection function

Figure 9.45: *Distribution of camera traps (n=88) in Nilgiri North Division, 2014.*



Sathyamangalam Tiger Reserve (Tamil Nadu)

Vijaya Kumar. K., Ravi Kumar. N., Vinoth. A., B. Balraj, C. Nithan, Ramachandran, Kalicharan and Kannan.
World Wide Fund for Nature, India.

Sathyamangalam Tiger Reserve (SMTR) is located at 11° 38′ 24′′ N, 77° 13′ 34′′ E and covers an area of 1,411.6 km^2.Sathyamangalam forest range is an important wildlife corridor in the Nilgiri Biosphere Reserve between the Western Ghats and the rest of the Eastern Ghats. It forms a genetic link between the four other protected areas which it adjoins, the Billigiri Ranga Swamy Temple Wildlife Sanctuary, Sigur Plateau, Mudumalai National Park and Bandipur National Park.

The Sathyamangalam forest is mostly tropical dry forest and is part of the South Deccan Plateau dry deciduous forests ecoregion. There are five distinct forest types: tropical evergreen (Shola), semi-evergreen, mixed-deciduous, dry deciduous and thorn forests.

Major carnivores found here are tiger, leopard, sloth bear and striped hyena. Some of the major herbivores found here are elephants, gaur, chital, blackbuck, sambar, barking deer, four-horned antelope and wild pig.

Sampling Details

a) Camera Trap field survey was carried out in SMTR in four blocks. In Block one from 17-01-2013 to 21-03-2013, Block two from 26-06-2013 to 31-08-2013, Block three from 26-08-2013 to 06-10-2013and Block four from 28-02-2014 to 22-03-2014. A total of 206 camera trap stations were set up and sampled over 53 occasions accounting for cumulative sampling effort of 10918 trap nights. The minimum bounding polygon for SMTR was 688.71 km^2 (Table 9.76) and (Fig. 9.46).

Table 9.76: *Sampling details and tiger density parameter estimates using spatially explicit capture mark-recapture analysis in a likelihood framework for Sathyamangalam Tiger Reserve, 2013.*

Variables	Estimates
Minimum bounding polygon (km^2)	688.71
Camera Points	206
Trap Nights (effort)	10918
Unique tigers captured	57
Model	g0(.)[redacted])
$\hat{D}$ ML SECR (per 100 km^2)	2.98 (0.38)
Sigma (SE) km	3.14 (0.13)
g0 (SE)	0.02(0.0014)

SE: Standard error

$\hat{D}$ ML SECR: Density estimate from Maximum Likelihood based spatially explicit capture recapture

σ(Sigma): Spatial scale of detection function, g0: Magnitude (intercept) of detection function

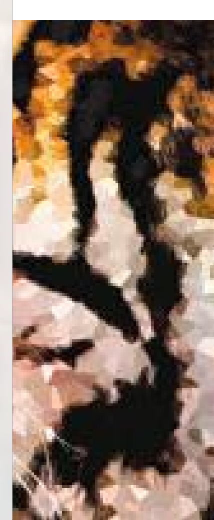
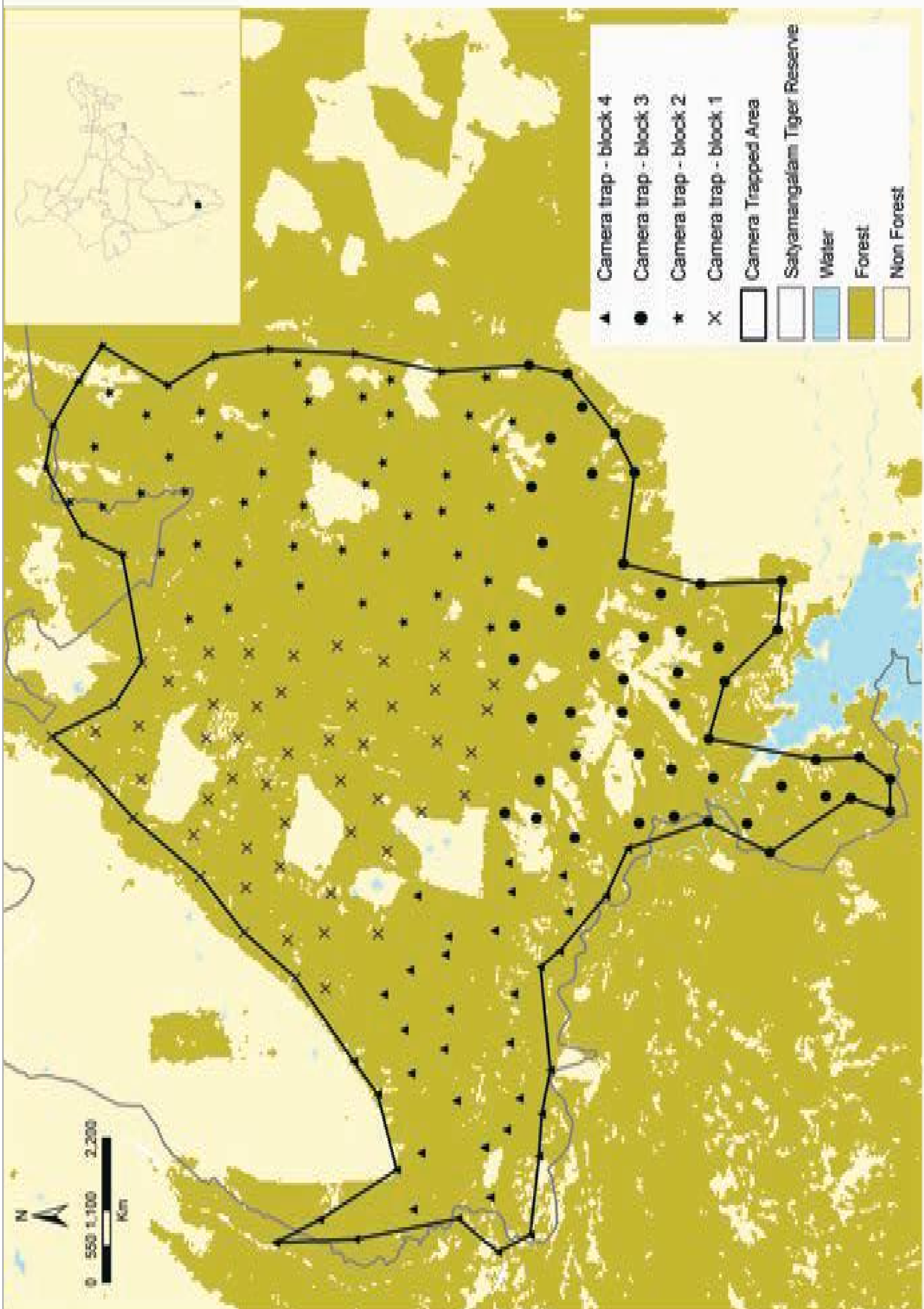


Figure 9.46: Distribution of camera traps (n=206) in Sathyamangalam Tiger Reserve, 2013.

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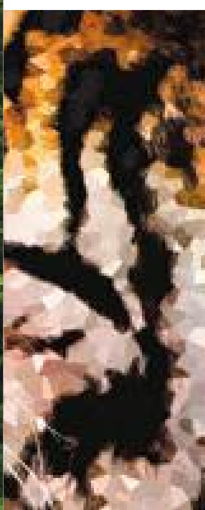


Parambikulam Tiger Reserve (Kerala)

Vijayananthan Anuraj B R[1], Shivashankar, Prabhu T[1], Anandan, Vasantharajan[1], Sreenivasan[1], Sajimon[1], Thankaswamy[1], Murali S[1], Vijayan, Vijayakumar[1], Parabita Basu[2], Y. V. Jhala[2] and Qamar Qureshi[2].

Parambikulam Tiger Reserve is located at 10° 23′ 0′′ N, 76° 42′ 30′′ E, between the Nelliampathy Hills of Kerala and the Anamalai Range of Tamil Nadu within a cluster of Protected Areas. It is located in the Palakkad District of Kerala. It is one of the biodiversity hot spots, with diverse habitat types and high endemism. It was declared as a Tiger Reserve during 2009, with total area of 643.66 km^2, which includes core area of 390.89 and 252.77 km^2 buffer area.The Reserve has six colonies with indigenous tribes such as the Kadar, Malasar, Muduvar and Malamalasars, living within the tiger reserve. There is also a resident colony in the Reserve which came up in the 1950's and 60's during the construction of the Parambikulam Aliyar Dam Project.

The sanctuary has a variety of trees noteworthy being teak, neem, sandalwood and rosewood. Even the oldest surviving teak tree, the Kannimara Teak is found here. It is estimated to be about 450 years old and has a girth of 6.8 meters and a height of 49.5 meters.

The major carnivores are tiger, leopard, dhole and sloth bear. Major ungulate species are nilgiri tahr, gaur, sambar and wild pig.

Sampling Details

a) Camera trap field surveys were carried out in Parambikulam Tiger Reserve from 20-04-2014 to 09-09-2014. A total of 67 camera trap stations were setup and sampled over 75 sampling occasions accounting for cumulative sampling effort of 4371 trap nights. The minimum bounding polygon for Parambikulam Tiger Reserve was 203.41 km^2 (Table 9.77) and (Fig. 9.47).

Table 9.77: Sampling details and tiger density parameter estimates using spatially explicit capture mark-recapture analysis in a likelihood framework for Parambikulam Tiger Reserve, 2014.

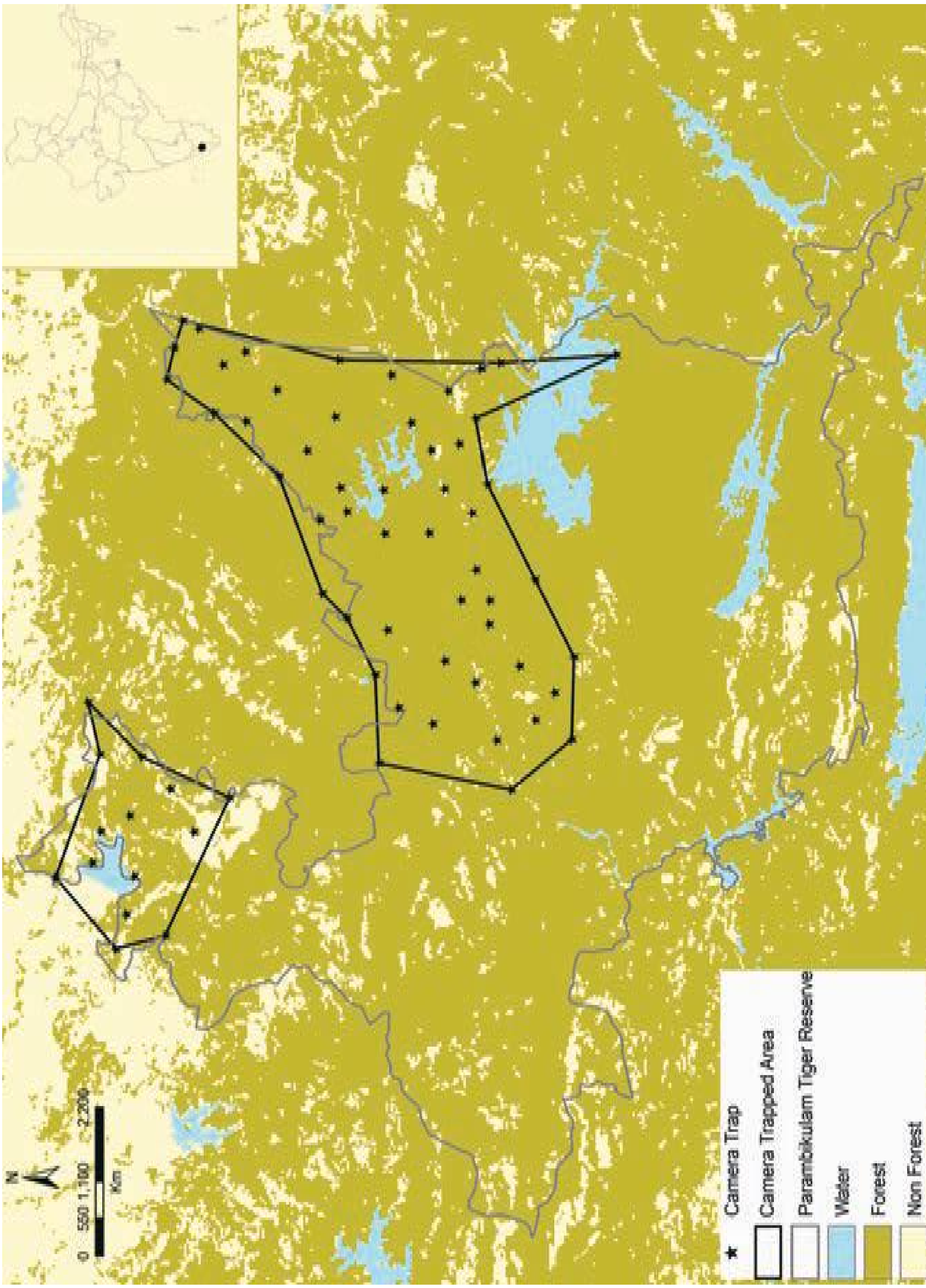
Variables	Estimates
Minimum bounding polygon (km^2)	203.41
Camera Points	67
Trap Nights (effort)	4371
Unique tigers captured	15
Model	g0(.)[redacted])
$\hat{D}$ ML SECR (per 100 km^2)	2.33(0.63)
Sigma (SE) km	3.24(0.31)
g0 (SE)	0.01(0.002)

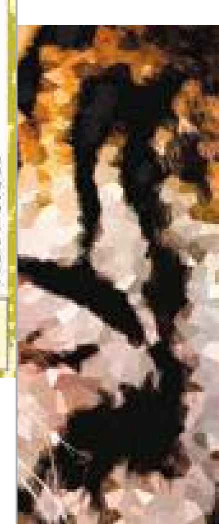
SE: Standard error

$\hat{D}$ ML SECR: Density estimate from Maximum Likelihood based spatially explicit capture recapture

σ(Sigma): Spatial scale of detection function, g0: Magnitude (intercept) of detection function

Figure 9.47: *Distribution of camera traps (n=67) in Parambikulam Tiger Reserve, 2014.*





Periyar Tiger Reserve (Kerala)

M.Balasubramaniam, Shiju Chacko and Ramesh Babu.\ Periyar Foundation

Periyar Tiger Reserve, Thekkady, located at 9° 28′ 0′′ N, 77° 10′ 0′′ E is also designated as an elephant reserve. It covers an area of 925 km² within Idukki and Pathanamthitta district. To the east of the Reserve are the Srivilliputhur Grizzled Giant Squirrel Wildlife Sanctuary and Thirunelveli Forest Division of Tamil Nadu. The Mullaperiyar dam constructed in 1895 resulted in a lake which covers 26 km² of the Reserve. Over five million pilgrims visit the Sabrimala Temple in the Reserve each year; most of these pilgrims reach the temple through Rani Forest Division by road, disturbing the habitat severely and polluting River Pamba. Only four small settlements exist within the Park at Labbakkandam near Kumily, Mannakudy, Paliyakudi and Vanchivayal.

The vegetation in the Periyar Tiger Reserve includes evergreen, semi-evergreen and moist deciduous forests, grasslands, an aquatic eco-system and eucalyptus groves. There are 1966 varieties of flowering plants. There are about 171 grass species and 140 species of orchids in the region.

Apart from tigers, a variety of mammals such as leopard, wild dog, elephant, gaur, sambar, barking deer, wild pig, sloth bear, nilgiri langur, small Travancore flying squirrel and stripe-necked mongoose are also found here. Of the 66 species of mammals reported, 10 species, including the lion-tailed macaque, nilgiri marten and nilgiri tahr, are endemic to the Western Ghats.

Sampling Details

a) Camera trap field surveys were carried out in Periyar Tiger Reserve from 19-02-2014 to 07-06-2014. A total of 261 camera trap stations were set up and sampled simultaneously over 109 sampling occasions accounting for cumulative sampling effort of 28449 trap nights (Fig. 9.48). The minimum bounding polygon for Periyar Tiger Reserve was 917.06 km² (Table 9.78)

Table 9.78: *Sampling details and tiger density parameter estimates using spatially explicit capture mark-recapture analysis in a likelihood framework for Periyar Tiger Reserve, 2014.*

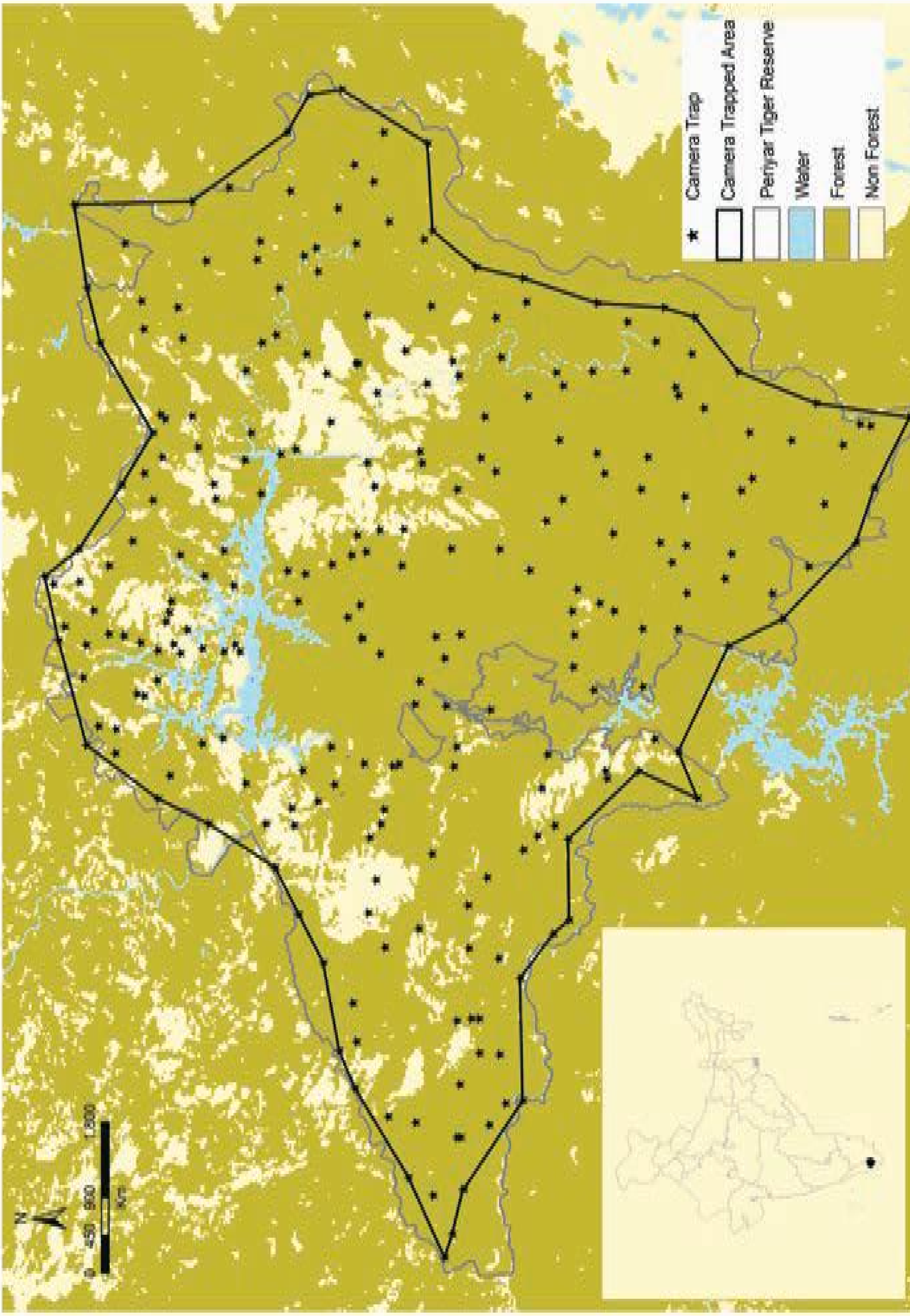
Variables	Estimates
Minimum bounding polygon (km²)	917.06
Camera Points	261
Trap Nights (effort)	28449
Unique tigers captured	22
Model	g0(.)[redacted].)
$\hat{D}$ ML SECR (per 100 km²)	1.2(0.26)
Sigma (SE) (km)	6.42(0.52)
g0 (SE)	0.001(0.0002)

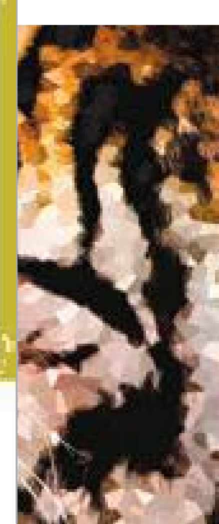
SE: Standard error

$\hat{D}$ ML SECR: Density estimate from Maximum Likelihood based spatially explicit capture recapture

σ(Sigma): Spatial scale of detection function, g0: Magnitude (intercept) of detection function

Figure 9.48: Distribution of camera traps (n=261) in Periyar Tiger Reserve, 2014.





Mudumalai Tiger Reserve (Tamil Nadu)

Raghuram Singh, D. Chandran, L.Sundarrajan, A.Pushpakaran.
Forest Department of Tamil Nadu

Mudumalai Tiger Reserve (MTR) is located at 11° 35′ 0′′ N, 76° 33′ 0′′ E. MTR is situated at the tri- junction of Tamil Nadu, Karnataka and Kerala states. It is contiguous with Wayanad wildlife Sanctuary on the north west, Bandipur Tiger Reserve on the north, the Singara and Sigur Reserved Forests which form the remaining boundary of Nilgiri North Division (Ramesh 2010). MTR also forms part of the Nilgiri Biosphere Reserve. The core area of the reserve is 321 km^2.

There are three main types of forest in the sanctuary: tropical moist deciduous occur in the western Benne Block, where rainfall is higher than in other blocks. Tropical dry deciduous forest occurs in the central part and southern tropical dry thorn forests occur in the east. In addition, there are patches of tropical semi-evergreen forest in the southwest and western part of Mudumalai.

The protected area is home to several endangered and vulnerable species including elephant, tiger, gaur and leopard. Other carnivores found here are wild dog, sloth bear, striped hyena, golden jackal, jungle cat, rusty spotted cat and leopard cat. Major ungulate species include chowsingha, mouse deer, sambar, chital, barking deer, blackbuck and wild pig. There are at least 266 species of birds in the sanctuary, including the critically endangered Indian white-rumped vulture and long-billed vulture.

Sampling Details

a) Camera Trap field survey was carried out in MTR in two blocks. Block one was from 20-11-2013 to 27-01-2014 and Block two from 23-01-2014 to 23-03-2014. A total of 105 camera trap stations were set up and sampled simultaneously over 63 sampling occasions accounting for cumulative sampling effort of 6615 trap nights. The minimum bounding polygon for MTR was 298.18 km^2 (Table 9.79) and (Fig. 9.49)

Table 9.79: Sampling details and parameter estimates of capture mark-recapture analysis using camera traps for tigers in Mudumalai Tiger Reserve, 2014.

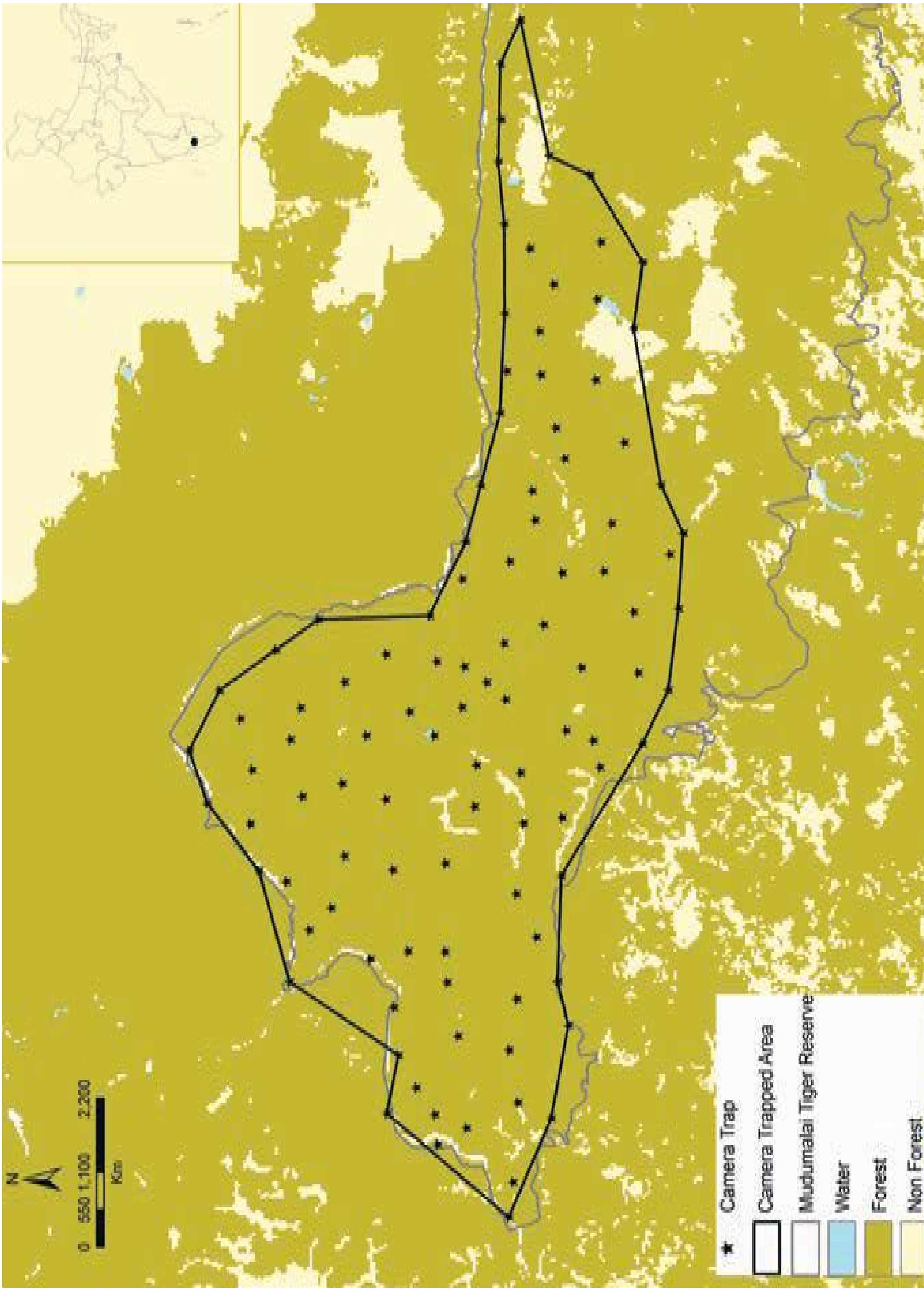
Variables	Estimates
Minimum bounding polygon (km^2)	298.18
Camera Points	105
Trap Nights (effort)	6615
Unique tigers captured	67
Model	g0(.)[redacted].)
$\hat{D}$ ML SECR (per 100 km^2)	8.04(1.03)
Sigma (SE) km	2.03(0.03)
g0 (SE)	0.041(0.001)

SE: Standard error

$\hat{D}$ ML SECR: Density estimate from Maximum Likelihood based spatially explicit capture recapture

σ(Sigma): Spatial scale of detection function, g0: Magnitude (intercept) of detection function

Figure 9.49: *Distribution of camera traps (n=105) in Mudumalai Tiger Reserve, 2014.*



North East Hills and Brahmaputra Flood Plains

Manas National Park (Assam)

M Firoz Ahmed[1], Dipankar Lahkar[1], Tridip Sharma[2], Pallabi Chakravarti[2], Jimmy Borah[2], J. Charles Leo Prabu[3], Aisho Sharma Adhikarimayum[3], Y.V. Jhala[3], Qamar Qureshi[3].

Manas Wildlife Sanctuary (with an area of 500 km^2) was upgraded to National Park status in September 1990. It is located in Baksa and Chirang districts (26°35' to 26°50'N and 90°45' to 91°15'E) of Bodo land Territorial Council in the State of Assam. In 2003, Manas National Park (MNP) became a part of Chirang-Ripu Elephant Reserve (2600 km^2) under the umbrella of "Project Elephant". It has been recognized as an "Important Bird Area" on the basis of the excellent birdlife and significant population of some globally threatened species (Islam and Rahmani, 2004). MNP forms the core area of the larger Manas Tiger Reserve which extends between the River Sankosh in the west, and the river Dhansiri in the east. Elevation ranges from 50 m above MSL on the southern boundary to 200 m above MSL along the Bhutan hills.

The monsoon and river system forms four principal geological habitats, viz. bhabar, terai, marshlands and riverine tracts. The dynamic ecosystem process supports broadly three types of vegetation: (a) semi-evergreen forests; (b) moist and mixed deciduous forests and; (c) alluvial grasslands. In total there are nearly 60 mammal species, 42 reptile species, 7 amphibians and 476 species of birds (Choudhury, 2006), of which 26 are globally threatened. Noteworthy among these are the Elephant, Tiger, Greater one-horned rhino, Clouded leopard, Sloth bear and other species. The wild buffalo population is probably the only pure strain of this species still found in India. It also harbours endemic species like pygmy hog, hispid hare and golden langur as well as the critically endangered Bengal florican.

Sampling Details

a) Camera traps were deployed over two blocks covering an area of 657.75 km^2 and 473.25 km^2 respectively (Fig. 9.50). Total effort for both the blocks are; 5501 and 2022 trap nights (Table 9.80).

b) A total of 14 line transect surveys were carried out and were replicated thrice with a total walk effort of 134 km (Fig. 9.50, Table 9.82). The number of observations for prey was too low to carry out analysis, hence only encounter rate has been provided (Table 9.81)

Analytical Details

Variables	Estimates
Camera Trapped Area (km^2)	1130
Camera Points	252
Trap Nights (effort)	7523
Unique tigers captured	9
Model	g0(.)[redacted].)
$\hat{D}$ ML SECR (per 100 km^2)	1.82 (0.63)
Sigma (SE) (km)	2.11 (0.13)
g0 (SE)	0.02 (0.003)

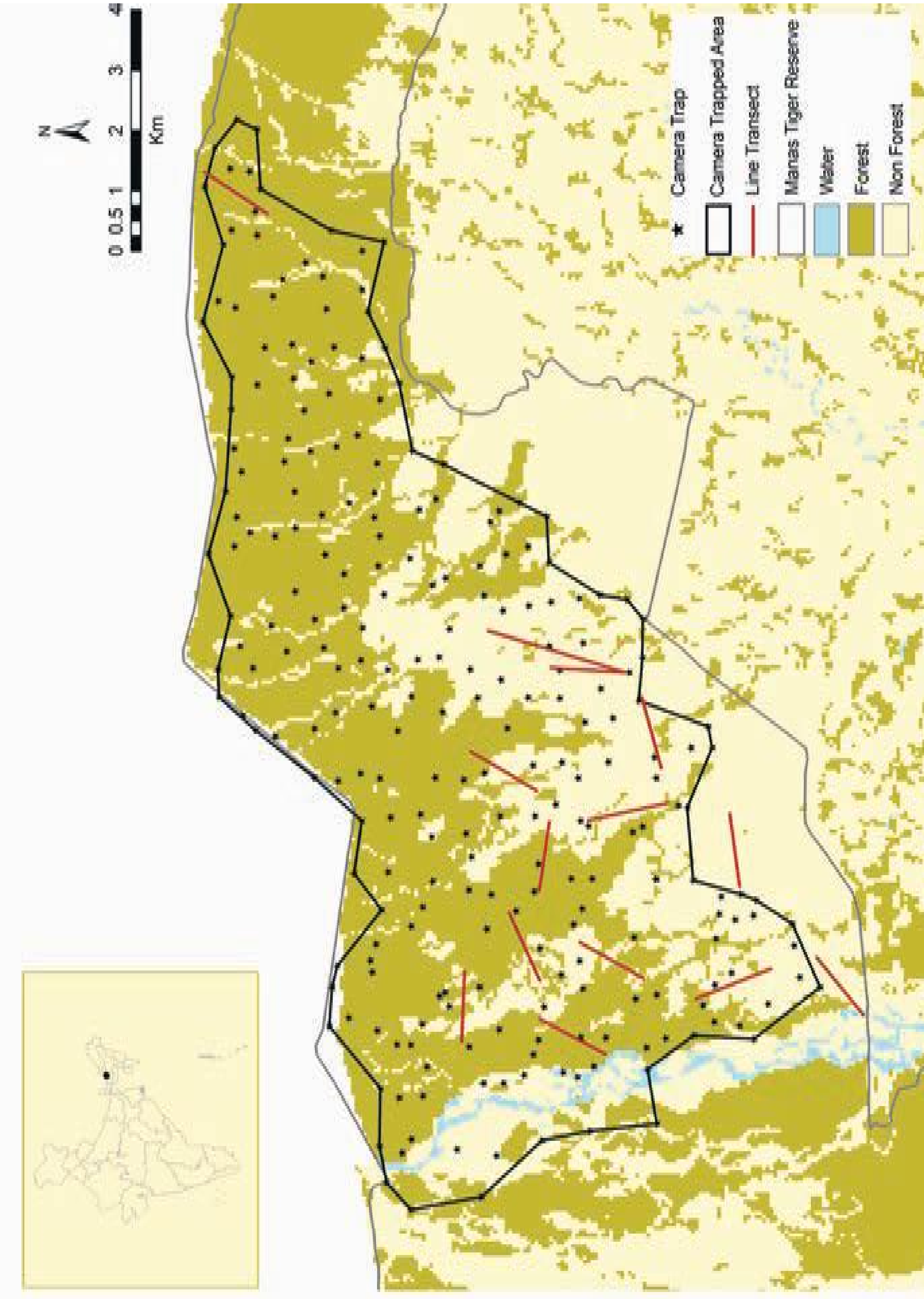
Table 9.80: Sampling details and parameter estimates of capture mark-recapture analysis using camera traps for Tiger at Manas National Park from 23/01/2014 to 02/05/2014.

SE: Standard error

$\hat{D}$ ML SECR: Density estimate from Maximum Likelihood based spatially explicit capture recapture

σ(Sigma): Spatial scale of detection function, g0: Magnitude (intercept) of detection function

Figure 9.50: Distribution of camera traps (n=252) and line transects (n=14)laid in Manas National Park, Assam



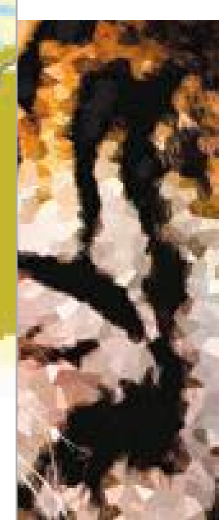
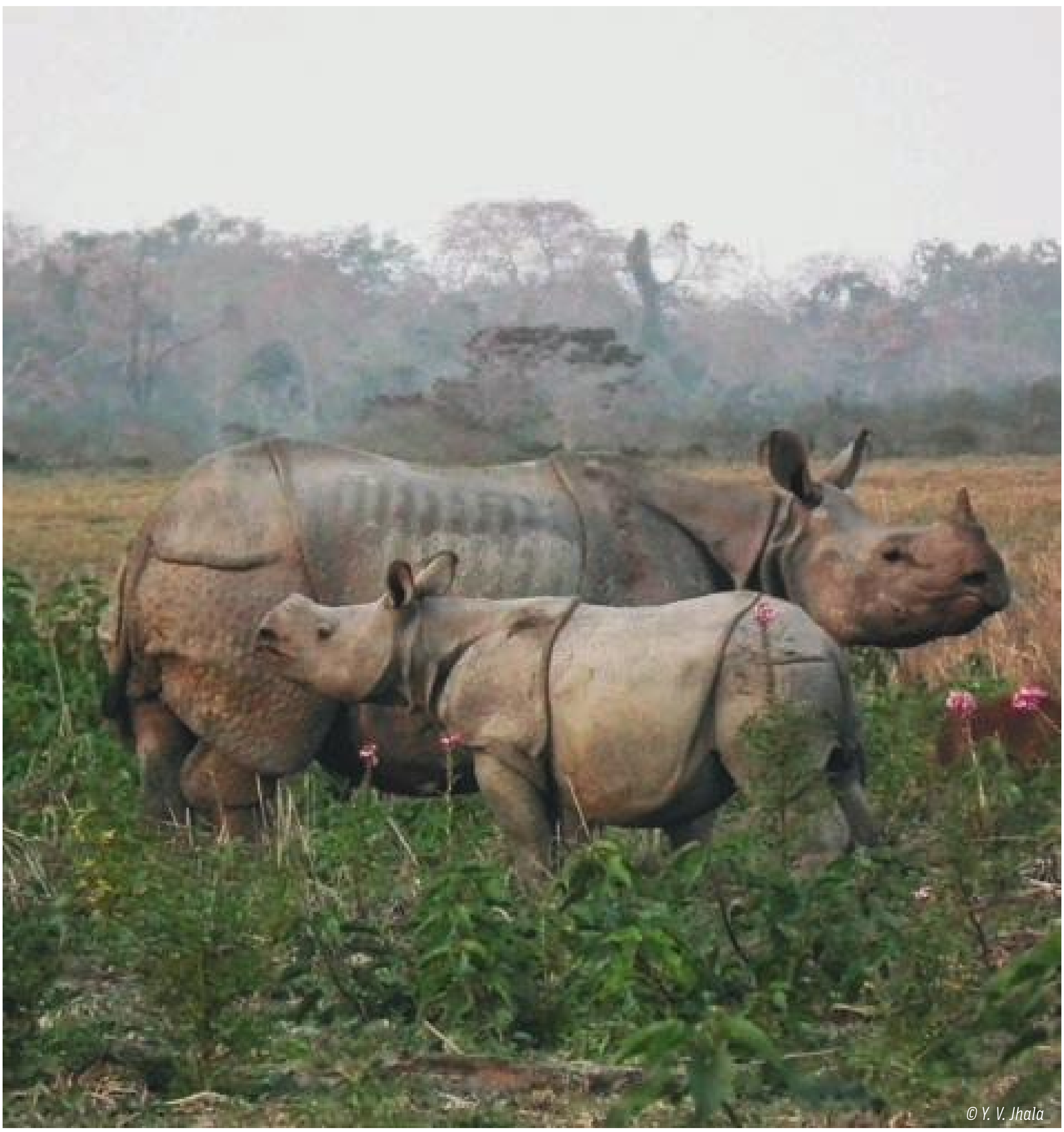


Table 9.81: Encounter rates of prey species seen on line transects (n=14, total effort of 134 km) in Manas National Park, 2014.

Species	No. of groups detected	Encounter Rate per Km
Gaur	14	0.10
Hog Deer	24	0.18
Sambar	13	0.1
Wild Pig	17	0.13



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Pakke Tiger Reserve (Arunachal Pradesh)

Tana Tapi, Chandan Ri.
Arunachal Forest Department

Pakke Wildlife Sanctuary was notified as a Tiger Reserve in 2002 based on a proposal in 1999. Earlier a part of the Khellong Forest Division, It covers an area of 861.95 km² and lies between 92°36' to 93°09'E and 26°54' to 27°16'N in the foothills of the Eastern Himalaya in the East Kameng District of Arunachal Pradesh. The elevation ranges from 100 metres (330 ft) to 2,000 metres (6,600 ft) metres above mean sea level.

PTR has a subtropical climate with cold weather from November to March. The temperature varies from 12 to 36 °C (54 to 97 °F). Annual rainfall is 2,500 millimetres. The habitat types are lowland semi-evergreen, evergreen forest and Eastern Himalayan broadleaf forests. The general vegetation type of the entire tract is classified as Assam Valley tropical semi-evergreen forest. Three large cats - the tiger, leopard and clouded leopard, share space with two canids – the wild dog and Asiatic jackal. Among the seven herbivore species, elephant, barking deer, gaur and sambar are most commonly encountered. Among the primates, rhesus and Assamese Macaques and Capped Langur are common. Commonly seen is the yellow-throated marten, and the highly endangered Assam roof turtle.

Sampling Details

a) A total of 31 camera trap stations were deployed in the first block (Fig. 9.51) between 5th December to 16th January adding upto 1890 trap nights and 35 stations in the second block were deployed covering a total area of 229.67 km² (minimum bounding polygon) for a period of 44 days from 16th January to 28th February adding upto 1890 trap nights (Table 9.82).

b) A total of 23 spatial transects were sampled thrice resulting into an effort of 130.1 km walk (Fig. 9.51, Table 9.84).

Table 9.82: *Sampling details and parameter estimates of capture mark-recapture analysis using camera traps for Tiger at Pakke Tiger Reserve from 05/12/2013 to 28/02/2014.*

Variables	Estimates
Camera Trapped Area km²	229.67
Camera Points	66
Trap Nights (effort)	1890
Unique Tigers captured	9
Model	g0(.)[redacted])
$\hat{D}$ ML SECR (per 100 km²)	0.90 (0.30)
Sigma (SE) km	5.8 (0.87)
g0 (SE)	0.006 (0.001)

$\hat{D}$ - Tiger density; s (Sigma) - movement parameter, g0 – capture probability, SE – standard error.

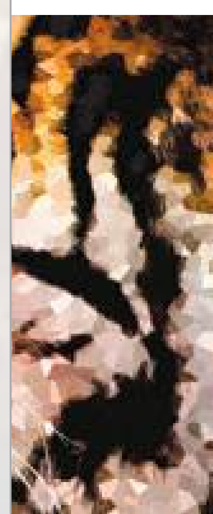


Figure 9.51: Distribution of Camera traps (n=66) and line transects (n=23) in Pakke Tiger Reserve, Arunanchal Pradesh.

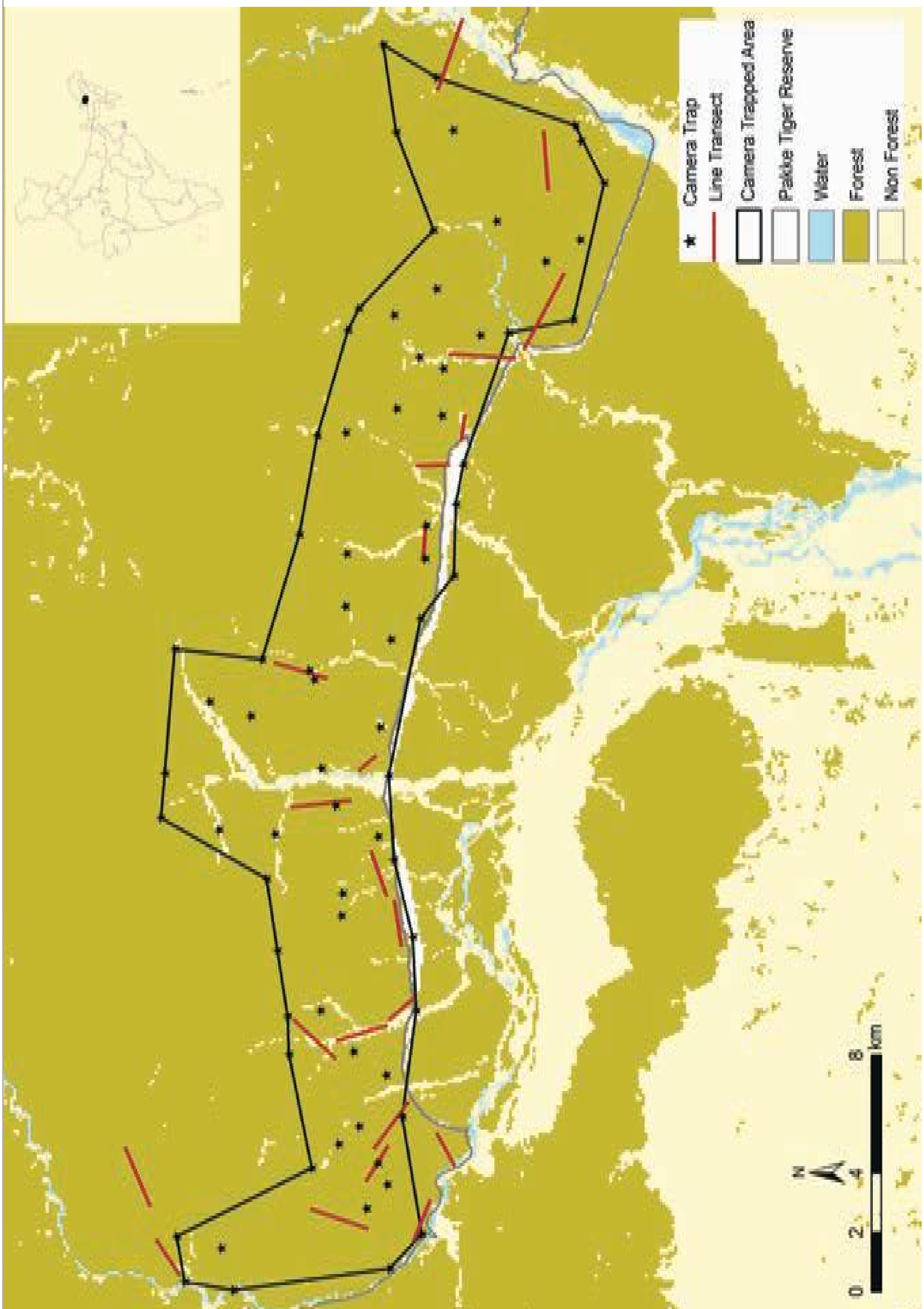
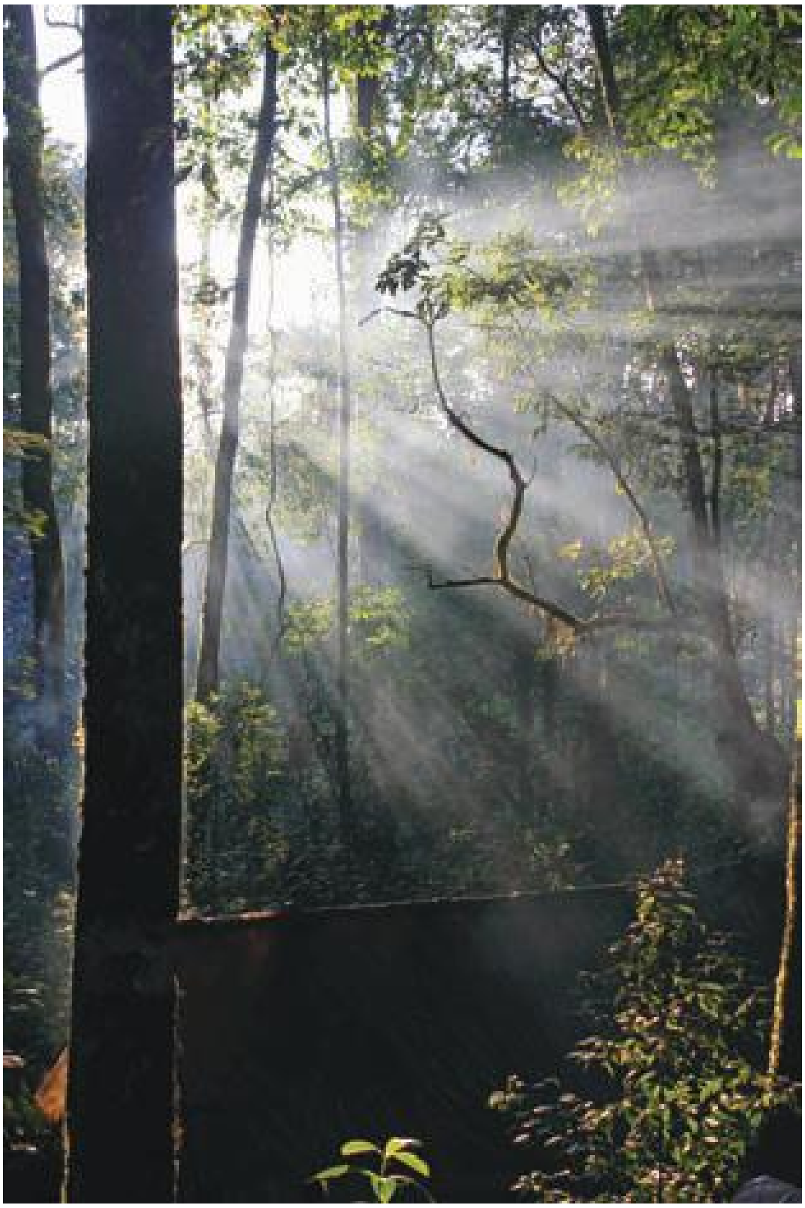


Table 9.83: Model statistics and parameter estimates of line transect (n=23, Total effort 130.1 km) based distance sampling for prey species in Pakke Tiger Reserve (Arunachal Pradesh), 2014.

Species	Model	Chi Sq P Value	Effective Strip Width (SE)	No. Groups Detected	Mean Group size (SE)	Detection Probability (SE)	Encounter Rate per km	Group Density (SE) per km^2	Individual Density (SE) per km^2
Barking Deer	Half normal cosine	0.41	16.78 (2.06)	48	0.98 (0.02)	0.32 (0.04)	0.36	10.98 (1.90)	10.87 (1.90)
Gaur	Half normal cosine	0.47	18.02 (3.21)	11	2.15 (0.67)	0.52 (0.09)	0.10	2.77 (0.81)	6.26 (2.49)
Sambar	Hazard Polynomial	0.89	13.36 (1.33)	44	1.22 (0.05)	0.56 (0.05)	0.33	12.65 (3.18)	15.54 (3.96)
Wild pig	Half normal	0.71	20.53 (4.16)	9	1.40 (0.22)	0.59 (0.12)	0.08	1.99 (0.89)	3.02 (1.43)



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Nameri Tiger Reserve (Assam)

Rajendra G Garawad[1], Jadav Medhi[1], Qamar Qureshi[2].
[1]Assam Forest Department, [2]Wildlife Institute of India

Nameri Tiger Reserve (NTR) is one of the important Protected Areas situated on the northern bank of river Brahmaputra. It is situated in the Sonitpur district of Assam and shares boundary on the northern side with the Pakke Tiger Reserve of Arunachal Pradesh. The core area of the reserve which constitutes the "Nameri National Park" is bound by rivers Jia-Bhoreli on the West and Bor-Dikorai on the East. It is spread over an area of 344 km^2. NTR is geographically located between 26° 48' N - 27° 03' N latitudes and 92° 38' E - 93° 05' E longitudes.

The habitat of NTR comprises of tropical evergreen, semi-evergreen, moist deciduous forests with cane brakes and narrow strips of grasslands along the riverine areas. Grassland comprises of less than 10% of the core area while the semi-evergreen and moist deciduous species dominate the area. The main forest types available within the reserve are: Assam Valley Tropical Evergreen Forests, Sub Himalayan Light Alluvial Semi-Ever- green Forests, Eastern Alluvial Secondary Semi Evergreen Forests, Cane Brakes, Low Alluvial Savanna Woodland, Eastern Hollock Forests, Eastern Seasonal Swamp Forests, Eastern Dillenia Swamp Forests and Eastern Wet Alluvial Grassland. The faunal diversity of the reserve includes 52 species of mammals. The major carnivores of the reserve are tiger, common leopard, clouded leopard and the wild dog. The carnivore prey base comprises of sambar, barking deer, hog deer, wild boar, gaur and domestic cattle in fringe areas. As a part of Sonitpur Elephant Reserve, NTR also supports sizeable population of Asian elephant. Nameri is a bird watcher's paradise with over 300 species of birds. The white winged wood duck, great pied hornbill, wreathed hornbill, rufous necked hornbill, black stork, ibis bill, blue-bearded bee-eaters, babblers, plovers and many other birds have made Nameri their home.

Sampling Details

a) For the purpose of camera trapping, the entire core of NTR was divided into two blocks of 100 km^2 each. In block 1, a total of 24 camera trap stations were installed from 4th November 2012 to 13th December 2013 and 25 stations were installed in block 2 from 18th Dec 2012 to 25th Jan 2013. The minimum of bounding polygon of camera trap area in block I & II was 136.3 km^2 (Fig. 9.52, Table 9.84).

Analytical Details

Table 9.84: Sampling details and parameter estimates of capture mark-recapture analysis using camera traps for Tiger at Nameri Tiger Reserve from 04/11/2012 to 27/01/2013.

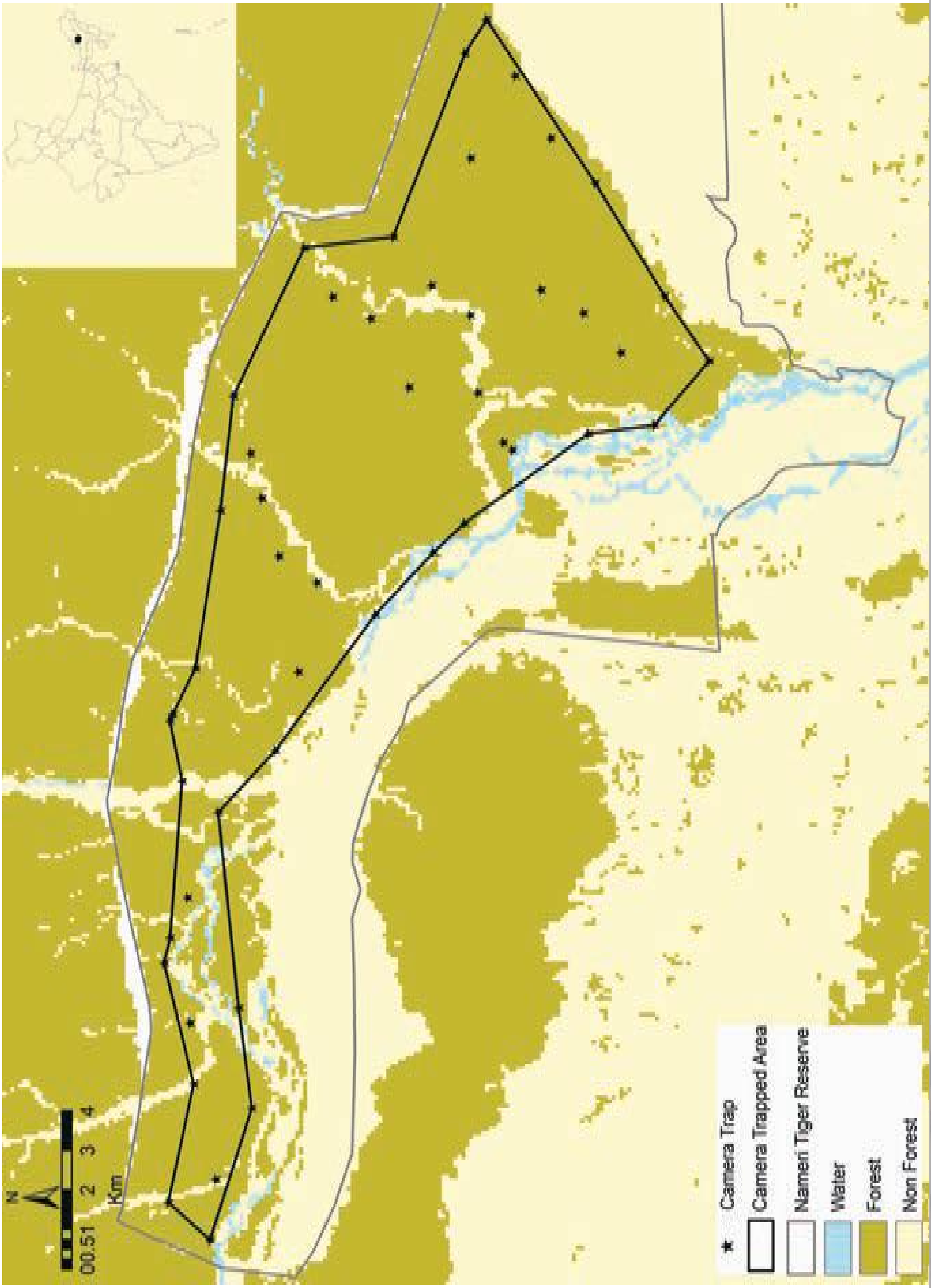
Variables	Estimates
Camera Trapped Area (km^2)	136.3
Camera Points	49
Trap Nights (effort)	1985
Unique tigers captured	7
Model	g0(.)[redacted].)
$\hat{D}$ ML SECR (per 100 km^2)	1.38 (0.55)
Sigma (SE) km	5.7 (0.51)
g0 (SE)	0.01 (0.002)

SE: Standard error

$\hat{D}$ ML SECR: Density estimate from Maximum Likelihood based spatially explicit capture recapture

σ(Sigma): Spatial scale of detection function, ^g0: Magnitude (intercept) of detection function

Figure 4.52: Distribution of Camera traps (n=49) in Nameri Tiger Reserve, Assam



Analytical Details

Due to the thick undergrowth of the forest coupled with occurrence of prey base at fairly low densities, the number of sightings obtained during the transect walking were few. Altogether 17 sightings of sambar deer were recorded for a walk effort of 72 km and sightings of other prey species like barking deer and hog deer were much less. Owing to insufficient number of sightings, analysis of transect data was not attempted.

For the first time the entire core area of Nameri Tiger Reserve was covered for camera trapping and the results indicate that the NTR falls under low tiger density category. There is considerable movement owing to contiguous forest complex between NTR and Pakke tiger reserve of Arunachal Pradesh. There is scope for further improving the tiger density through better management of riverine grasslands that are under varying degrees of degradation and by enhancing the existing protection regime. However, these two activities are dependent upon the timely release of adequate funds for park management and improvement in the overall law & order situation in the fringe areas, both in Nameri and Pakke tiger reserves. A unique feature of this monitoring program was that the entire exercise of camera trap based tiger monitoring was independently carried out by the park officials and the field staff of NTR. A photo captured tiger (NAMR4) in Nameri was earlier photo capture in Kaziranga National Park in 2011, providing the first authentic evidence of the functionality of the corridor on the Northern bank of the Brahmaputra. This result stresses the importance of conserving this connecting habitat linkage.

Kaziranga National Park (Assam)

M Firoz Ahmed[1], Dipankar Lahkar[1], Arif Hussain[1] and Bibhab Kumar Talukdar[1], Tridip Sharma[2], Imtiazuddin Ahmed[2], Monjit Kalita[2], Jimmy Borah[2], Nikunj Jambu[3], Ravi Sharma[3], Rohan B. Bhagat[3], Y.V. Jhala[3], Qamar Qureshi[3].

The Kaziranga National Park (26° 34' N - 26°46 N latitudes and 93° 08' E - 93° 36' E longitudes) sprawls across Nagaon, Sonitpur and Golaghat districts of Assam. The Brahmaputra River flows on the northern boundary and Karbi Anglong hills stand to the south of the park. It became a National Park in 1974 and covers an area of 860 km^2 including the added and proposed additions to its original area of 430 km^2.

Sampling Details

a) Camera trapping was conducted from 26.02.2014 to 25.05.2014 (Fig. 9.53). With total camera points of 415, the effort invested for both the blocks was 9,651 trap nights (Table 9.85).

Analytical Details

Table 9.85: Sampling details and parameter estimates of capture mark-recapture analysis using camera traps for Tiger at Kaziranga National Park from 26.02.2014 to 25.05.2014.

Variables	Estimates
Camera Trapped Area (km^2)	373
Camera Points	415
Trap Nights (effort)	9651
Unique tigers captured	96
Model	g0(.)[redacted])
$\hat{D}$ ML SECR (per 100 km^2)	12.72(1.31)
Sigma (SE) km	1.4 (0.23)
g0 (SE)	0.09(0.003)

SE: Standard error

$\hat{D}$ ML SECR: Density estimate from Maximum Likelihood based spatially explicit capture recapture

σ(Sigma): Spatial scale of detection function, g0: Magnitude (intercept) of detection function

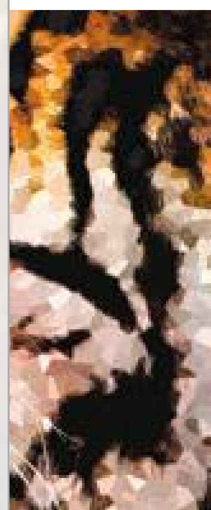
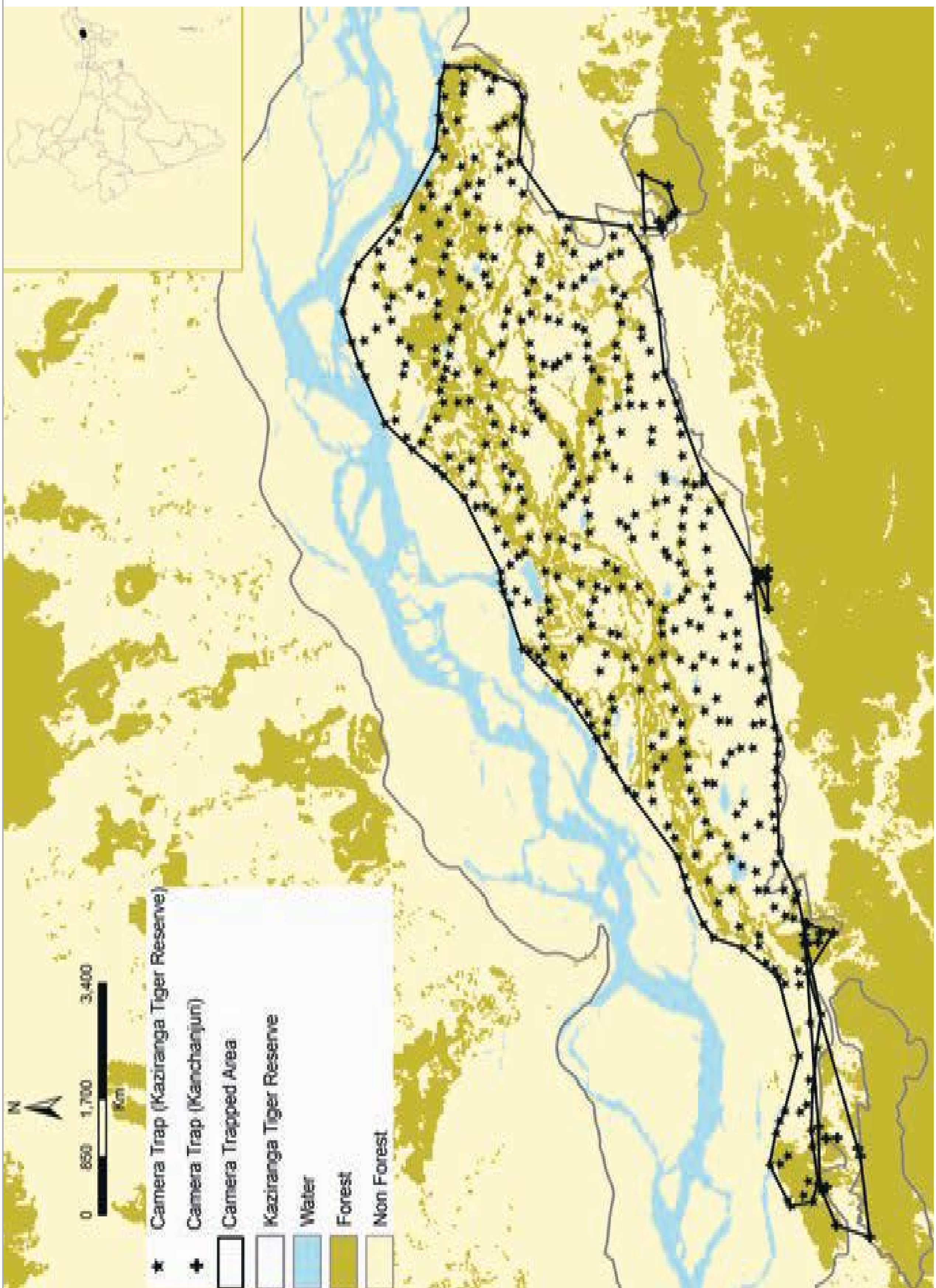


Figure 4.53: Camera traps (n=415) laid in Kaziranga National Park, Assam



Orang National Park (Assam)

M Firoz Ahmed and Dipankar Lahkar.
Aaranyak

Orang National Park is located in Darrang and Sonitpur districts of Assam and has an area of 78.8 km^2 (Talukdar and Sarma, 1995). The geographical coordinates include 92°16' to 92°27' E longitudes and 26°29' to 26°40' latitudes.

The Park experiences about 3000 mm of average annual rainfall with 66% to 95% of humidity. It has loamy, sandy loamy and sandy types of soil, and situated at 40 to 70 meter above mean sea level (Talukdar and Sharma, 1995). The river Brahmaputra flows through southern boundary of the Park and is crisscrossed by a network of channels connecting the river, particularly during the monsoon. Tributaries Pachnoi River, Belsiri River and Dhansiri River flow along the boundary of the Park and ultimately meet the Brahmaputra River. The national park is bordered by river Dhansiri on the west. There are twelve wetlands and 26 manmade water bodies in the Park (Talukdar and Sharma, 1995). The park harbours about 68 rhino (Rhinoceros unicornis) along with sympatric species like, elephant (Elephas maximus), hog deer (Axis porcinus), wild pig (Sus scrofa), fishing cat (Prionailurus viverrinus), jungle cat (Felis chaus), leopard cat (Prionailurus bengalensis), small indian civet (Viverricula indica), etc. Orang National Park has diverse land cover pattern, with the capacity to accomplish all the basic demands to harbour a good population of tiger.

Sampling Details

a) Camera trapping operation was carried out from April 26th to May 30th 2014 (Fig. 9.54). A total of 74 camera trap stations were setup covering an area of 47.13 km^2 (minimum bounding polygon) and sampled for 35 days. The total effort is 1617 trap nights (Table 9.86).

Analytical Details

Table 9.86: Sampling details and parameter estimates of capture mark-recapture analysis using camera traps for Tiger at Orang National Park from 26.04.2014 to 30.04.2014.

Variables	Estimates (SE)
Camera Trapped Area km^2	47.13
Camera Points	74
Trap Nights (effort)	1617
Unique tigers captured	15
Model	g0(.)[redacted].)
$\hat{D}$ ML SECR (per 100 km^2)	10.55 (2.82)
Sigma (SE) km	1.78 (0.12)
g0 (SE)	0.06 (0.01)

SE: Standard error

$\hat{D}$ ML SECR: Density estimate from Maximum Likelihood based spatially explicit capture recapture

σ(Sigma): Spatial scale of detection function, g0: Magnitude (intercept) of detection function

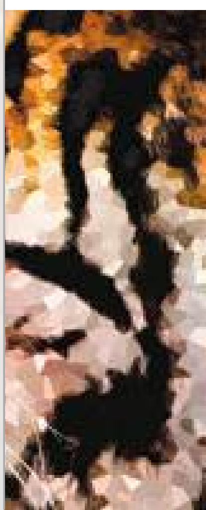
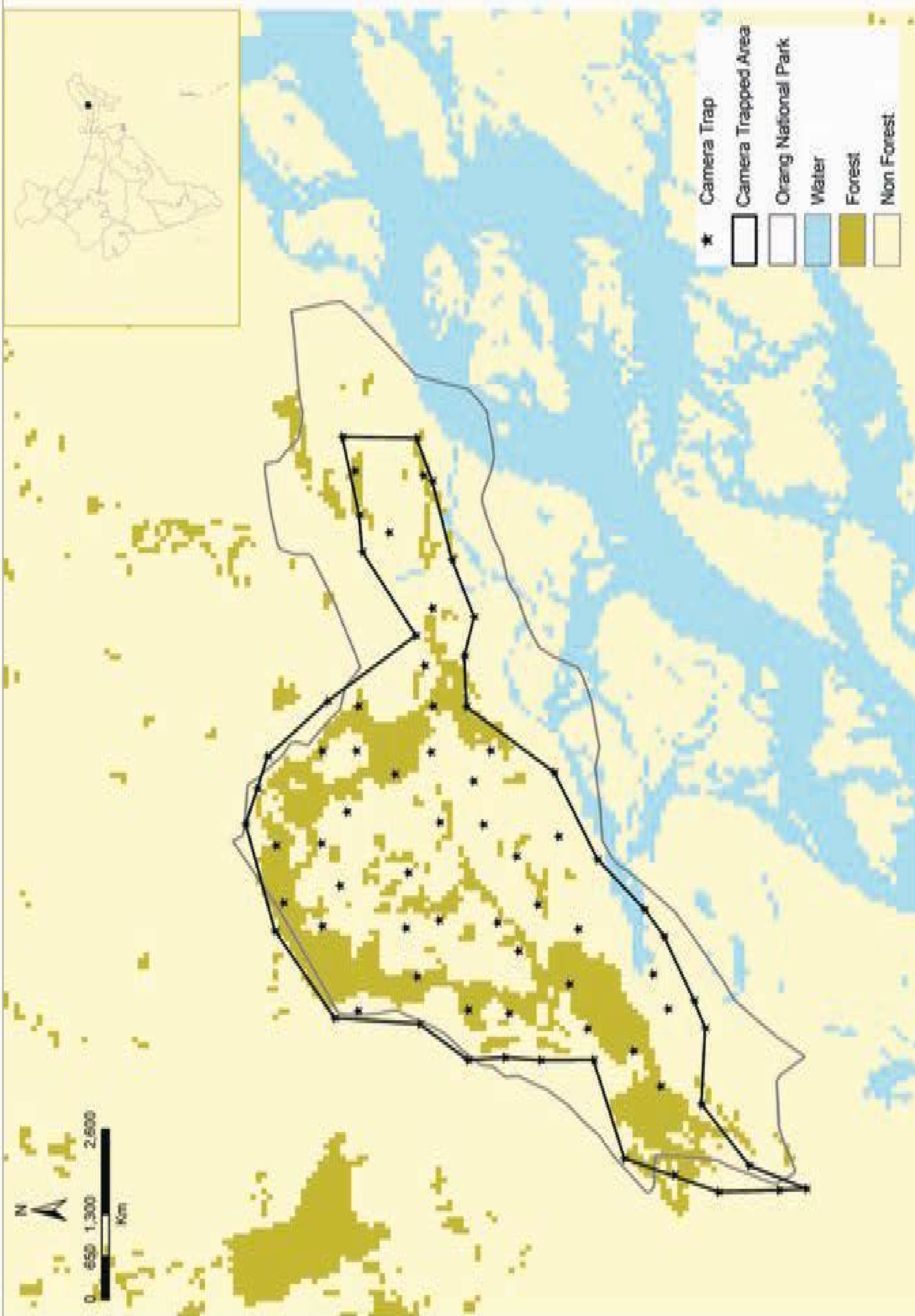


Figure 4.54: Distribution of Camera traps (n=74) in Orang National Park, Assam



Sundarban Landscape

Sundarban Biosphere Reserve (Basirhat Range, Ramganga Range & East Range)

Sunit Kumar Das, Debmalya Roy Chowdhury, Pankaj Sarkar & Ratul Saha.
World Wide Fund for Nature-India

World Wide Fund for Nature-India (WWF) conducted camera trapping in Basirhat Range in 2013 and in Ramganga Range and East Range in 2014 (Fig. 4.54).

Basirhat Range, a part of the Sundarban Tiger Reserve, is designated as the buffer zone where regulated harvest of forest resources is permitted. It is bound on the east by the international border with Bangladesh formed by the rivers Harinbhanga, Raimangal and Kalindi, while the western and the southern sides are flanked by the Wildlife Sanctuary of Sajnekhali Range and National Park East Range, respectively. The deltaic forested islands of Ramganga are a part of 24-Parganas (South) Forest Division. The western part of the forest division is flanked by villages. In the eastern side of the forest division, Sundarban Tiger Reserve is located across river Matla. The East Range is part of the National Park which is also designated as the core area within the Sundarban Tiger Reserve. This range is bound by Harinbhanga river on the east and is adjacent to the National Park West Range separated by the river Goasaba. On the south lies the Bay of Bengal.

Analytical Details

Table 9.87: Parameter estimates of spatially explicit capture recapture analysis for camera trap data on tigers in secr package in Program R for Sundarbans Biosphere Reserve 2013-2014.

Parameters	Basirhat	Ramganga	National Park East
Number of camera trap locations	56	30	60
Sampling dates	13th March - 12th April 2013	11th January - 15th February 2014 1st February - 31st March 2014	
Sampling period in days	31	36	31
Trap Nights	1736	1080	2280
Minimum Bounding Polygon in km^2	325.4	228.76	485.45
Unique tigers captured	14	5	20
Best Model	g0(bk)σ(.)	g0(.)σ(.)	g0(bk)σ(.)
$\hat{D}$ ML SECR (SE) in tigers/100 km^2	3.43 (0.99)	1.57 (0.74)	3.77 (1.03)
g0 (SE)	0.01 (0.003)	0.01 (0.004)	0.003 (0.001)
Sigma (SE) in km	3.07 (0.41)	9.06 (1.87)	5.84 (1.17)

^SE: Standard error,

$\hat{D}$ ML SECR: Density estimate from Maximum Likelihood based spatially explicit capture recapture,

g0: Magnitude (intercept) of detection function,

σ(Sigma): Spatial scale of detection function.

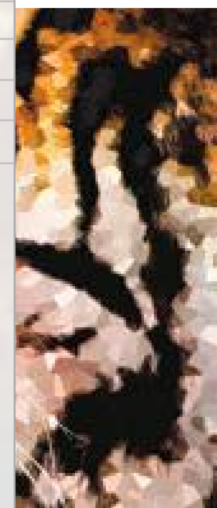
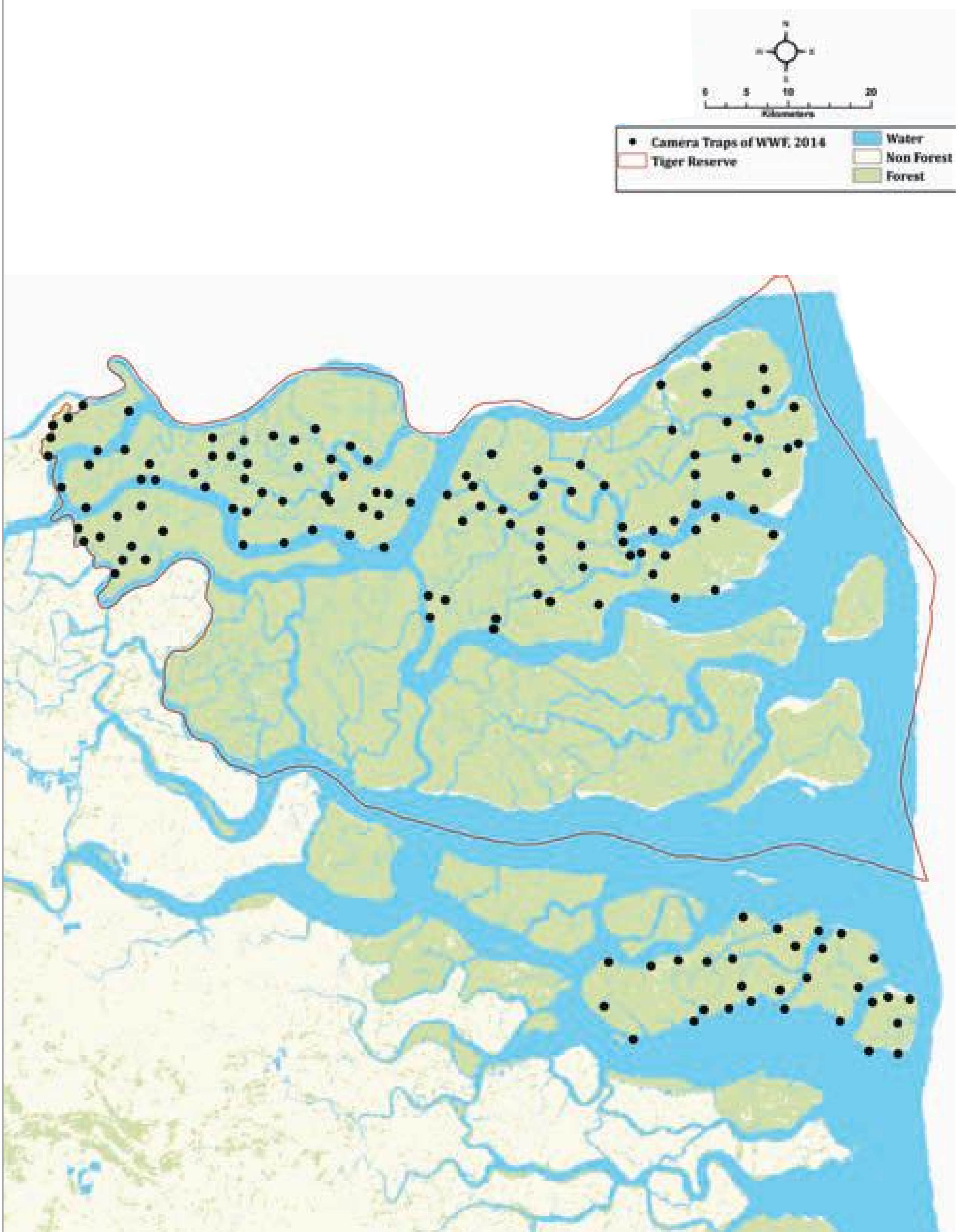


Figure 9.55: Distribution of Camera traps (n=146) in Sundarban Tiger Reserve and parts of Biosphere Reserve by World Wide Fund for Nature, India.



Sundarban Tiger Reserve (West Range & Sajnekhali Range)

Manjari Roy, Bhaskar J Bora, Dipanjan Naha, Manendra Kaneria, Rahul K Talegaonkar, Sougata Sadhukhan, Urjit Mahesh Bhatt, Qamar Qureshi and Y. V. Jhala.
Wildlife Institute of India

Wildlife Institute of India (WII) conducted camera trapping in West Range and Sajnekhali Wildlife Sanctuary Range in 2014 (Fig. 4.56)

West Range is part of the National Park which forms the core area of the Sundarban Tiger Reserve. It is bound by river Matla on the west and Bay of Bengal on the south. It is separated from the northern Sajnekhali Range by the river Netidhopani and from the western East Range by the river Goasaba. The Sajnekhali Range is a wildlife sanctuary where regulated tourism is permitted.

Boat transect surveys have been carried out by WII since 2011. Since we had extremely low sightings of wild pigs, we used only chital data for analysis in program Distance. (Fig. 9.56)

Analytical Details

Table 9.88: Sampling details and parameter estimates of spatially explicit capture recapture analysis for camera trap data on tigers in secr package in Program R for Sundarban Tiger Reserve 2013-2014.

Parameters	National Park West	Sajnekhali
Number of camera trap locations	76	40
Sampling dates	13th March - 20th April 2014	16th May - 8th June 2014
Sampling period in days	32	23
Trap Nights	2763	960
Minimum Bounding Polygon in km^2	420.33	188.51
Unique tigers captured	14	14
Best Model	g0(bk)σ(h2)	g0(bk)σ(h2)
Density (SE) in tigers/100 km^2	3.15 (0.88)	4.79 (1.31)
g0 (SE)	0.04 (0.007)	0.04 (0.007)
Sigma (SE) in km	$\blacksquare_1$= 1.89 (0.21) $\blacksquare_2$= 4.24 (0.43) pmix1 = 0.71 (0.10)	$\blacksquare_1$= 1.89 (0.21) $\blacksquare_2$= 4.24 (0.43) pmix1 = 0.71 (0.10)

^SE: Standard error,

D̂ ML SECR: Density estimate from Maximum Likelihood based spatially explicit capture recapture,

g0: Magnitude (intercept) of detection function,

σ(Sigma): Spatial scale of detection function.

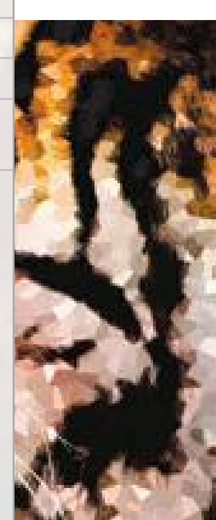


Table 9.89: *Model statistics and parameter estimates of boat transect based Distance sampling for prey species in Sundarban Tiger Reserve 2014.*

Species	# Detections	Best Model	Chi sq P value	Effective strip width (SE)	Detection probability* (SE)	Encounter Rate per km	Group Density (SE) per km²	Individual Density (SE) per km²
Chital	80	Half normal cosine	0.81	28.04 (2.43)	0.31 (0.027)	0.032	1.14 (0.26)	2.54 (0.69)
Wild Pig	2	-	-	-	-	0.003	-	-

* Detection pooled across years

Figure 9.56: *Distribution of Camera trap (n=116) and boat transect in Sundarban Tiger Reserve by Wildlife Institute of India.*

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Appendix 10

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K. Ullas Karanth and N. Samba Kumar led the research team. Field researchers Killivalavan Rayar, Somashekar, Shantaram Kamat, Kirthidhar Hegde, Vinayak Kori, Jitendra Shankaraiah, Mahi Puri, Srikanth Rao, Biswanath N. G., Santosh M. N., Santosh C. U., Shivakumar M. D., Harsha L., Binny Devaiah, Prashanth, Dhanush, KabirManav, Binod Borah and Subbaiah K. S carried out field surveys. Analytic support was provided by Ravishankar Parameshwaran, Arjun Srivathsa, Narendra Patil, Kiran Yadav, Vinay L., Sushma Sharma and Shivani Poojari. The research team was assisted by 76 forest department staff and 114 civil society volunteers in field surveys.

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Appendix – 2: Details of spatial and attribute data used for assessing patterns of tiger distribution

Details of remotely sensed data used for analyzing patterns governing tiger occupancy.

	Dataset	Sensors	Spatial Resolution	Radiometric Resolution
1	Forest Cover Forest Survey of India (2006,2009 & 2011)	IRS 1D LISS III	23.5 m	4 Multispectral bands
2	Normalized Difference Vegetation Index (NDVI) (2013, 2014)	Moderate Resolution Imaging Spectroradiometer (MODIS)	250 m	3 Multispectral bands
3	Digital Elevation Model (DEM)	Shuttle Radar Topography Mission (SRTM)	90 m	2 bands
4	Night-time visible lights (1992-2012)	US Air Force Defense Meteorological Satellite Program (DMSP) Operational Linescan System (OLS)	1000m	2 bands (NIR&IR)

Night Light Data

Night light data was obtained form NOAA/NGDC. Data was collected by Defense Meteorological Satellite Program's Operational Line-scan system (DMSP/OLS) with a pixel size of 2.7 km x 2.7 km. The visible (0.47 - 0.95 µm) and near-infrared (VNIR) spectral bands which are sensitive to the night-time light of cities, towns, fires, lightning, etc. are useful for mapping human habitation (Elvidge et al. 1997). The high contrast between lit and unlit areas and the sensor's spatial resolution makes it a useful tool in identifying regions of intense human activity (Croft 1973, 1978).

MODIS-NDVI

Normalized difference vegetation index (NDVI) composites were derived from 250 m Moderate Resolution Imaging Spectroradiometer (MODIS) data. MODIS data was retrieved from the online Data Pool, courtesy of the NASA Land Processes Distributed Active Archive Center (LP DAAC), USGS/Earth Resources Observation and Science (EROS) Center, Sioux Falls, South Dakota. MODIS products are available at 16-day intervals with 250 m spatial resolution. This data was further resampled at 1000m. The data also includes a Enhanced Vegetation Index (EVI) which reduces the variations in canopy background and maintains the sensitivity over dense vegetation conditions. The MODIS product are very useful for the monitoring of biomass health of the ecosystem, vegetation and for landscape characterization (Lunetta et al 2006; Beck et al 2006).

Census data:

Human population data was obtained from the office of Registrar General, India, for the year 2011, under the section Primary Census Abstract (PCA). The PCA gives the data on number of houses and households, total population, Scheduled Castes and Scheduled Tribes, population in the age groups of 0-6 years, number of literates, number of workers classified by industrial categories, marginal workers and non workers. This data is available at the resolution of village level for rural areas, and at ward level for cities and towns.

Forest Cover Map

Forest Cover map was obtained from Forest Survey of India (FSI 2003, 2009 & 2011). The assessment is based on digital interpretation of satellite data for the entire country. LISS-III sensor data of IRS-1C satellite, with a resolution of 23.5 m, has been used. This was one of the main layers in the GIS that was used for deriving landscape characteristics.

Roads & Drainage

The roads and drainage maps of digital chart of the world (ESRI 1992) for the country, at a scale of 1: 1000,000 was used. Euclidean distances and densities were generated using ArcGIS (ESRI) software.

Protected Areas

The locations of the Protected Areas, National Parks, Wildlife Sancturies, and Tiger Reserves were obtained from the Wildlife Database cell, Wildlife Institute of India and Project Tiger Directorate.

Core Areas

Forested habitats are like islands in a sea of human dominated landscapes. People living on the edges (and within forests) utilize these forests to varying degrees depending on their life styles, legal status of the forests, and implementation of protection measures. These anthropogenic pressures penetrate inwards from the edges. To model these effects and to assess the amount of forest that likely remains free of such disturbances, we buffered each forest patch with an inward buffer of 3 km. These buffered "disturbance free" patches are referred to as cores.

Landscape Characterization

For the Landscape characterization and evaluation, fragmentation metrics like forest patch size, distribution and density, patch shape complexity and core area metrics were calculated using Fragstat (McGarigal and Marks 1995).

We derived Euclidian distance from protected areas, night light, drainage, roads, and density of roads and drainage in 10 x 10 km grids to asses the human influence and habitat suitability.

DEM (Digital Elevation Model)

The Shuttle Radar Topography Mission produced the most complete and highest resolution digital elevation model of the Earth (Rodriguez et al 2005). The project was a joint endeavor of NASA, the National Geospatial-Intelligence Agency, and the German and Italian Space Agencies, and was launched in February 2000. It used dual radar antennas to acquire interferometric radar data, processed to digital topographic data at 1 arc-sec resolution (approximately 30 x 30 m). The data has a linear vertical absolute height error of less than 16 m (Rodriguez et al 2005).

CAMERA TRAP PICTURES OF SOME SPECIES


TIGER


TIGER


TIGER


TIGER


TIGER


TIGER CARRYING CUB


LEOPARD


LEOPARD


MELANIASTIC LEOPARD


LEOPARD


CLOUDED LEOPARD

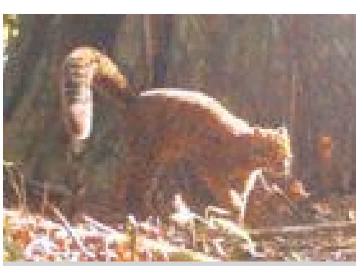

WILD DOG (DHOLE)


WOLF


RUSTY SPOTTED CAT


HYENA


JACKAL

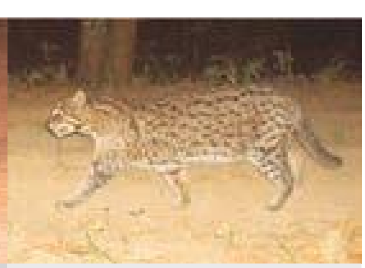

MARBLED CAT


LEOPARD CAT


INDIAN FOX


CARACAL


DESERT CAT


FISHING CAT


SMALL INDIAN CIVET


RATEL


SMOOTH COATED OTTER


PANGOLIN


PORCUPINE


LARGE INDIAN CIVET


RUDDY MONGOOSE


CRAB EATING MONGOOSE


PALM CIVET


HOG BADGER

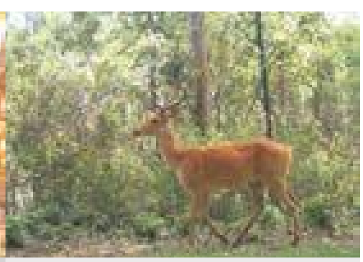

ONE HORNED RHINO

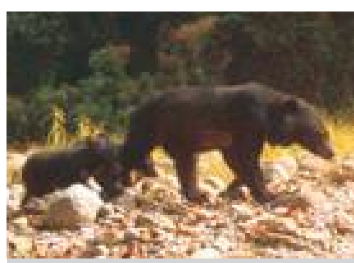

GAUR


ELEPHANT


SLOTH BEAR


WILD BUFFALO

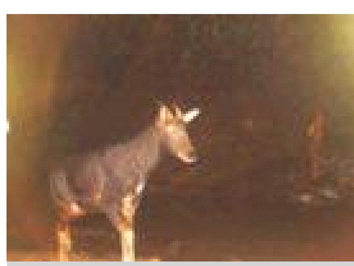

SWAMP DEER


HIMALAYAN BLACK BEAR


SAMBAR


CHITAL


HISPID HARE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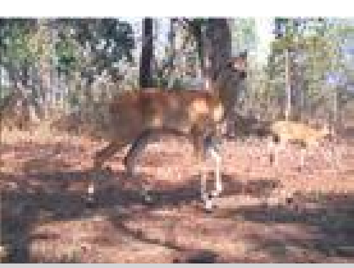
NILGAI


CHOWSINGA


HOG DEER


BARKING DEER


MOUSE DEER

HARE

LANGUR

WILD PIG

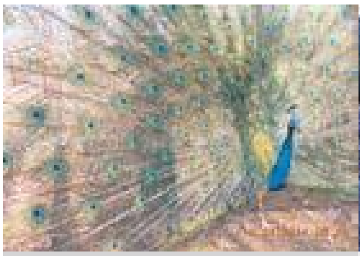
LESSER ADJUTANT STORK

GREAT HORNBILL

EURASIAN THICKNEE

RED WATTLED LAPWING

RED JUNGLE FOWL



PEAFOWL

RED BILLED BLUE MAGPIE

WHITE THROATED KINGFISHER

BENGAL FLORICAN

© Deb Ranjan Laha

CORBETT NATIONAL PARK 124 Nos.

CORB-1 RIGHT

CORB-1 LEFT

CORB-2 RIGHT

CORB-2 LEFT

CORB-3 RIGHT

CORB-3 LEFT

CORB-4 RIGHT

CORB-4 LEFT

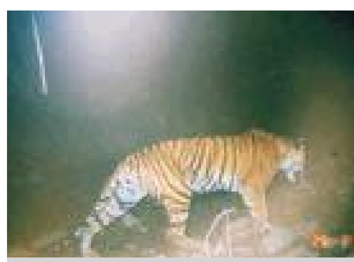
CORB-5 RIGHT

CORB-5 LEFT

CORB-6 RIGHT

CORB-6 LEFT

CORB-7 RIGHT ONLY



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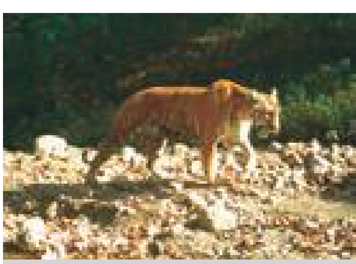

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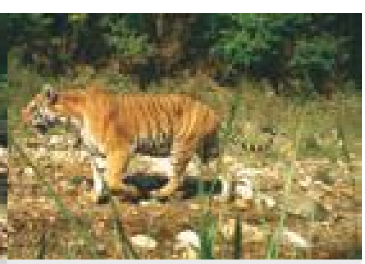

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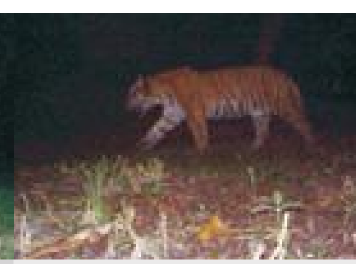

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CORB-11 RIGHT ONLY

CORB-13 RIGHT

CORB-13 LEFT


CORB-14 RIGHT


CORB-14 LEFT


CORB-15 RIGHT


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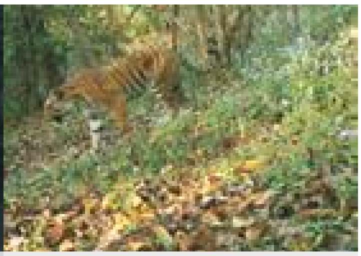
CORB-17 RIGHT


CORB-17 LEFT


CORB-18 RIGHT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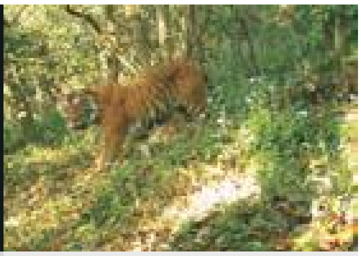
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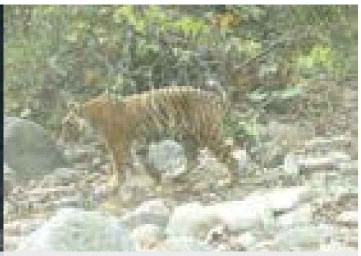
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CORB-21 RIGHT


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CORB-22 RIGHT


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CORB-23 RIGHT ONLY


CORB-24 RIGHT ONLY


CORB-25 RIGHT


CORB-25 LEFT


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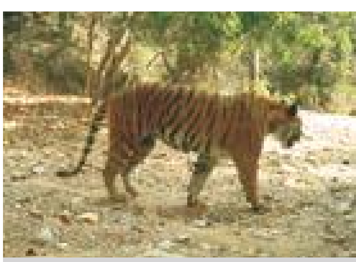
CORB-30 LEFT ONLY


CORB-31 RIGHT ONLY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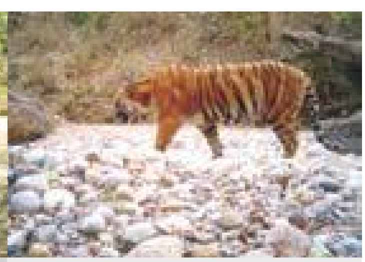
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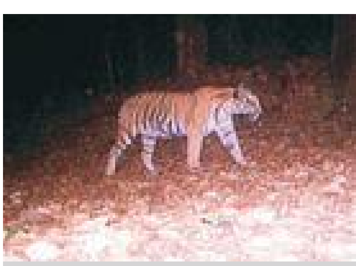
CORB-33 RIGHT


CORB-33 LEFT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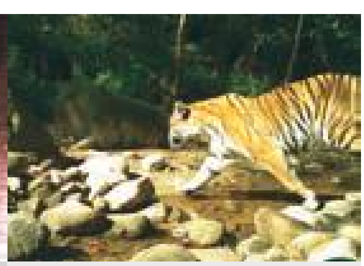
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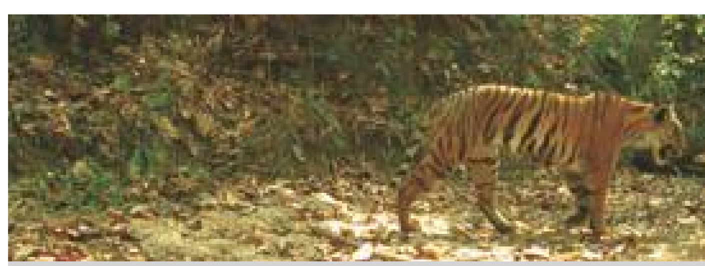
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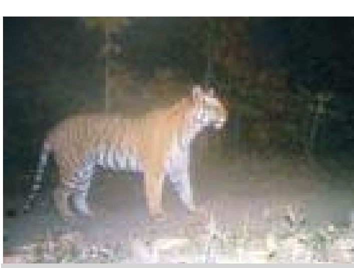
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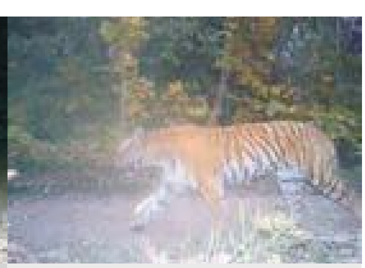
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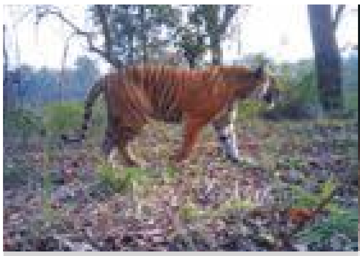
CORB-38 RIGHT ONLY


CORB-39 RIGHT ONLY

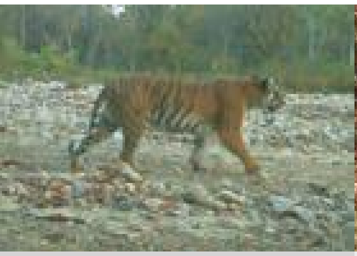

CORB-41 RIGHT ONLY


CORB-42 RIGHT


CORB-42 LEFT


CORB-43 RIGHT

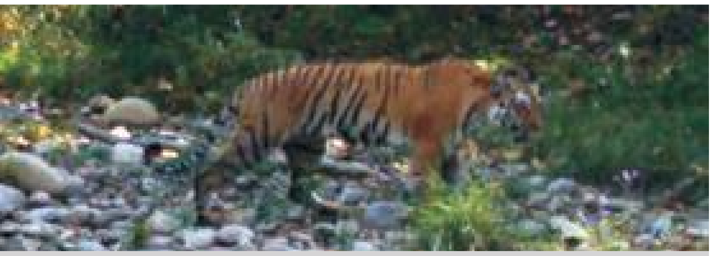

CORB-43 LEFT


CORB-44 RIGHT


CORB-44 LEFT


CORB-45 RIGHT


CORB-45 LEFT


CORB-46 RIGHT ONLY


CORB-47 RIGHT ONLY


CORB-48 RIGHT ONLY


CORB-49 RIGHT


CORB-49 LEFT


CORB-50 RIGHT


CORB-50 LEFT


CORB-51 RIGHT


CORB-51 LEFT


CORB-52 RIGHT


CORB-52 LEFT


CORB-53 RIGHT ONLY


CORB-54 RIGHT


CORB-54 LEFT


CORB-55 RIGHT


CORB-55 LEFT


CORB-56 RIGHT


CORB-56 LEFT


CORB-57 RIGHT ONLY


CORB-59 RIGHT


CORB-59 LEFT

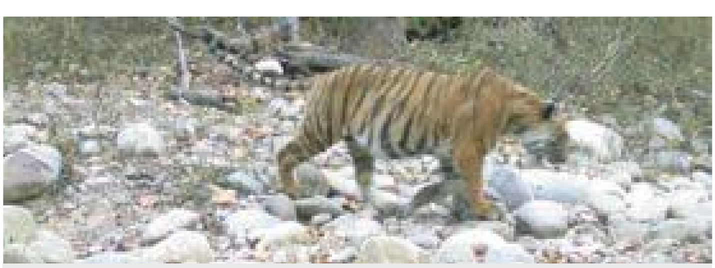

CORB-61 RIGHT


CORB-61 LEFT


CORB-62 RIGHT


CORB-62 LEFT


CORB-63 RIGHT ONLY


CORB-64 RIGHT ONLY


CORB-65 RIGHT


CORB-65 LEFT


CORB-66 RIGHT ONLY


CORB-67 RIGHT ONLY


CORB-68 RIGHT

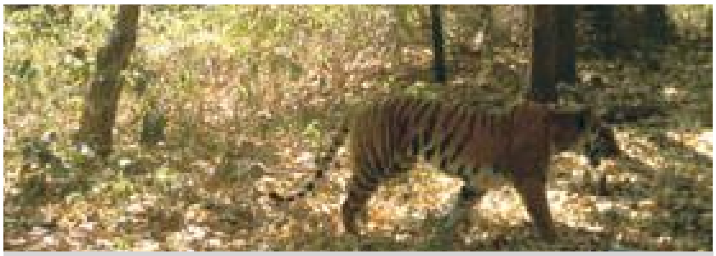

CORB-68 LEFT


CORB-69 RIGHT


CORB-69 LEFT


CORB-70 RIGHT


CORB-70 LEFT


CORB-71 RIGHT ONLY


CORB-72 RIGHT ONLY


CORB-73 RIGHT ONLY


CORB-75 RIGHT


CORB-75 LEFT


CORB-76 RIGHT

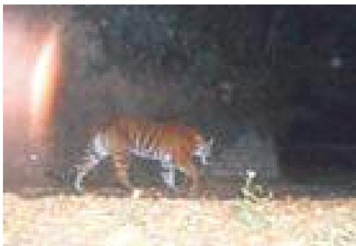

CORB-76 LEFT


CORB-77 RIGHT


CORB-77 LEFT


CORB-78 RIGHT


CORB-78LEFT


CORB-79 RIGHT


CORB-79 LEFT


CORB-80 RIGHT


CORB-80 LEFT


CORB-81 RIGHT


CORB-81 LEFT


CORB-82 RIGHT ONLY

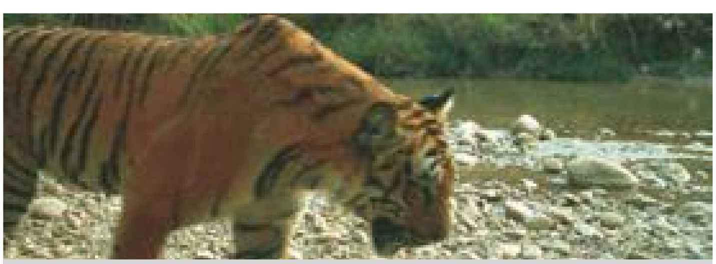

CORB-83 RIGHT ONLY

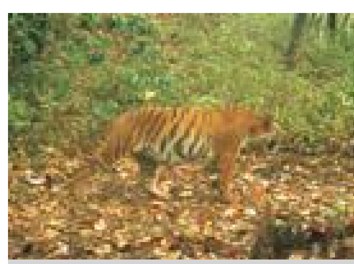

CORB-84 LEFT ONLY


CORB-85 RIGHT ONLY


CORB-86 RIGHT


CORB-86 LEFT

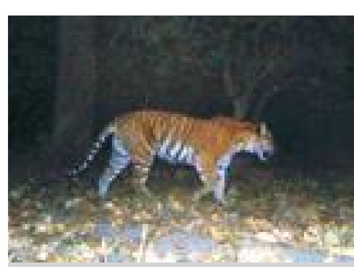

CORB-87 RIGHT ONLY

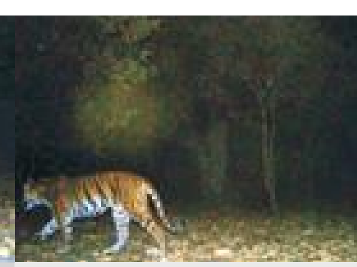

CORB-89 RIGHT

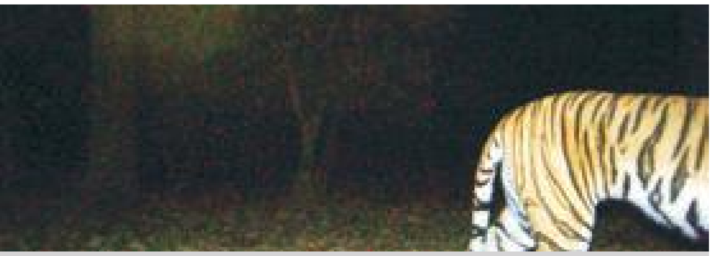

CORB-89 LEFT


CORB-90 RIGHT


CORB-90 LEFT


CORB-91 RIGHT


CORB-91 LEFT



CORB-92 RIGHT ONLY

CORB-93 RIGHT

CORB-93 LEFT

CORB-94 RIGHT

CORB-94 LEFT

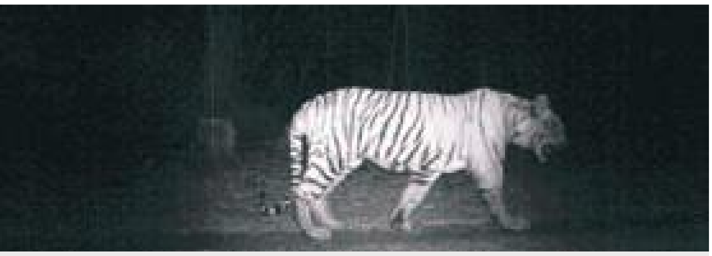
CORB-95 RIGHT

CORB-95 LEFT

CORB-97 RIGHT

CORB-97 LEFT

CORB-99 RIGHT ONLY



CORB-100 RIGHT ONLY

CORB-101 RIGHT ONLY

CORB-102 RIGHT

CORB-102 LEFT

CORB-103 RIGHT

CORB-103 LEFT

CORB-104 RIGHT

CORB-104 LEFT

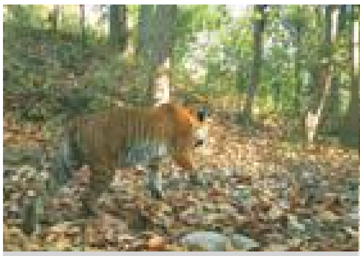
CORB-105 RIGHT

CORB-105 LEFT

CORB-106 RIGHT ONLY

CORB-108 RIGHT

CORB-108 LEFT



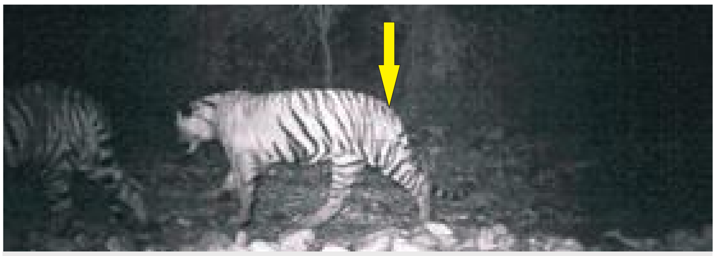
CORB-109 RIGHT

CORB-109 LEFT

CORB-110 LEFT ONLY

CORB-111 RIGHT ONLY

CORB-112 RIGHT ONLY



CORB-113 LEFT ONLY

CORB-114 RIGHT ONLY

CORB-115 LEFT ONLY

CORB-116 RIGHT ONLY

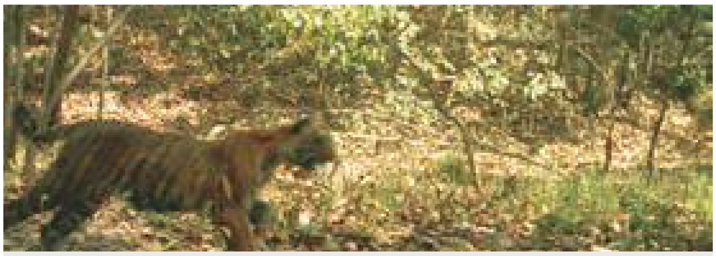
CORB-117 LEFT ONLY

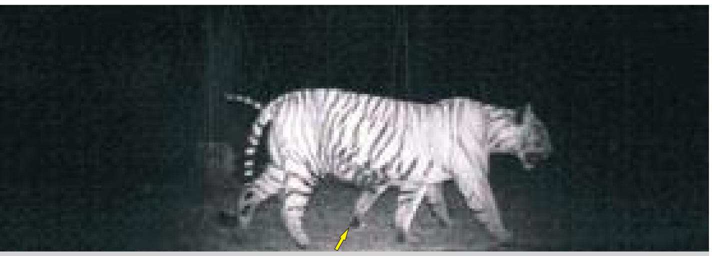
CORB-118 RIGHT ONLY


CORB-119 RIGHT ONLY


CORB-120 RIGHT ONLY


CORB-121 RIGHT ONLY


CORB-122 RIGHT ONLY


CORB-123 RIGHT ONLY


CORB_AMAN-1 RIGHT ONLY


CORB_AMAN-2 RIGHT


CORB_AMAN-2 LEFT


CORB_AMAN-3 RIGHT


CORB_AMAN-3 LEFT


CORB_AMAN-4 RIGHT


CORB_AMAN-4 LEFT


CORB_KALA-1 RIGHT


CORB_KALA-1 LEFT


CORB_KALA-2 RIGHT


CORB_KALA-2 LEFT


CORB_KALA-3 RIGHT

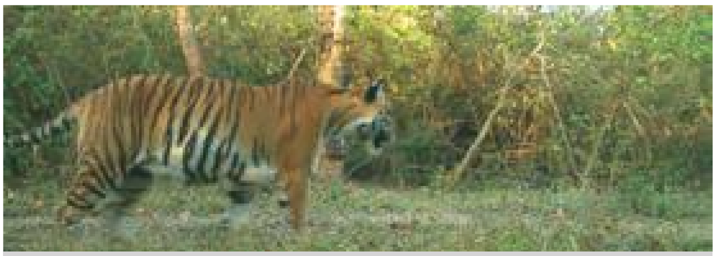

CORB_KALA-3 LEFT

CORB_KALA-4 RIGHT

CORB_KALA-4 LEFT

CORB_KALA-5 RIGHT

CORB_KALA-5 LEFT



CORB_TER(W)-1 RIGHT ONLY

CORB_TER(W)-2 RIGHT

CORB_TER(W)-2 LEFT

KALAGARH TIGER RSERVE

71 Nos.


KALA-1 RIGHT


KALA-1 LEFT


KALA-2 LEFT ONLY


KALA-3 LEFT ONLY


KALA-4 LEFT ONLY


KALA-5 LEFT ONLY

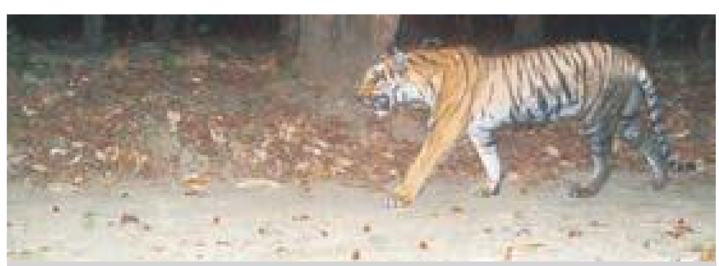

KALA-6 LEFT ONLY


KALA-7 RIGHT


KALA-7 LEFT


KALA-8 LEFT ONLY


KALA-9 LEFT ONLY


KALA-10 LEFT ONLY


KALA-11 LEFT ONLY


KALA-12 RIGHT

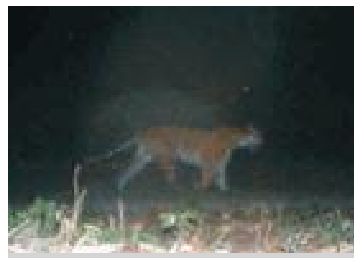

KALA-12 LEFT

KALA-13 LEFT ONLY

KALA-14 LEFT ONLY

KALA-15 RIGHT

KALA-15 LEFT



KALA-16 RIGHT

KALA-16 LEFT

KALA-17 LEFT ONLY

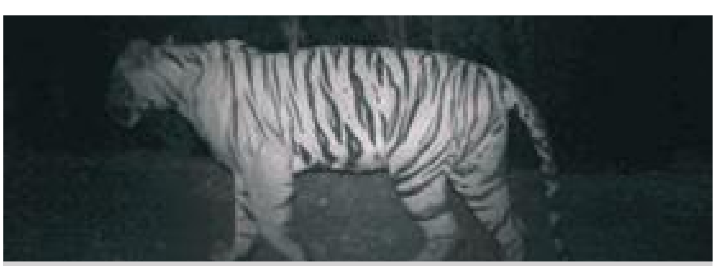
KALA-18 RIGHT

KALA-18 LEFT

KALA-19 LEFT ONLY

KALA-20 RIGHT

KALA-20 LEFT



KALA-21 LEFT ONLY

CORB-22 RIGHT

CORB-22LEFT

KALA-23 LEFT ONLY

CORB-24 RIGHT

CORB-24 LEFT


KALA-25 LEFT ONLY


KALA-26 RIGHT


KALA-26 LEFT


KALA-27 LEFT ONLY


KALA-28 LEFT ONLY


KALA-29 LEFT ONLY


KALA-30 LEFT ONLY


KALA-31 RIGHT


KALA-31 LEFT


KALA-32 RIGHT


KALA-32 LEFT


KALA-33 RIGHT


KALA-33 LEFT


KALA-34 LEFT ONLY


KALA-35 RIGHT


KALA-35 LEFT


KALA-36 RIGHT


KALA-36 LEFT

KALA-37 RIGHT

KALA-37 LEFT

KALA-38 RIGHT

KALA-38 LEFT

KALA-39 RIGHT

KALA-39 LEFT

KALA-40 LEFT ONLY

KALA-41 LEFT ONLY

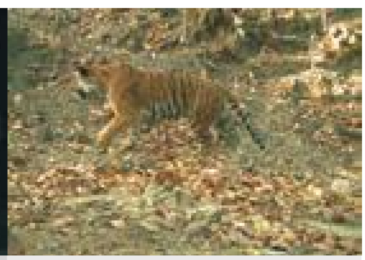
KALA-42 RIGHT

KALA-42 LEFT

KALA-43 LEFT ONLY

KALA-44 RIGHT ONLY

KALA-45 RIGHT



KALA-45 LEFT

KALA-46 LEFT ONLY

CORB-47 RIGHT

CORB-47 LEFT

CORB-48 RIGHT

CORB-48 LEFT


KALA-49 RIGHT

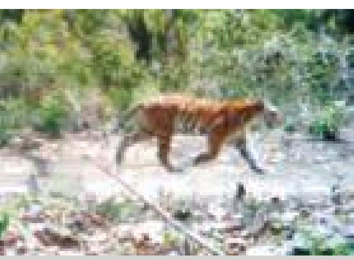

KALA-49 LEFT


KALA-50 LEFT ONLY

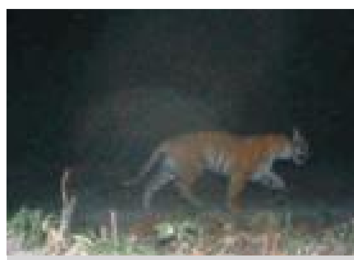

KALA-51 RIGHT

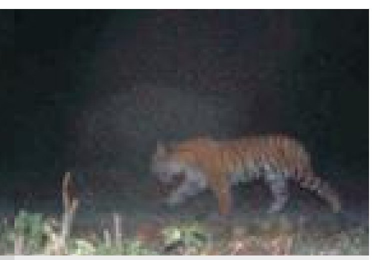

KALA-51 LEFT


KALA-52 LEFT ONLY


KALA-64 RIGHT


KALA-64 LEFT


KALA-65 RIGHT


KALA-65 LEFT


KALA-66 LEFT ONLY


KALA-67 LEFT ONLY


KALA-68 LEFT ONLY


KALA-69 LEFT ONLY


KALA-70 LEFT ONLY


KALA-71 LEFT ONLY

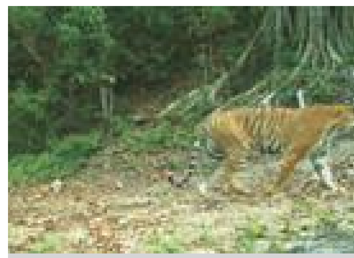

KALA-LANS-1 RIGHT


KALA-LANS-1 LEFT

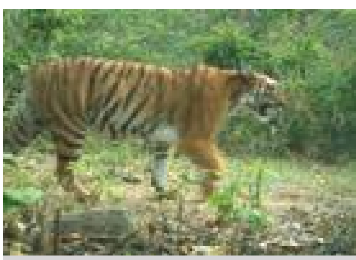

KALA-LANS-2 LEFT ONLY


KALA-LANS-3 RIGHT


KALA-LANS-3 LEFT


KALA-LANS-4 RIGHT


KALA-LANS-4 LEFT


KALA-NAJB-1 RIGHT


KALA-NAJB-1 LEFT


KALA-NAJB-2 RIGHT ONLY


CORB-KALA-1 LEFT ONLY


CORB-KALA-2 LEFT ONLY


CORB-KALA-3 RIGHT


CORB-KALA-3 LEFT


CORB-KALA-4 RIGHT


CORB-KALA-4 LEFT


CORB-KALA-5 RIGHT


CORB-KALA-5 LEFT

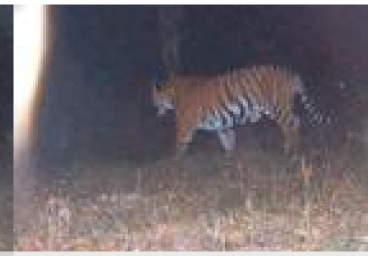
RAMNAGAR FOREST DIVISION

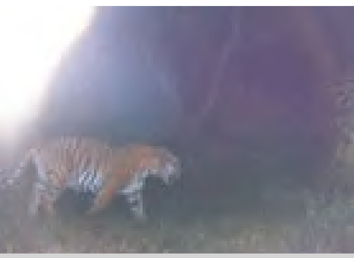
41 Nos.


RAMN-1 RIGHT


RAMN-1 LEFT


RAMN-2 RIGHT

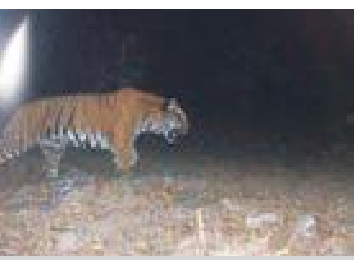

RAMN-2 LEFT


RAMN-3 RIGHT

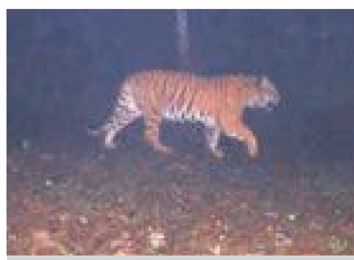

RAMN-3 LEFT

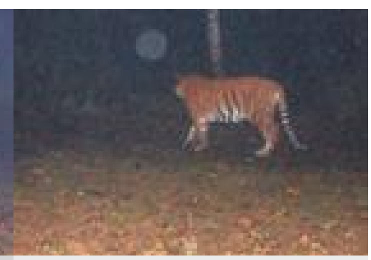

RAMN-4 RIGHT

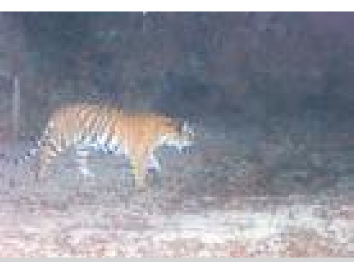

RAMN-4 LEFT

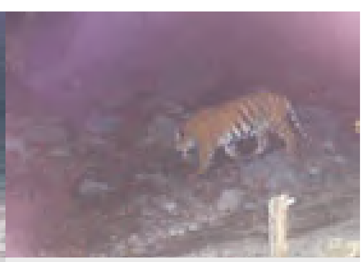

RAMN-5 RIGHT


RAMN-5 LEFT


RAMN-6 RIGHT

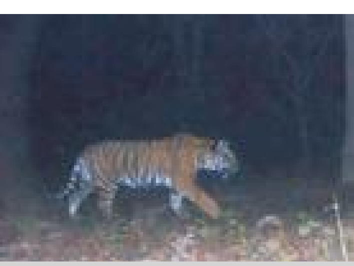

RAMN-6 LEFT

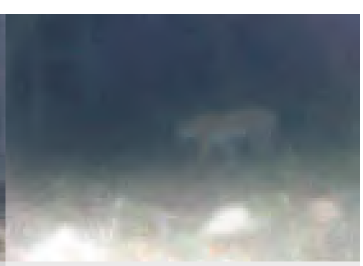

RAMN-7 RIGHT

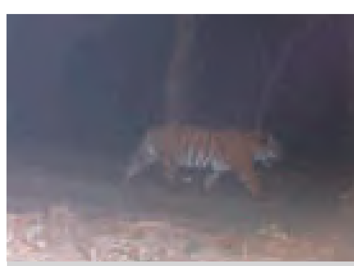

RAMN-7 LEFT


RAMN-8 RIGHT


RAMN-8 LEFT

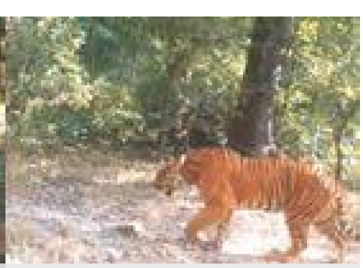

RAMN-9 RIGHT

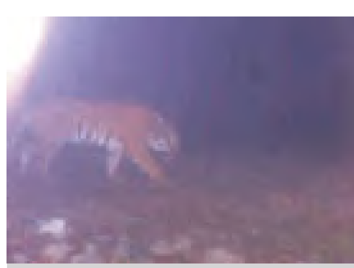

RAMN-9 LEFT

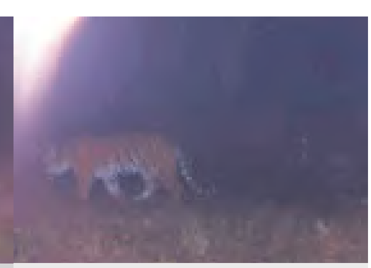

RAMN-10 RIGHT


RAMN-10 LEFT

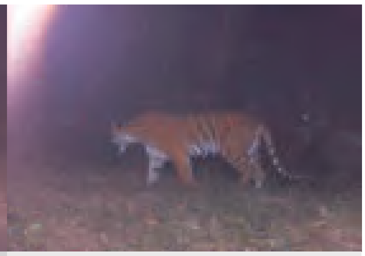

RAMN-11 RIGHT


RAMN-11 LEFT


RAMN-12 RIGHT

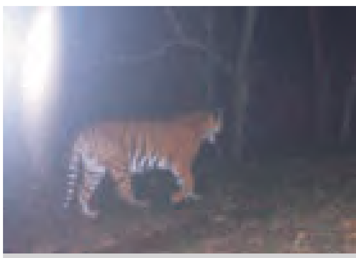

RAMN-12 LEFT

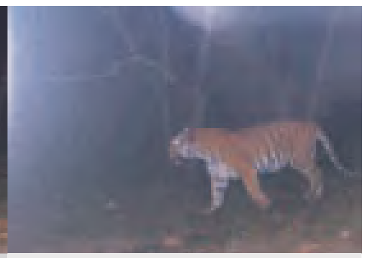

RAMN-13 RIGHT


RAMN-13 LEFT


RAMN-14 RIGHT

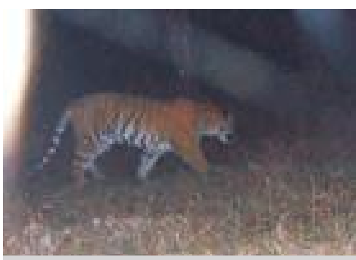

RAMN-14 LEFT


RAMN-15 RIGHT

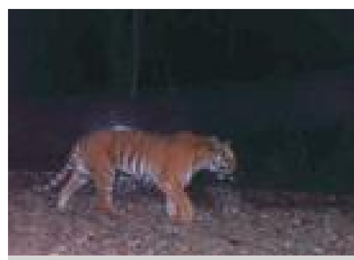

RAMN-15 LEFT


RAMN-16 RIGHT

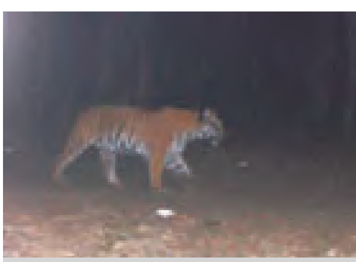

RAMN-16 LEFT

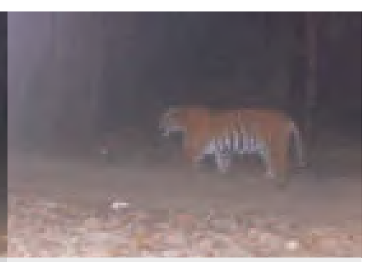

RAMN-17 RIGHT

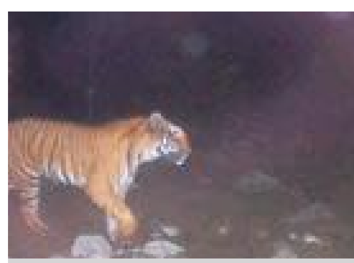

RAMN-17 LEFT

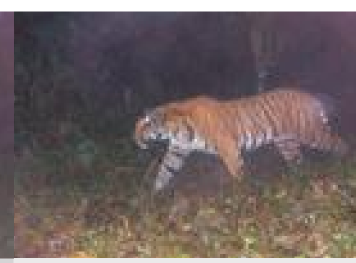

RAMN-18 RIGHT

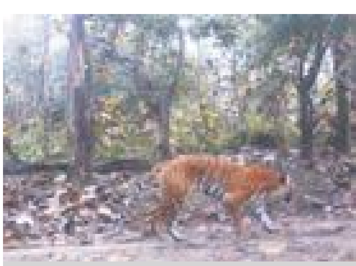

RAMN-18 LEFT


RAMN-19 RIGHT

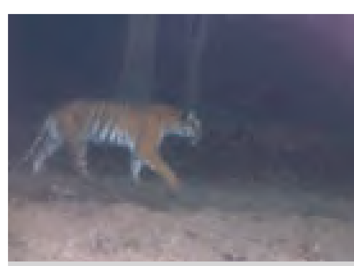

RAMN-19 LEFT

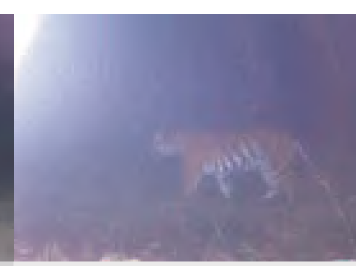

RAMN-20 RIGHT

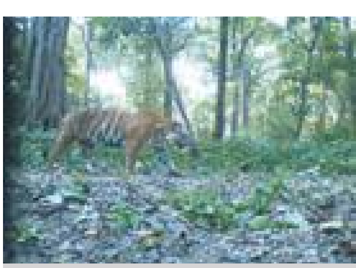

RAMN-20 LEFT

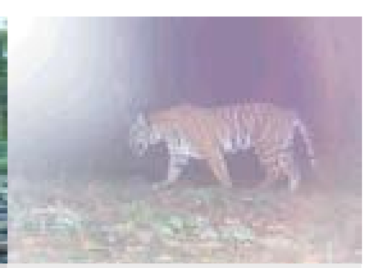

RAMN-21 RIGHT


RAMN-21 LEFT

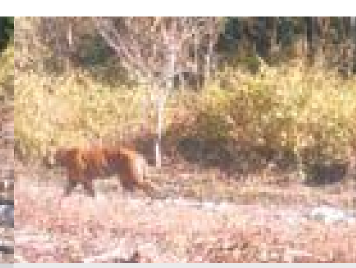

RAMN-22 RIGHT


RAMN-22 LEFT

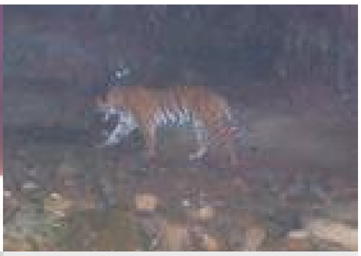

RAMN-23 RIGHT

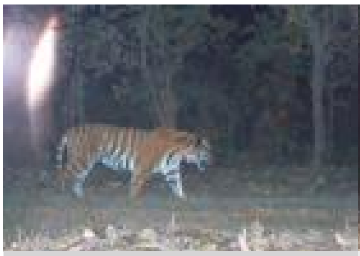

RAMN-23 LEFT


RAMN-24 RIGHT


RAMN-24 LEFT


RAMN-25 RIGHT


RAMN-25 LEFT


RAMN-26 RIGHT

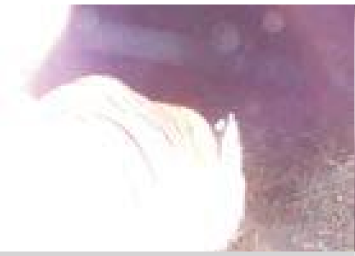

RAMN-26 LEFT


RAMN-27 RIGHT


RAMN-27 LEFT


RAMN-28 RIGHT


RAMN-28 LEFT

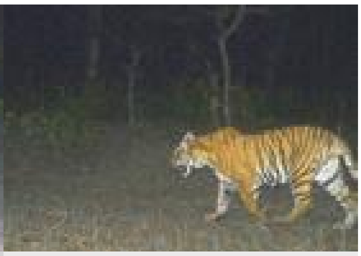

RAMN-29 RIGHT


RAMN-29 LEFT


RAMN-30 RIGHT


RAMN-30 LEFT


RAMN-31 RIGHT


RAMN-31 LEFT


RAMN-32 RIGHT


RAMN-32 LEFT


RAMN-33 RIGHT


RAMN-33 LEFT


RAMN-34 RIGHT

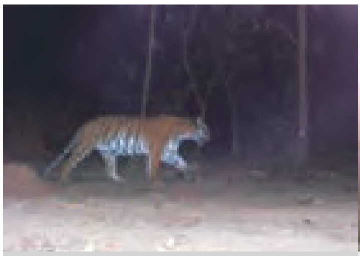

RAMN-34 LEFT


RAMN-35 RIGHT


RAMN-35 LEFT


RAMN-36 RIGHT

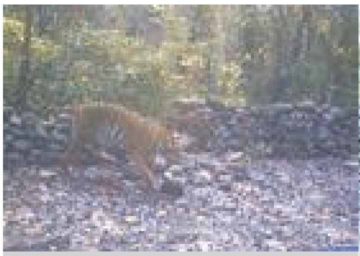

RAMN-36 LEFT


RAMN-37 RIGHT


RAMN-37 LEFT


RAMN-38 RIGHT


RAMN-38 LEFT


RAMN-39 RIGHT


RAMN-39 LEFT

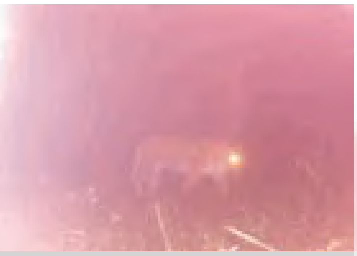

RAMN-40 RIGHT


RAMN-40 LEFT

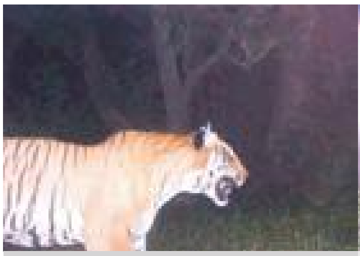

RAMN-41 RIGHT ONLY

TERAI EAST FOREST DIVISION

13 Nos.


TER_E-1 RIGHT


TER_E-1 LEFT


TER_E-2 LEFT


TER_E-2 LEFT


TER_E-3 RIGHT

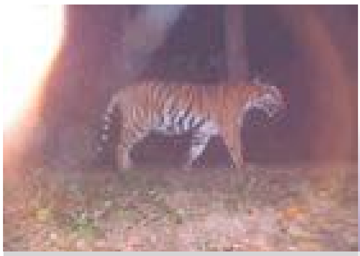

TER_E-3 LEFT


TER_E-4 LEFT


TER_E-4 LEFT


TER_E-5 RIGHT


TER_E-5 LEFT


TER_E-6 LEFT


TER_E-6 LEFT


TER_E-7 RIGHT


TER_E-7 LEFT

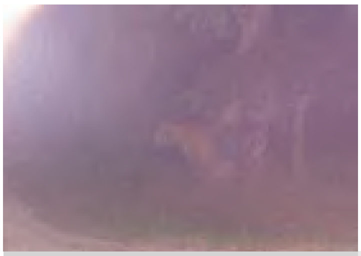

TER_E-8 LEFT


TER_E-8 LEFT


TER_E-9 LEFT ONLY

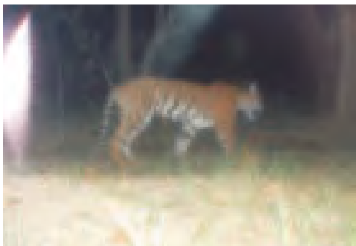

TER_E-10 LEFT ONLY


TER_E-11 LEFT ONLY


TER_E-12 LEFT ONLY


TER_E-13 RIGHT ONLY

TERAI WEST FOREST DIVISION 10 Nos.



AMAN_TER_W-2 RIGHT

AMAN_TER_W-2 LEFT

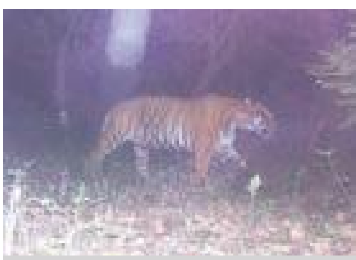
CORB_TER_W-1 RIGHT

CORB_TER_W-1 LEFT

CORB_TER_W-2 LEFT ONLY

TER_W-1 RIGHT

TER_W-1 LEFT



TER_W-3 RIGHT

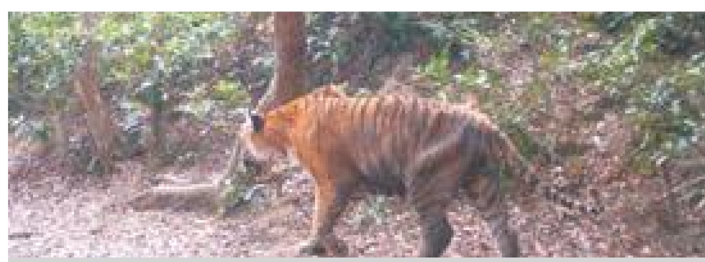
TER_W-3 LEFT

TER_W-4 RIGHT

TER_W-4 LEFT

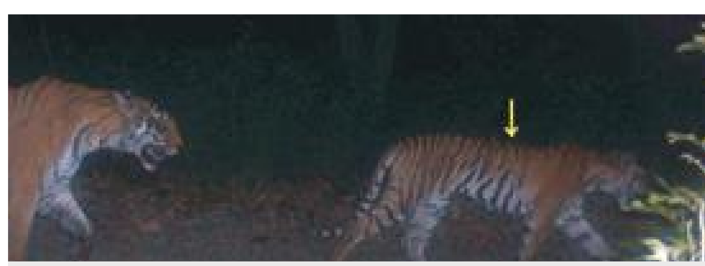
TER_W-6 RIGHT

TER_W-6 LEFT



TER_W-8 LEFT ONLY

TER_W-9 RIGHT ONLY



TER_W-10 RIGHT ONLY

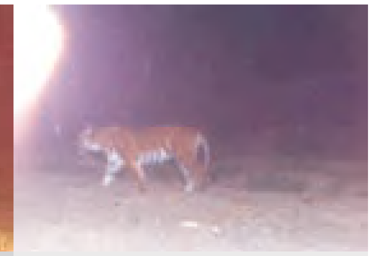
NAJIBABAD FOREST DIVISION

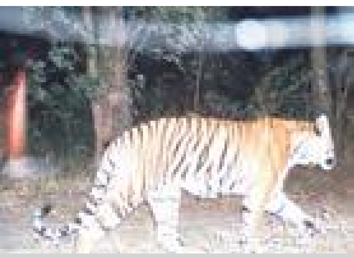
6 Nos.

KALA_NAJB-1 RIGHT


KALA_NAJB-1 LEFT


KALA_NAJB-2 RIGHT


KALA_NAJB-2 LEFT

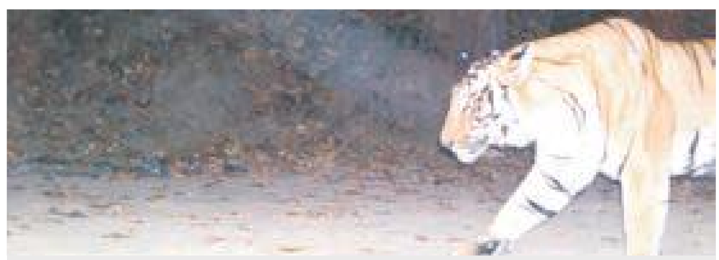

KALA_NAJB-3 RIGHT


KALA_NAJB-3 LEFT


KALA_NAJB-4 RIGHT


KALA_NAJB-4 LEFT


KALA_NAJB-5 RIGHT ONLY


KALA_NAJB-6 RIGHT ONLY

STATUS OF TIGERS CO PREDATORS AND PREY IN INDIA, 2014

HALDWANI FOREST DIVISION

9 Nos.


HALD-1 RIGHT

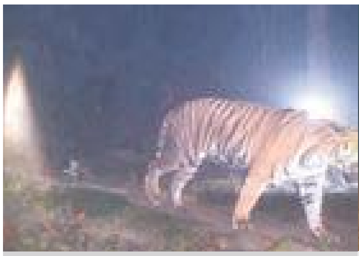

HALD-1 LEFT


HALD-2 RIGHT


HALD-2 LEFT


HALD-3 RIGHT

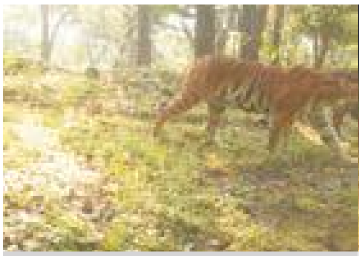

HALD-3 LEFT

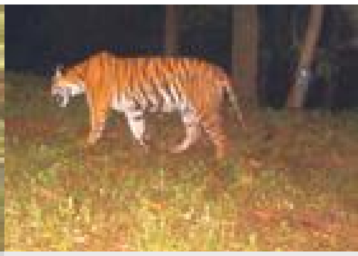

HALD-4 RIGHT

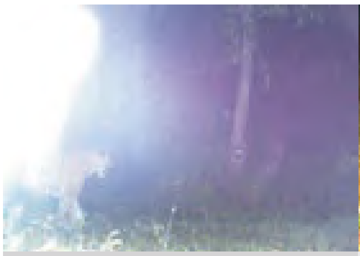

HALD-4 LEFT

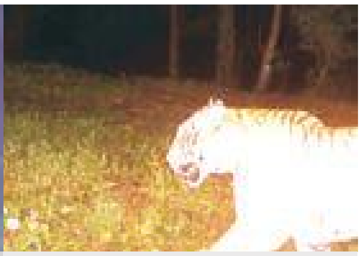

HALD-5 RIGHT


HALD-5 LEFT


HALD-6 RIGHT


HALD-6 LEFT


HALD-7 RIGHT

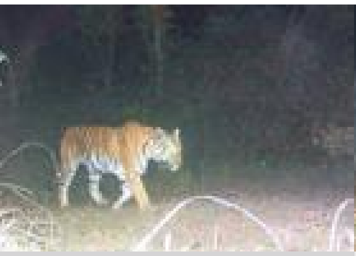

HALD-7 LEFT


HALD-8 RIGHT ONLY


HALD-9 RIGHT ONLY

AMANGARH TIGER RESERVE

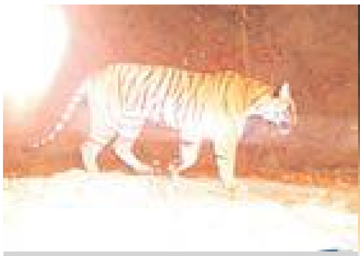
11 Nos.




AMAN-2 RIGHT AMAN-2 LEFT


AMAN-3 RIGHT AMAN-3 LEFT

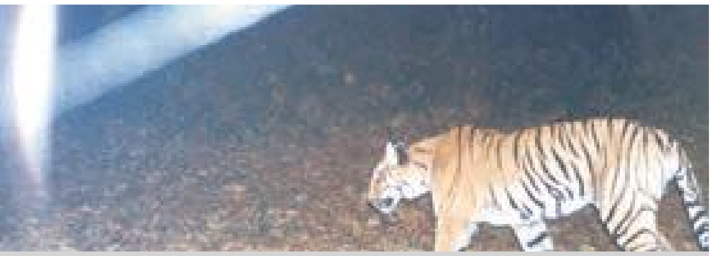

AMAN-4 RIGHT AMAN-4 LEFT




AMAN-8 RIGHT AMAN-8 LEFT

AMAN-10 LEFT ONLY

AMAN-11 RIGHT ONLY



AMAN_TER(W) - 2 LEFT ONLY

AMAN-12 LEFT ONLY


CORB_AMAN-2 RIGHT CORB_AMAN-2 LEFT


CORB_AMAN-3 RIGHT CORB_AMAN-3 LEFT


CORB_AMAN-4 RIGHT CORB_AMAN-4 LEFT

RAJAJI NATIONAL PARK

14 Nos.


RAJA-1 RIGHT


RAJA-1 LEFT


RAJA-2 RIGHT


RAJA-2 LEFT


RAJA-3 RIGHT


RAJA-3 LEFT


RAJA-4 RIGHT


RAJA-4 LEFT


RAJA-5 LEFT ONLY


RAJA-6 RIGHT


RAJA-6 LEFT


RAJA-7 LEFT ONLY


RAJA-8 RIGHT


RAJA-8 LEFT


RAJA-9 LEFT ONLY


RAJA-10 LEFT ONLY


RAJA-11 LEFT ONLY


RAJA-12 RIGHT ONLY


RAJA-13 RIGHT ONLY


RAJA-14 RIGHT ONLY

LANSDOWNE FOREST DIVISION 21 Nos.


KALA_LANS-1 RIGHT


KALA_LANS-1 LEFT


KALA_LANS-2 RIGHT


KALA_LANS-2 LEFT


KALA_LANS-3 LEFT ONLY


KALA_LANS-4 RIGHT


KALA_LANS-4 LEFT


LANS-1 RIGHT


LANS-1 LEFT

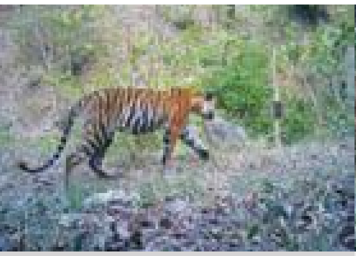

LANS-2 LEFT ONLY

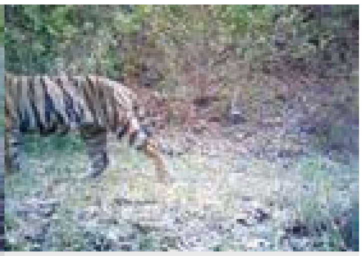

LANS-4 RIGHT


LANS-4 LEFT


LANS- 5 RIGHT


LANS-5 LEFT


LANS-6 RIGHT

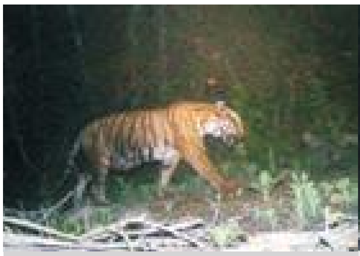

LANS-6 LEFT


LANS-8 RIGHT


LANS-8 LEFT


LANS-9 RIGHT


LANS-9 LEFT


LANS-10 RIGHT


LANS-10 LEFT

LANS-12 RIGHT

LANS-12 LEFT

LANS-13 RIGHT

LANS-13 LEFT

LANS-14 RIGHT

LANS-14 LEFT

LANS-15 RIGHT

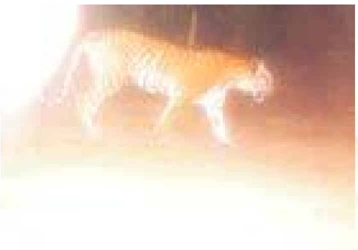
LANS-15 LEFT

LANS-17 RIGHT

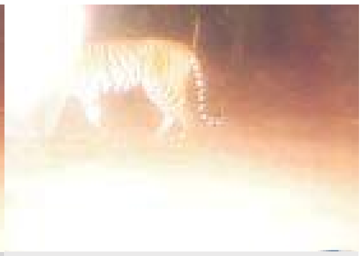
LANS-17 LEFT

LANS-18 RIGHT

LANS-18 LEFT



LANS-19 RIGHT



LANS-19 LEFT

LANS-20 RIGHT

LANS-20 LEFT

LANS-21 RIGHT

LANS-21 LEFT

DUDHWA NATIONAL PARK 14 Nos.

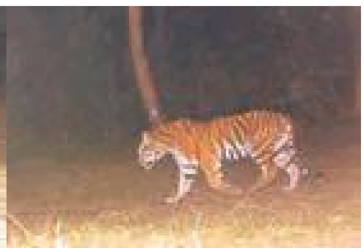

DUDW-1 RIGHT


DUDW-1 LEFT


DUDW-2 RIGHT


DUDW-2 LEFT


DUDW-3 RIGHT

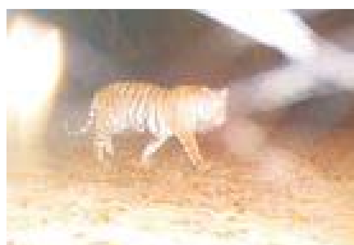

DUDW-3 LEFT


DUDW-4 RIGHT


DUDW-4 LEFT

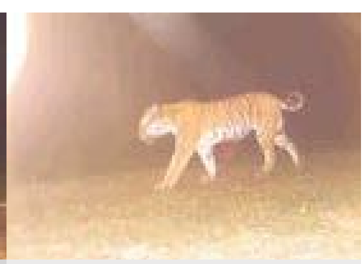

DUDW-5 RIGHT


DUDW-5 LEFT


DUDW-6 RIGHT


DUDW-6 LEFT

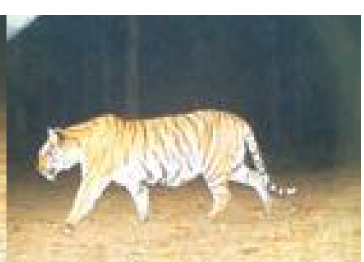

DUDW-7 RIGHT

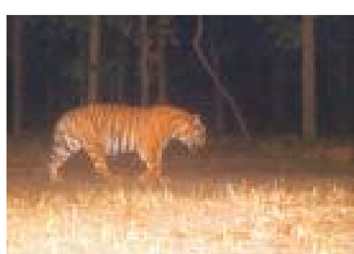

DUDW-7 LEFT

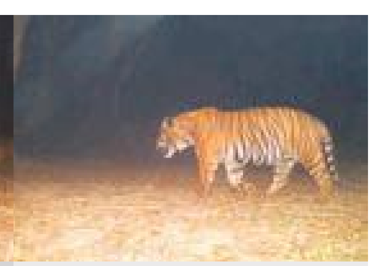

DUDW-8 RIGHT


DUDW-8 LEFT


DUDW-9 RIGHT


DUDW-9 LEFT


DUDW-10 RIGHT


DUDW-10 LEFT


DUDW-11 RIGHT


DUDW-11 LEFT


DUDW-12 RIGHT ONLY


DUDW-13 RIGHT


DUDW-13 LEFT


DUDW-14 RIGHT


DUDW-14 LEFT

KATARNIAGHAT WILDLIFE SANCTUARY 17 Nos.


KATR-1 RIGHT


KATR-1 LEFT


KATR-2 RIGHT ONLY


KATR-3 RIGHT ONLY


KATR-4 RIGHT ONLY


KATR-5 RIGHT


KATR-5 LEFT


KATR-6 RIGHT ONLY


KATR-7 RIGHT

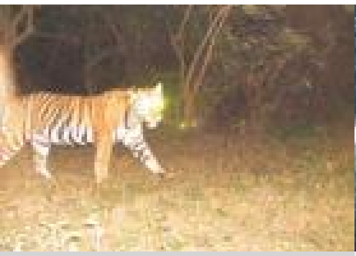

KATR-7 LEFT


KATR-8 RIGHT


KATR-8 LEFT


KATR-9 RIGHT ONLY


KATR-10 LEFT ONLY


KATR-11 RIGHT


KATR-11 LEFT


KATR-12 RIGHT ONLY

KATR-13 RIGHT

KATR-13 LEFT

KATR-14 RIGHT

KATR-14 LEFT

KATR-15 RIGHT

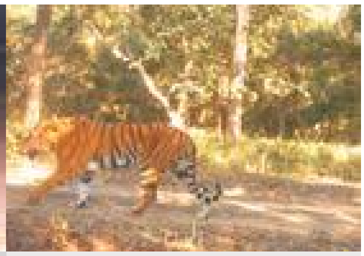
KATR-15 LEFT

KATR-16 RIGHT ONLY

KATR-17 RIGHT ONLY

KISHANPUR WILDLIFE SANCTUARY 30 Nos.


KSHN-1 RIGHT


KSHN-1 LEFT


KSHN-2 RIGHT


KSHN-2 LEFT

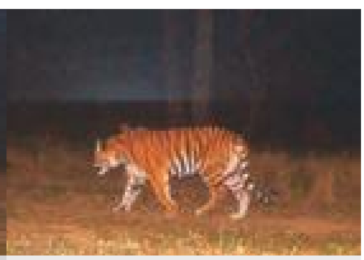

KSHN-3 RIGHT

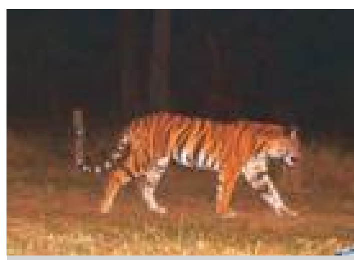

KSHN-3 LEFT


KSHN-4 RIGHT


KSHN-4 LEFT


PILB_KSHN-1 RIGHT


PILB_KSHN-1 LEFT

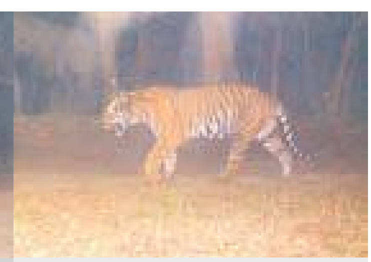

KSHN-6 RIGHT


KSHN-6 LEFT


KSHN-7 RIGHT


KSHN-7 LEFT

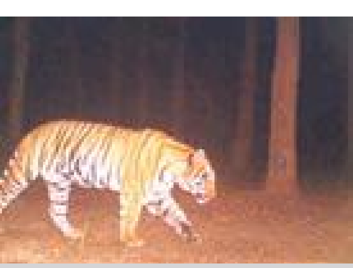

KSHN-8 RIGHT


KSHN-8 LEFT

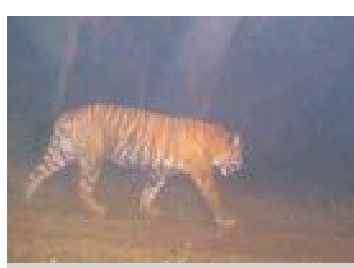

KSHN-9 RIGHT


KSHN-9 LEFT

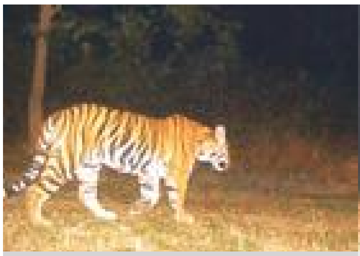

KSHN-10 RIGHT ONLY


PILB_KSHN-2 RIGHT


PILB_KSHN-2 LEFT


KSHN-12 RIGHT


KSHN-12 LEFT


KSHN-13 RIGHT


KSHN-13 LEFT


KSHN-14 RIGHT


KSHN-14 LEFT


KSHN-15 RIGHT


KSHN-15 LEFT


KSHN-16 RIGHT


KSHN-16 LEFT


KSHN-17 RIGHT


KSHN-17 LEFT


KSHN-18 RIGHT


KSHN-18 LEFT


KSHN-19 LEFT ONLY


KSHN-20 RIGHT


KSHN-20 LEFT


KSHN-21 RIGHT

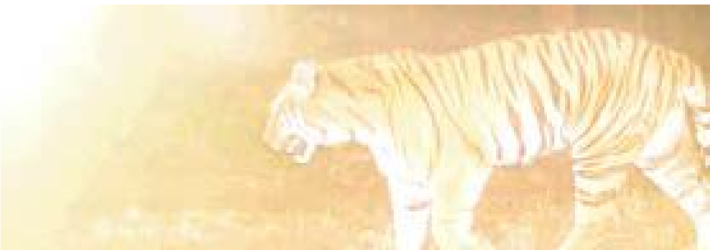

KSHN-21LEFT

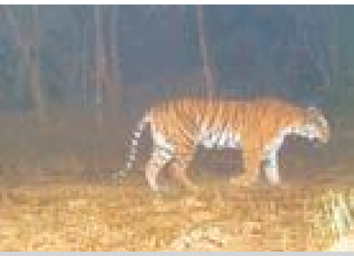

PILB_KSHN-3 RIGHT


PILB_KSHN-3 LEFT


KSHN-22 RIGHT


KSHN-22 LEFT

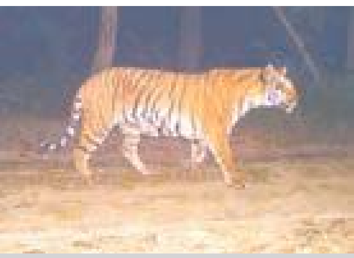

KSHN-24 LEFT ONLY

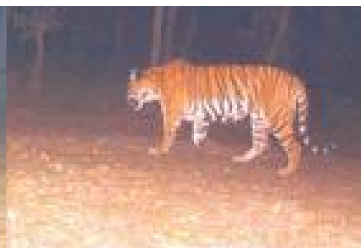

KSHN-25 RIGHT


KSHN-25 LEFT


KSHN-26 RIGHT


KSHN-26 LEFT


KSHN-27 RIGHT


KSHN-27 LEFT


KSHN-28 LEFT ONLY


KSHN-29 RIGHT


KSHN-29 LEFT


KSHN-30 RIGHT


KSHN-30 LEFT

PILIBHIT TIGER RESERVE 23 Nos.

PILB-2 LEFT ONLY

PILB-3 LEFT ONLY

PILB-5 LEFT ONLY

PILB-6 RIGHT

PILB-6 LEFT

PILB-7 LEFT ONLY

PILB-8 LEFT ONLY

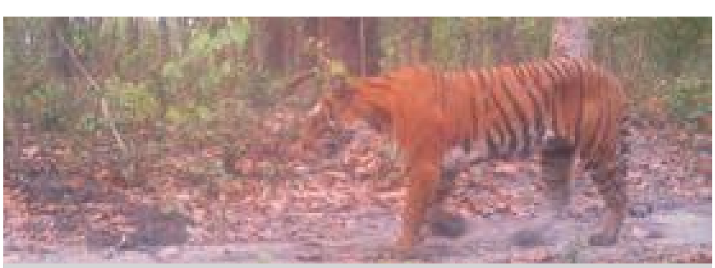
PILB-9 LEFT ONLY

PILB-10 RIGHT

PILB-10 LEFT

PILB-11 LEFT ONLY

PILB-12 LEFT ONLY

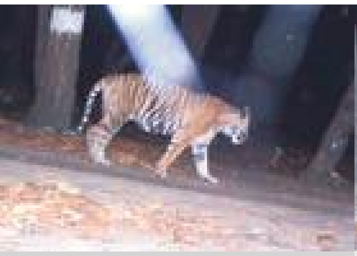


PILB-13 LEFT ONLY

PILB-14 LEFT ONLY


PILB-15 LEFT ONLY


PILB-16 LEFT ONLY


PILB-17 RIGHT


PILB-17 LEFT


PILB-18 LEFT ONLY


PILB-19 RIGHT


PILB-19 LEFT


PILB-20 RIGHT


PILB-20 LEFT


PILB-21 LEFT ONLY


PILB-23 LEFT ONLY


PILB_KSHN-1 LEFT ONLY


PILB_KSHN-2 LEFT ONLY


PILB_KSHN-3 LEFT ONLY


VALM-1 RIGHT


VALM-1 LEFT


VALM-2 RIGHT


VALM-2 LEFT


VALM-3 RIGHT


VALM-3 LEFT


VALM-4 RIGHT


VALM-4 LEFT


VALM-5 RIGHT


VALM-5 LEFT


VALM-6 RIGHT


VALM-6 LEFT


VALM-7 RIGHT


VALM-7 LEFT


VALM-8 RIGHT


VALM-8 LEFT


VALM-9 RIGHT


VALM-9 LEFT


VALM-10 RIGHT


VALM-10 LEFT


VALM-11 RIGHT


VALM-11 LEFT


VALM-12 RIGHT


VALM-12 LEFT

VALMIKI TIGER RESERVE 21 Nos.


VALM-13 RIGHT


VALM-13 LEFT


VALM-14 RIGHT


VALM-14 LEFT


VALM-15 RIGHT


VALM-15 LEFT


VALM-16 RIGHT


VALM-16 LEFT


VALM-17 RIGHT


VALM-17 LEFT


VALM-18 RIGHT

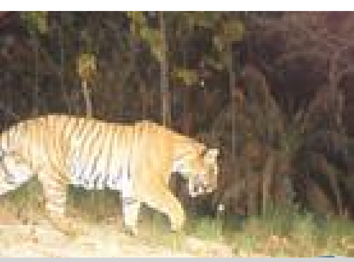

VALM-18 LEFT


VALM-19 RIGHT


VALM-19 LEFT


VALM-20 RIGHT


VALM-20 LEFT


VALM-21 RIGHT


VALM-21 LEFT

CENTRAL INDIAN & EASTERN GHATS LANDSCAPE COMPLEX


KNHA-1 RIGHT


KNHA - 1 LEFT


KNHA-2 RIGHT


KNHA - 2 LEFT


KNHA-3 RIGHT


KNHA - 3 LEFT


KNHA-4 RIGHT


KNHA - 4 LEFT


KNHA-5 RIGHT


KNHA - 5 LEFT


KNHA-6 RIGHT


KNHA - 6 LEFT


KNHA-7 RIGHT


KNHA - 7 LEFT


KNHA-8 RIGHT


KNHA - 8 LEFT


KNHA-9 RIGHT


KNHA - 9 LEFT


KNHA-10 RIGHT


KNHA - 10 LEFT


KNHA-11 RIGHT


KNHA - 11 LEFT


KNHA-12 RIGHT


KNHA - 12 LEFT

KANHA TIGER RESERVE 105 Nos.


KNHA-13 RIGHT


KNHA - 13 LEFT


KNHA-14 RIGHT


KNHA - 14 LEFT


KNHA-15 RIGHT


KNHA - 15 LEFT


KNHA-16 RIGHT


KNHA - 16 LEFT


KNHA-17 RIGHT


KNHA - 17 LEFT


KNHA-18 RIGHT


KNHA - 18 LEFT


KNHA-19 RIGHT


KNHA - 19 LEFT


KNHA-20 RIGHT


KNHA - 20 LEFT


KNHA-21 RIGHT


KNHA - 21 LEFT


KNHA-22 RIGHT


KNHA - 22 LEFT


KNHA-23 RIGHT


KNHA - 23 LEFT


KNHA-24 RIGHT


KNHA - 24 LEFT


KNHA-25 RIGHT


KNHA - 25 LEFT


KNHA-26 RIGHT


KNHA - 26 LEFT


KNHA-27 RIGHT


KNHA - 27 LEFT


KNHA-28 RIGHT


KNHA - 28 LEFT


KNHA-29 RIGHT


KNHA - 29 LEFT

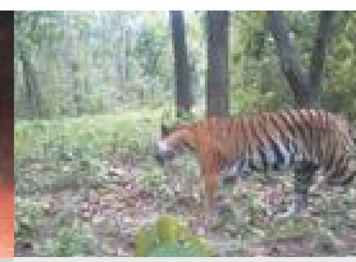

KNHA-30 RIGHT


KNHA - 30 LEFT


KNHA-31 RIGHT


KNHA - 31 LEFT


KNHA-32 RIGHT

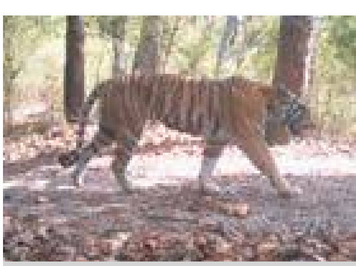

KNHA - 32 LEFT


KNHA-33 RIGHT


KNHA - 33 LEFT

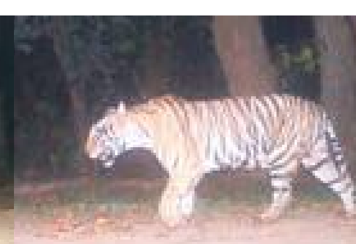

KNHA-34 RIGHT


KNHA - 34 LEFT


KNHA-35 RIGHT


KNHA - 35 LEFT


KNHA-36 RIGHT


KNHA - 36 LEFT


KNHA-37 RIGHT


KNHA - 37 LEFT


KNHA-38 RIGHT


KNHA - 38 LEFT


KNHA-39 RIGHT


KNHA - 39 LEFT


KNHA-40 RIGHT


KNHA - 40 LEFT


KNHA-41 RIGHT


KNHA - 42 LEFT


KNHA-42 RIGHT


KNHA - 42 LEFT


KNHA-43RIGHT


KNHA - 43 LEFT


KNHA-44 RIGHT


KNHA - 44 LEFT

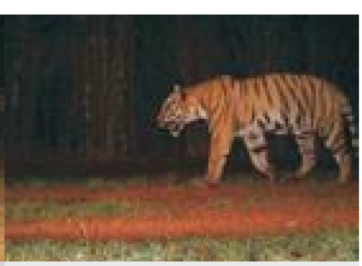

KNHA-45 RIGHT


KNHA - 45 LEFT


KNHA-46 RIGHT


KNHA - 46 LEFT


KNHA-47 RIGHT


KNHA -47 LEFT


KNHA-48 RIGHT


KNHA - 48 LEFT


KNHA-49 RIGHT


KNHA - 49 LEFT


KNHA-50 RIGHT


KNHA - 50 LEFT


KNHA-51 RIGHT


KNHA - 51 LEFT

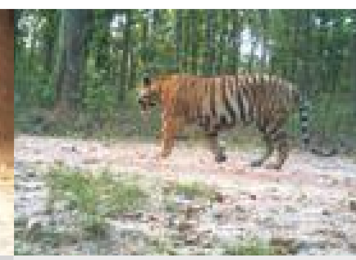

KNHA-52 RIGHT


KNHA - 52 LEFT


KNHA-53 RIGHT


KNHA - 53 LEFT


KNHA-54 RIGHT


KNHA - 54 LEFT


KNHA-55 RIGHT


KNHA - 55 LEFT


KNHA-56 RIGHT


KNHA - 56 LEFT


KNHA-57 RIGHT


KNHA - 57 LEFT


KNHA-58 RIGHT


KNHA - 58 LEFT


KNHA-59 RIGHT


KNHA - 59 LEFT


KNHA-60 RIGHT


KNHA - 60 LEFT


KNHA-61 RIGHT KNHA - 61 LEFT

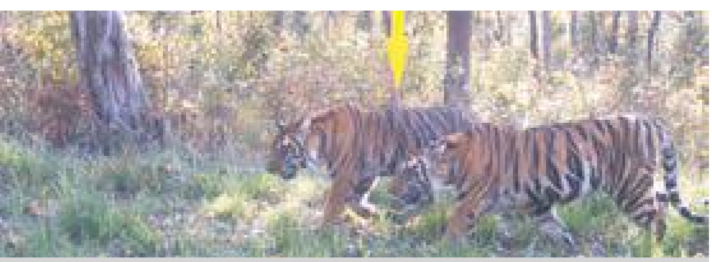

KNHA-62 RIGHT KNHA - 62 LEFT


KNHA-63 RIGHT KNHA - 63 LEFT


KNHA-64 RIGHT KNHA - 64 LEFT

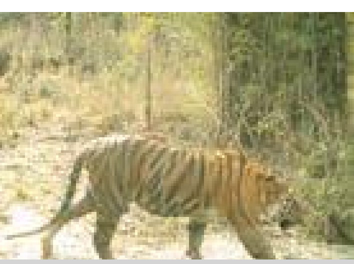

KNHA-65 RIGHT KNHA - 65 LEFT


KNHA-66 RIGHT KNHA - 66 LEFT



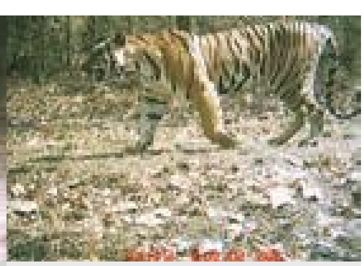
KNHA-67 LEFT ONLY

KNHA-68 LEFT ONLY




KNHA-69 RIGHT KNHA - 69 LEFT


KNHA-70 RIGHT KNHA - 70 LEFT

KNHA-71 RIGHT KNHA - 71 LEFT


KNHA- 72 RIGHT KNHA - 72 LEFT


KNHA-73 RIGHT


KNHA - 73 LEFT


KNHA-74 RIGHT


KNHA - 74 LEFT


KNHA-75 RIGHT


KNHA - 75 LEFT


KNHA-76 RIGHT


KNHA - 76 LEFT


KNHA-77 RIGHT


KNHA - 77 LEFT


KNHA-78 RIGHT ONLY


KNHA-79 RIGHT ONLY


KNHA-80 RIGHT ONLY


KNHA-81 RIGHT ONLY


KNHA-82 RIGHT ONLY


KNHA-83 RIGHT ONLY

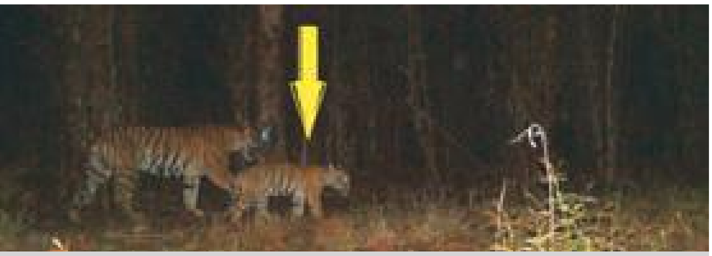

KNHA-84 RIGHT ONLY

KNHA-85 RIGHT ONLY

KNHA-86 RIGHT ONLY

KNHA-87 LEFT ONLY

KNHA-88 LEFTT ONLY



KNHA-89 RIGHT ONLY

KNHA - 90 RIGHT

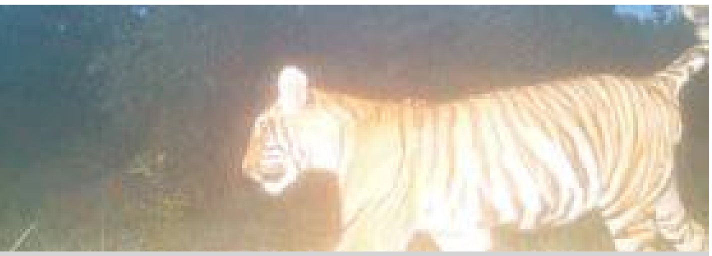
KNHA - 90 LEFT

KNHA-91 RIGHT

KNHA - 91 LEFT

KNHA-92 RIGHT

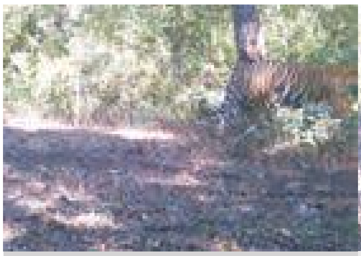
KNHA - 92 LEFT



KNHA-93 LEFT ONLY

KNHA-94 LEFTT ONLY

KNHA-95 LEFT ONLY



KNHA-96 RIGHT

KNHA - 96 LEFT


KNHA-97 RIGHT ONLY


KNHA-98 RIGHT ONLY


KNHA-99 RIGHT ONLY


KNHA-100 RIGHT ONLY


KNHA-101 RIGHT ONLY


KNHA-102 RIGHT ONLY


KNHA-103 LEFT ONLY


KNHA-104 LEFT ONLY


KNHA-105 RIGHT ONLY

KANHA PENCH CORRIDOR

5 Nos.

KPCR - 1 LEFT ONLY

KPCR - 3 LEFT ONLY

KPCR - 4 RIGHT

KPCR - 4 LEFT

KPCR - 5 RIGHT

KPCR - 5 LEFT

KPCR - 6 RIGHT

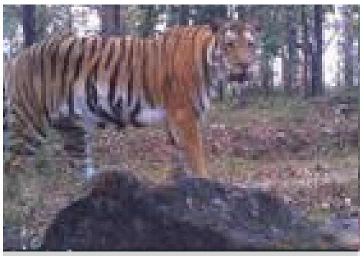
KPCR - 6 LEFT

PENCH TIGER RESERVE, MADHYA PRADESH

53 Nos.

PNMH_PNMP-1 RIGHT

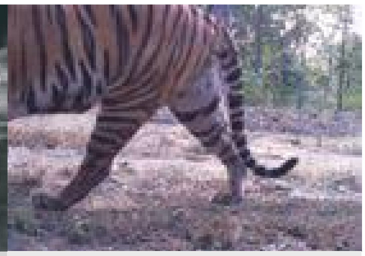
PNMH_PNMP-1 LEFT



PNMH_PNMP-7 RIGHT

PNMH_PNMP-7 LEFT

PNMH_PNMP-12 RIGHT



PNMH_PNMP-12 LEFT

PNMH_PNMP-13 RIGHT

PNMH_PNMP-13 LEFT

PNMH_PNMP-18 RIGHT

PNMH_PNMP-18 LEFT

PNMH_PNMP-21 LEFT ONLY

PNMP-1 RIGHT

PNMP-1 LEFT

PNMP-2 RIGHT

PNMP-2 LEFT

PNMP-3 RIGHT

PNMP-3 LEFT

PNMP-4 RIGHT

PNMP-4 LEFT

PNMP-5 LEFT ONLY

PNMP-6 RIGHT

PNMP-6 LEFT

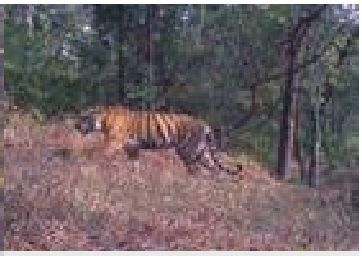

PNMP-8 RIGHT


PNMP-8 LEFT


PNMP-9 RIGHT


PNMP-9 LEFT


PNMP-11 RIGHT


PNMP-11 LEFT


PNMP-12 LEFT ONLY


PNMP-13 RIGHT


PNMP-13 LEFT

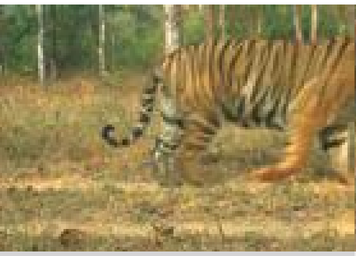

PNMP-14 RIGHT


PNMP-14 LEFT


PNMP-15 LEFT ONLY


PNMP-16 RIGHT


PNMP-16 LEFT


PNMP-17 RIGHT


PNMP-17 LEFT


PNMP-18 LEFT ONLY


PNMP-19 RIGHT


PNMP-19 LEFT


PNMP-20 RIGHT


PNMP-20 LEFT


PNMP-21 RIGHT


PNMP-21 LEFT


PNMP-22 RIGHT

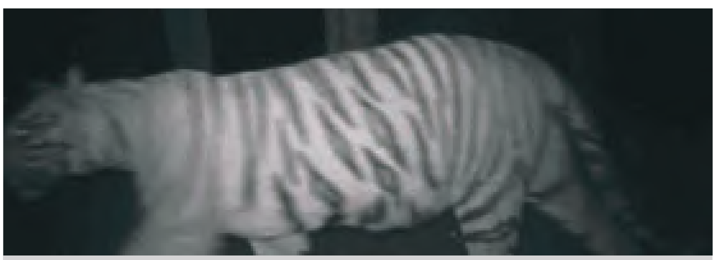

PNMP-22 LEFT


PNMP-23 RIGHT


PNMP-23 LEFT


PNMP-24 RIGHT

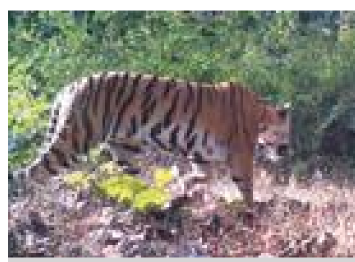

PNMP-24 LEFT


PNMP-26 LEFT ONLY


PNMP-28 RIGHT


PNMP-28 LEFT


PNMP-30 LEFT ONLY

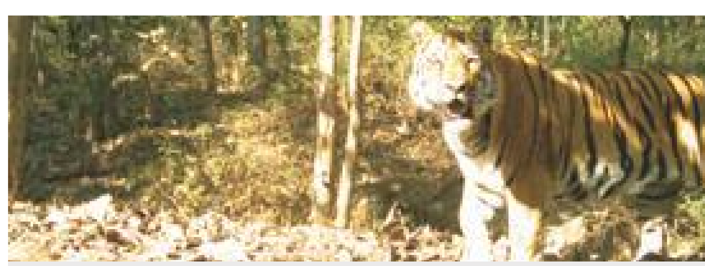

PNMP-31 RIGHT


PNMP-31 LEFT


PNMP-33 LEFT ONLY


PNMP-34 LEFT ONLY


PNMP-35 LEFT ONLY


PNMP-36 LEFT ONLY

PNMP-37 RIGHT

PNMP-37 LEFT

PNMP-38 LEFT ONLY

PNMP-39 LEFT ONLY

PNMP-40 RIGHT

PNMP-40 LEFT

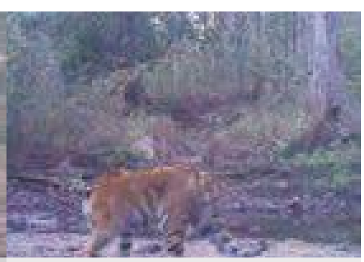
PNMP-41 RIGHT

PNMP-41 LEFT

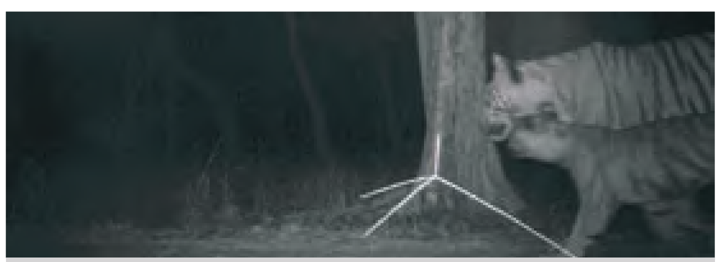
PNMP-42 RIGHT

PNMP-42 LEFT

PNMP-43 RIGHT



PNMP-43 LEFT



PNMP-44 LEFT ONLY

PNMP-45 LEFT ONLY

PNMP-46 RIGHT

PNMP-46 LEFT

PNMP-47 LEFT ONLY

PNMP-48 RIGHT

PNMP-48 LEFT

PNMP-49 LEFT ONLY

PNMP-50 LEFT ONLY

PNMP-51 LEFT ONLY

PNMP-52 LEFT ONLY

PNMP-53 RIGHT

PNMP-53 LEFT

PENCH TIGER RESERVE, MAHARASHTRA 25 Nos.


PNMH-2 RIGHT


PNMH-2 LEFT


PNMH-3 RIGHT


PNMH-3 LEFT


PNMH-4 RIGHT


PNMH-4 LEFT


PNMH-5 RIGHT


PNMH-5 LEFT


PNMH-6 RIGHT


PNMH-6 LEFT


PNMH-8 RIGHT ONLY


PNMH-9 RIGHT


PNMH-9 LEFT

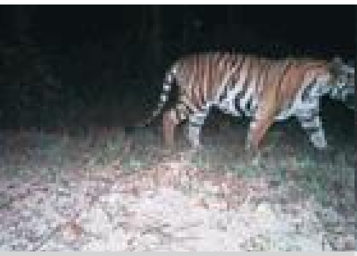

PNMH-10 RIGHT


PNMH-10 LEFT


PNMH-11 RIGHT


PNMH-11 LEFT


PNMH-14 RIGHT ONLY


PNMH-15 RIGHT


PNMH-15 LEFT


PNMH-16 RIGHT


PNMH-16 LEFT


PNMH-17 RIGHT PNMH-17 LEFT


PNMH-19 RIGHT PNMH-19 LEFT


PNMH-20 RIGHT PNMH-20 LEFT


PNMH-22 RIGHT PNMH-22 LEFT


PNMH-23 RIGHT PNMH-23 LEFT


PNMH-24 RIGHT PNMH-24 LEFT


PNMH-25 RIGHT ONLY


PNMH_PNMP-1 RIGHT PNMH_PNMP-1 LEFT


PNMH_PNMP-7 RIGHT PNMH_PNMP-7 LEFT


PNMH_PNMP-12 RIGHT PNMH_PNMP-12 LEFT


PNMH_PNMP-13 RIGHT PNMH_PNMP-13 LEFT

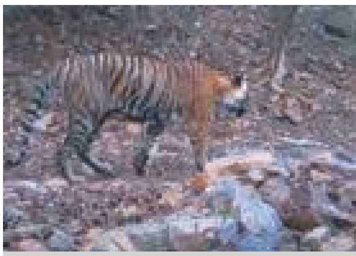

PNMH_PNMP-18 RIGHT PNMH_PNMP-18 LEFT

PNMH_PNMP-21 RIGHT

PNMH_PNMP-21 LEFT

RANT-3 RIGHT

RANT-3 LEFT

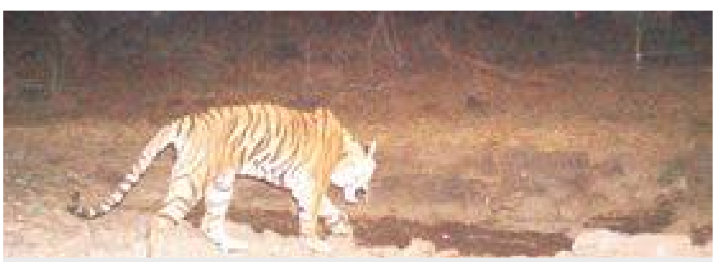


RANT-8 RIGHT

RANT-8 LEFT

RANT-11 RIGHT

RANT-11 LEFT



RANT-16 RIGHT ONLY

RANT-20 RIGHT

RANT-20 LEFT

RANT-23 RIGHT

RANT-23 LEFT

RANT-6 RIGHT

RANT-6 LEFT

RANT-9 RIGHT

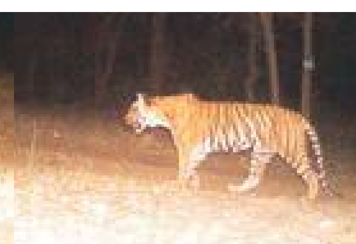
RANT-9 LEFT

RANT-13 LEFT ONLY

RANT-19 RIGHT

RANT-19 LEFT

RANT-22 RIGHT



RANT-22 LEFT

RANT-24 RIGHT

RANT-24 LEFT

RANTHAMBHORE TIGER RESERVE

48 Nos.


RANT-25 RIGHT


RANT-25 LEFT


RANT-26 RIGHT


RANT-26 LEFT


RANT-28 RIGHT


RANT-28 LEFT


RANT-30 RIGHT


RANT-30 LEFT


RANT-33 RIGHT


RANT-33 LEFT


RANT-34 RIGHT


RANT-34 LEFT


RANT-39 RIGHT


RANT-39 LEFT


RANT-41 RIGHT

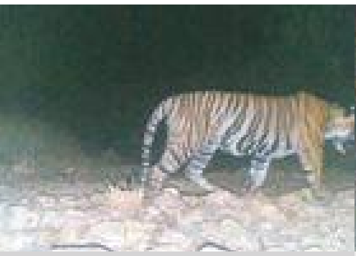

RANT-41 LEFT


RANT-42 RIGHT


RANT-42 LEFT


RANT-43 RIGHT


RANT-43 LEFT


RANT-47 RIGHT


RANT-47 LEFT


RANT-48 RIGHT


RANT-48 LEFT


RANT-54 RIGHT


RANT-54 LEFT


RANT-57 RIGHT


RANT-57 LEFT


RANT-58 LEFT ONLY


RANT-59 RIGHT


RANT-59 LEFT


RANT-60 RIGHT


RANT-60 LEFT


RANT-61 LEFT ONLY


RANT-63 RIGHT

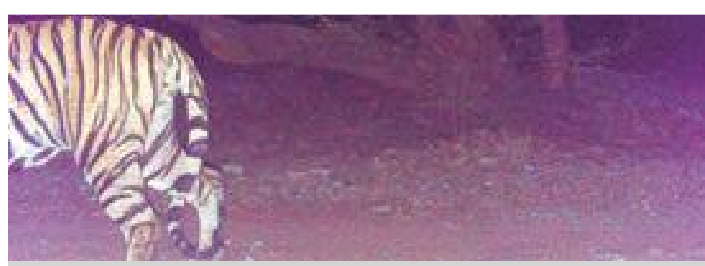

RANT-63 LEFT


RANT-64 RIGHT


RANT-64 LEFT


RANT-65 RIGHT


RANT-65 LEFT


RANT-66 LEFT ONLY


RANT-69 RIGHT


RANT-69 LEFT


RANT-72 RIGHT


RANT-72 LEFT


RANT-73 RIGHT ONLY


RANT-74 RIGHT ONLY


RANT-75 RIGHT


RANT-75 LEFT


RANT-76 RIGHT ONLY


RANT-77 RIGHT


RANT-77 LEFT


RANT-78 RIGHT


RANT-78 LEFT


RANT-79 LEFT ONLY


RANT-81 LEFT ONLY


RANT-82 LEFT ONLY


RANT-83 LEFT ONLY


RANT-84 LEFT ONLY


RANT-86 LEFT ONLY

KAILADEVI WILDLIFE SANCTUARY

1 Nos.

KDVI-1 RIGHT

KDVI-1 LEFT

KUNO WILDLIFE SANCTUARY

1 Nos.

KUNO-1 RIGHT

KUNO-1 LEFT

RAMGARH WILDLIFE SANCTUARY

1 Nos.

RAMG-1 RIGHT

RAMG-1 LEFT

SARISKA TIGER RESERVE 13 Nos.


SRSK-1 RIGHT


SRSK-1 LEFT


SRSK-2 RIGHT


SRSK-2 LEFT


SRSK-3 RIGHT


SRSK-3 LEFT


SRSK-4 RIGHT ONLY


SRSK-5 RIGHT


SRSK-5 LEFT


SRSK-6 RIGHT


SRSK-6 LEFT


SRSK-7 RIGHT


SRSK-7 LEFT

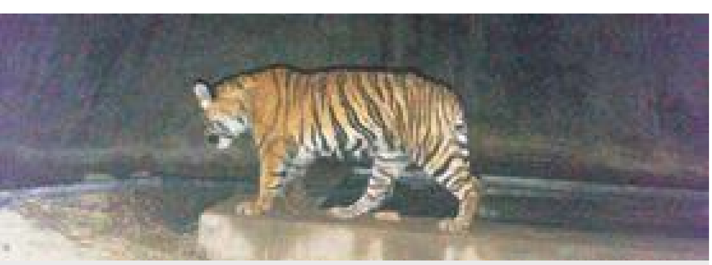

SRSK-8 RIGHT


SRSK-8 LEFT


SRSK-9 RIGHT


SRSK-9 LEFT


SRSK-10 LEFT ONLY


SRSK-11 LEFT ONLY


SRSK-12 LEFT ONLY


SRSK-13 LEFT ONLY

PANNA TIGER RESERVE

18 Nos.


PNNA-1 RIGHT


PNNA-1 LEFT


PNNA-2 RIGHT


PNNA-2 LEFT


PNNA-3 RIGHT ONLY


PNNA-4 RIGHT


PNNA-4 LEFT


PNNA-5 RIGHT


PNNA-5 LEFT


PNNA-6 RIGHT


PNNA-6 LEFT


PNNA-7 RIGHT


PNNA-7 LEFT


PNNA-8 RIGHT


PNNA-8 LEFT


PNNA-9 RIGHT


PNNA-9 LEFT


PNNA-10 RIGHT ONLY


PNNA-11 RIGHT


PNNA-11 LEFT


PNNA-12 RIGHT


PNNA-12 LEFT

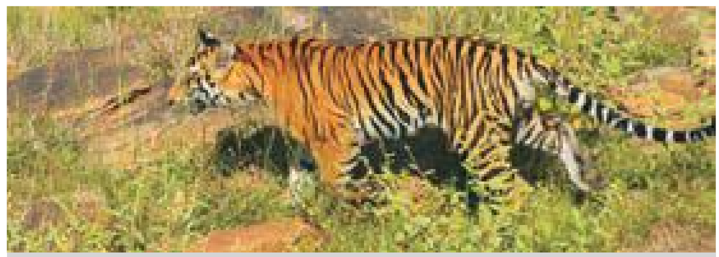
PNNA-13 LEFT ONLY

PNNA-14 RIGHT

PNNA-14 LEFT

PNNA-15 RIGHT

PNNA-15 LEFT



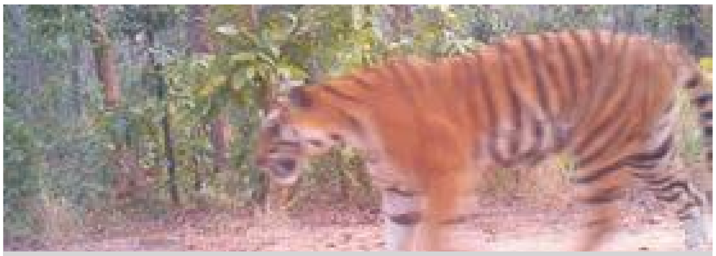
PNNA-16 LEFT ONLY

PNNA-17 LEFT ONLY

PNNA-18 RIGHT

PNNA-18 LEFT

SANJAY DUBRI TIGER RESERVE 8 Nos.



SNJY-1 LEFT ONLY

SNJY-2 LEFT ONLY

SNJY-3 LEFT ONLY

SNJY-4 LEFT ONLY

SNJY-5 LEFT ONLY

SNJY-6 LEFT ONLY

SNJY-7 LEFT ONLY

SNJY-8 LEFT ONLY

BANDHAVGARH TIGER RESERVE 70 Nos.

BDGH-1 LEFT ONLY

BDGH-2 LEFT ONLY

BDGH-3 RIGHT

BDGH-3 LEFT

BDGH-4 LEFT ONLY

BDGH-5 RIGHT

BDGH-5 LEFT

BDGH-6 LEFT ONLY

BDGH-7 LEFT ONLY

BDGH-8 RIGHT

BDGH-8 LEFT

BDGH-9 RIGHT

BDGH-9 LEFT

BDGH-10 LEFT ONLY

BDGH-11 RIGHT

BDGH-11 LEFT

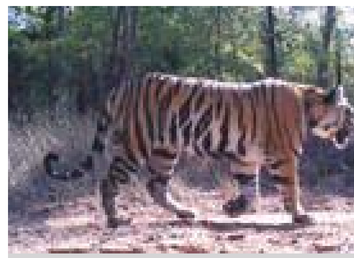

BDGH-12 RIGHT


BDGH-12 LEFT


BDGH-13 LEFT ONLY


BDGH-14 RIGHT


BDGH-14 LEFT


BDGH-15 RIGHT


BDGH-15 LEFT


BDGH-16 RIGHT


BDGH-16 LEFT

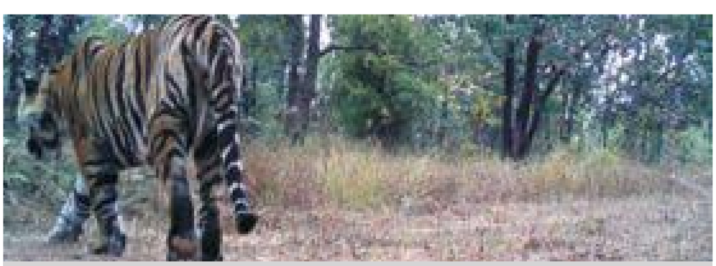

BDGH-17 RIGHT


BDGH-17 LEFT


BDGH-18 LEFT ONLY

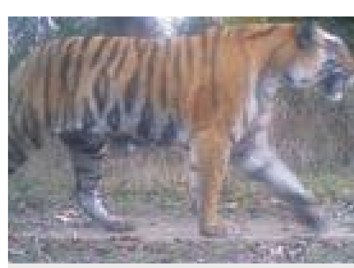

BDGH-19 RIGHT

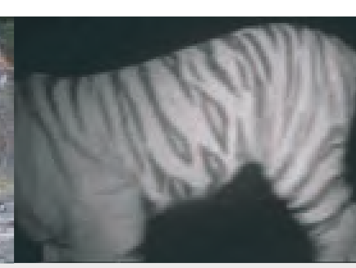

BDGH-19 LEFT


BDGH-20 LEFT ONLY


BDGH-21 LEFT ONLY


BDGH-22 LEFT ONLY


BDGH-23 RIGHT


BDGH-23 LEFT


BDGH-24 RIGHT


BDGH-24 LEFT


BDGH-25 RIGHT


BDGH-25 LEFT


BDGH-26 RIGHT


BDGH-26 LEFT


BDGH-27 RIGHT


BDGH-27 LEFT


BDGH-28 RIGHT


BDGH-28 LEFT


BDGH-29 RIGHT


BDGH-29 LEFT


BDGH-30 RIGHT


BDGH-30 LEFT

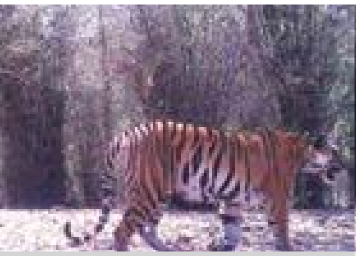

BDGH-31 LEFT ONLY


BDGH-32 RIGHT


BDGH-32 LEFT


BDGH-33 RIGHT


BDGH-33 LEFT


BDGH-34 RIGHT


BDGH-34 LEFT


BDGH-35 RIGHT


BDGH-35 LEFT

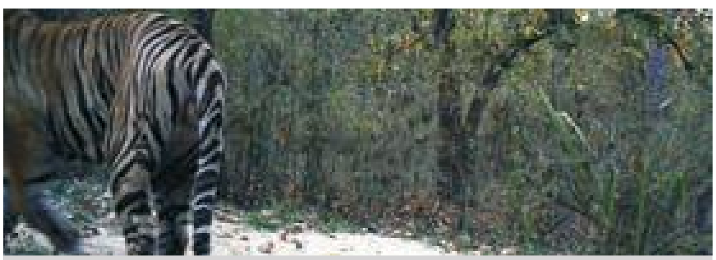

BDGH-36 LEFT ONLY


BDGH-37 RIGHT


BDGH-37 LEFT


BDGH-38 LEFT ONLY


BDGH-39 LEFT ONLY


BDGH-40 LEFT ONLY


BDGH-41 RIGHT


BDGH-41 LEFT


BDGH-42 LEFT ONLY


BDGH-43 RIGHT


BDGH-43 LEFT


BDGH-44 RIGHT


BDGH-44 LEFT


BDGH-45 LEFT ONLY


BDGH-46 RIGHT


BDGH-46 LEFT


BDGH-47 RIGHT


BDGH-47 LEFT


BDGH-48 LEFT ONLY


BDGH-49 LEFT ONLY


BDGH-50 LEFT ONLY


BDGH-51 LEFT ONLY


BDGH-52 RIGHT ONLY


BDGH-53 LEFT ONLY


BDGH-54 RIGHT ONLY


BDGH-55 RIGHT ONLY


BDGH-56 RIGHT ONLY


BDGH-57 LEFT ONLY


BDGH-58 LEFT ONLY


BDGH-59 RIGHT

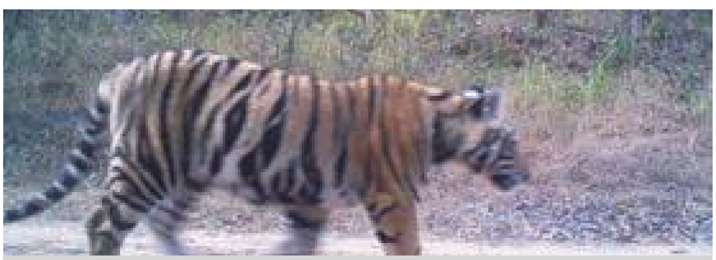

BDGH-59 LEFT


BDGH-60 LEFT ONLY


BDGH-61 LEFT ONLY


BDGH-62 LEFT ONLY

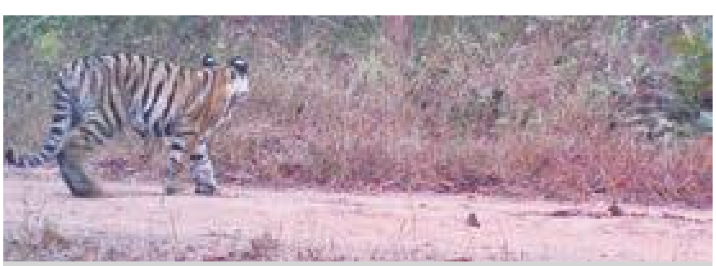

BDGH-63 LEFT ONLY


BDGH-64 RIGHT ONLY


BDGH-65 RIGHT ONLY


BDGH-66 RIGHT ONLY


BDGH-67 RIGHT ONLY


BDGH-68 RIGHT ONLY


BDGH-69 RIGHT


BDGH-69 LEFT


BDGH-70 RIGHT


BDGH-70 LEFT

SATPURA TIGER RESERVE 30 Nos.


SATP-1 RIGHT


SATP-1 LEFT


SATP-2 RIGHT


SATP-2 LEFT


SATP-3 RIGHT


SATP-3 LEFT


SATP-4 RIGHT


SATP-4 LEFT


SATP-5 RIGHT


SATP-5 LEFT


SATP-6 RIGHT ONLY

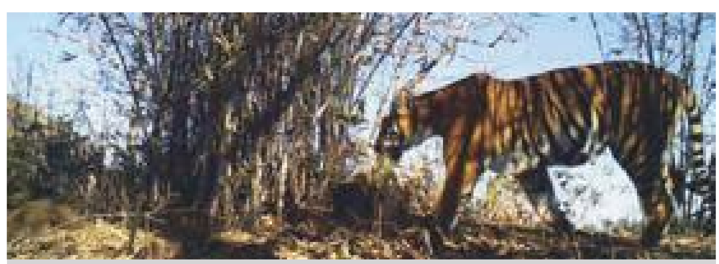

SATP-7 RIGHT


SATP-7 LEFT


SATP-8 RIGHT ONLY


SATP-9 RIGHT


SATP-9 LEFT


SATP-10 LEFT ONLY


SATP-11 RIGHT


SATP-11 LEFT


SATP-12 RIGHT ONLY


SATP-13 RIGHT


SATP-13 LEFT


SATP-14 RIGHT

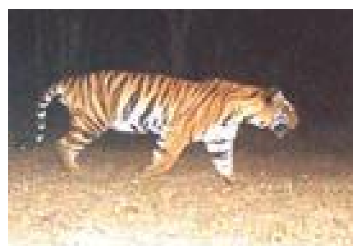

SATP-14 LEFT


SATP-15 LEFT ONLY

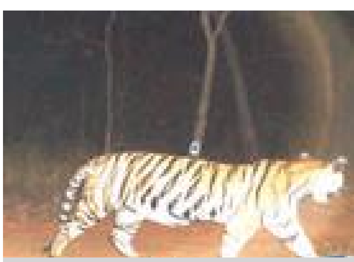

SATP-16 LEFT ONLY


SATP-17 RIGHT


SATP-17 LEFT


SATP-18 RIGHT


SATP-18 LEFT

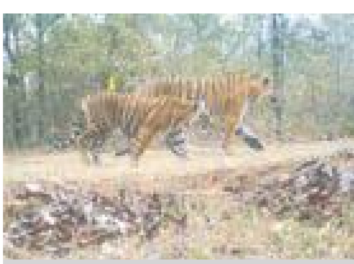

SATP-19 RIGHT


SATP-19 LEFT


SATP-20 RIGHT ONLY

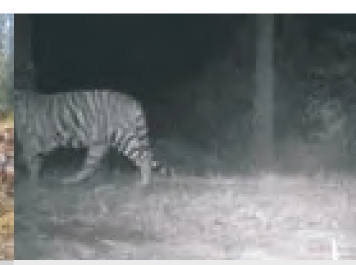

SATP-21 LEFT ONLY


SATP-22 LEFT ONLY

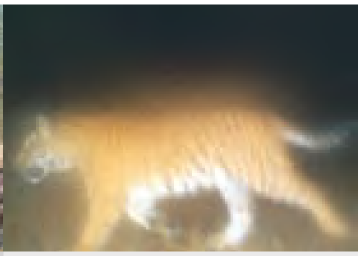

SATP-23 RIGHT


SATP-23 LEFT


SATP-24 RIGHT


SATP-24 LEFT

SATP-25 RIGHT



SATP-25 LEFT

SATP-26 RIGHT ONLY

SATP-27 RIGHT ONLY

SATP-28 RIGHT ONLY

SATP-29 RIGHT ONLY

SATP-30 RIGHT ONLY

BOR TIGER RESERVE 7 Nos.

BOR-1 RIGHT

BOR-1 LEFT

BOR-2 RIGHT

BOR-2 LEFT

BOR-3 RIGHT

BOR-3 LEFT

BOR-4 RIGHT

BOR-4 LEFT

BOR-5 RIGHT

BOR-5 LEFT

BOR-6 RIGHT ONLY

BOR-7 RIGHT ONLY

MELGHAT TIGER RESERVE 22 Nos.


MLGT-1 RIGHT


MLGT-1 LEFT


MLGT-2 RIGHT


MLGT-2 LEFT


MLGT-3 RIGHT


MLGT-3LEFT


MLGT-4 LEFT ONLY

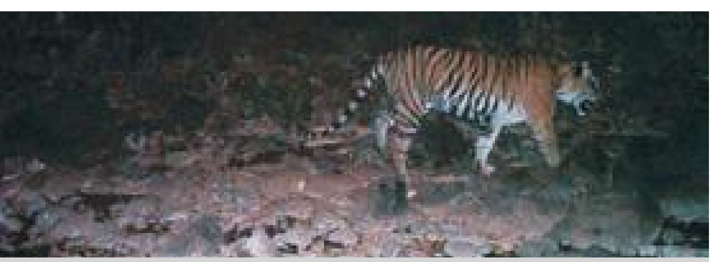

MLGT-5 LEFT ONLY


MLGT-6 RIGHT


MLGT-6 LEFT


MLGT-7 RIGHT ONLY


MLGT-8 RIGHT ONLY


MLGT-9 RIGHT ONLY


MLGT-10 RIGHT


MLGT-10 LEFT


MLGT-11 RIGHT


MLGT-11 LEFT


MLGT-12 RIGHT ONLY

MLGT-13 RIGHT ONLY

MLGT-15 RIGHT ONLY

MLGT-16 RIGHT ONLY

MLGT-17 RIGHT ONLY

MLGT-18 LEFT ONLY

MLGT-19 RIGHT ONLY

MLGT-20 RIGHT ONLY

MLGT-21 RIGHT ONLY

MLGT-22 RIGHT ONLY

MLGT-23 RIGHT ONLY

MELGHAT TIGER RESERVE BUFFER

4 Nos.


MGBF-1 RIGHT


MGBF-1 LEFT


MGBF-2 RIGHT


MGBF-2 LEFT


MGBF-3 RIGHT


MGBF-3 LEFT


MGBF-4 RIGHT


MGBF-4 LEFT

NAVEGAON NAGZIRA TIGER RESERVE

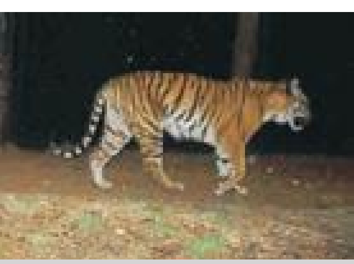
6 Nos.


NNTR-1 RIGHT

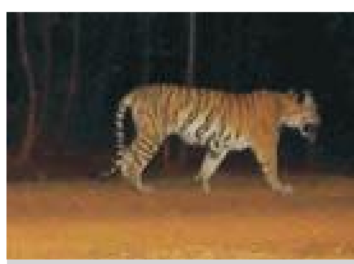

NNTR-1 LEFT


NNTR-2 RIGHT


NNTR-2 LEFT


NNTR-3 RIGHT


NNTR-3 LEFT


NNTR-4 RIGHT


NNTR-4 LEFT


NNTR-5 RIGHT


NNTR-5 LEFT


NNTR-6 RIGHT


NNTR-6 LEFT

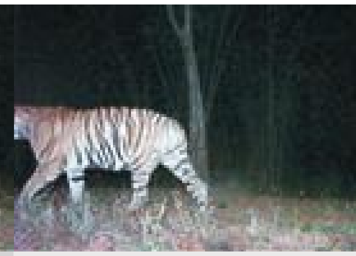
TADOBA ANDHARI TIGER RESERVE

62 Nos.

TATR-1 RIGHT

TATR- 1 LEFT

TATR-2 RIGHT



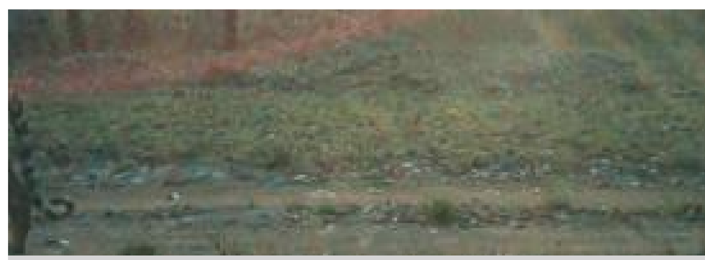
TATR- 2 LEFT

TATR-3 RIGHT

TATR-3 LEFT

TATR-4 LEFT ONLY

TATR-5 LEFT ONLY



TATR-6 LEFT ONLY

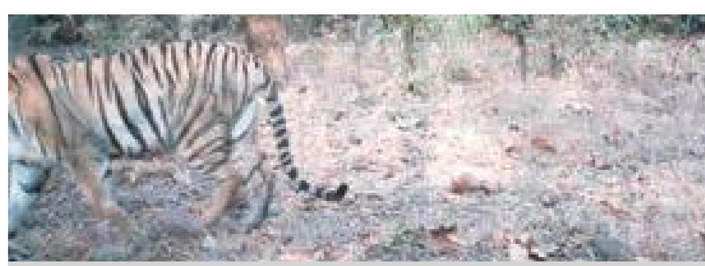
TATR-7 LEFT ONLY

TATR-8 RIGHT

TATR-8 LEFT

TATR-9 RIGHT

TATR-9 LEFT



TATR-10 LEFT ONLY

TATR-11 LEFT ONLY

TATR-12 RIGHT

TATR-12 LEFT


TATR-13 RIGHT


TATR-13 LEFT


TATR-14 RIGHT


TATR-14 LEFT


TATR-15 RIGHT


TATR-15 LEFT


TATR-16 RIGHT


TATR-16 LEFT


TATR-17 RIGHT


TATR-17 LEFT


TATR-18 RIGHT


TATR-18 LEFT


TATR-19 RIGHT


TATR-19 LEFT


TATR-20 RIGHT ONLY


TATR-21 RIGHT


TATR-21 LEFT


TATR-22 RIGHT


TATR-22 LEFT


TATR-23 LEFT ONLY


TATR-24 LEFT ONLY


TATR-25 RIGHT


TATR-25 LEFT


TATR-26 RIGHT


TATR-26 LEFT


TATR-27 LEFT ONLY


TATR-28 LEFT ONLY


TATR-29 RIGHT


TATR-29 LEFT


TATR-30 RIGHT


TATR-30 LEFT


TATR-31 LEFT ONLY


TATR-32 RIGHT


TATR-32 LEFT


TATR-33 RIGHT


TATR-33 LEFT


TATR-34 LEFT ONLY


TATR-35 RIGHT

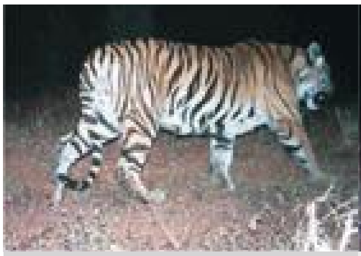

TATR-35 LEFT


TATR-36 RIGHT


TATR-36 LEFT

TATR-37 RIGHT

TATR-37 LEFT



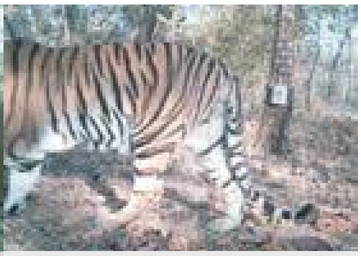
TATR-38 RIGHT

TATR-38 LEFT

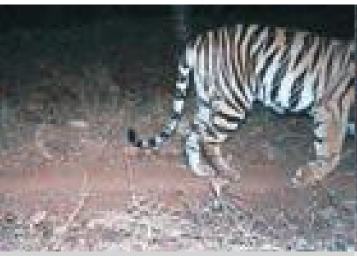
TATR-39 RIGHT

TATR-39 LEFT

TATR-40 RIGHT



TATR-40 LEFT



TATR-41 RIGHT

TATR-41 LEFT

TATR-42 RIGHT

TATR-42 LEFT

TATR-43 LEFT ONLY

TATR-44 RIGHT

TATR-44 LEFT

TATR-45 RIGHT

TATR-45 LEFT

TATR-46 RIGHT ONLY

TATR-47 RIGHT ONLY

TATR-48 RIGHT ONLY

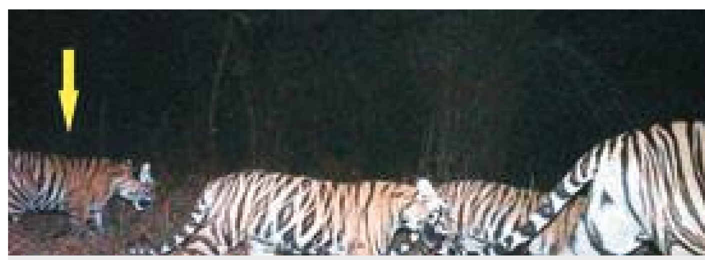

TATR-49 RIGHT ONLY


TATR-50 RIGHT ONLY


TATR-51 RIGHT ONLY

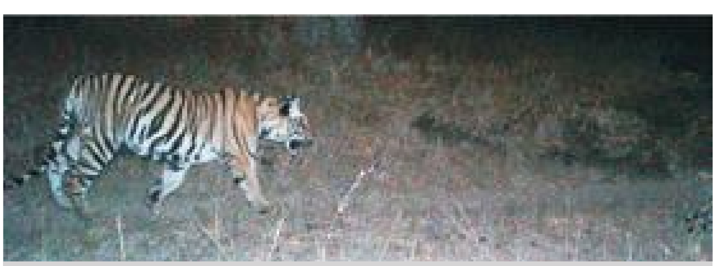

TATR-52 RIGHT ONLY


TATR-53 RIGHT ONLY


TATR-54 RIGHT ONLY


TATR-55 RIGHT ONLY


TATR-56 RIGHT ONLY


TATR-57 RIGHT ONLY


TATR-58 RIGHT ONLY


TATR-59 RIGHT ONLY


TATR-60 RIGHT ONLY


TATR-61 RIGHT ONLY


TATR-62 RIGHT ONLY

TIPPESHWAR WILDLIFE SANCTUARY

2 Nos.

TIPP-1 RIGHT

TIPP-1 LEFT

TIPP-2 RIGHT

TIPP-2 LEFT

UDANTI-SITANADI TIGER RESERVE

1 Nos.

UDAN-1 RIGHT ONLY

UMRED WILDLIFE SANCTUARY 3 Nos.


UMRE-1 RIGHT


UMRE-1 LEFT


UMRE-2 RIGHT


UMRE-2 LEFT


UMRE-3 RIGHT


UMRE-3 LEFT

GUNDLA BRAHMESHWARAM WILDLIFE SANCTUARY 16 Nos.


GBM-1 RIGHT


GBM-1 LEFT


GBM-2 RIGHT


GBM-2 LEFT


GBM-3 LEFT ONLY


GBM-4 LEFT ONLY


GBM-5 LEFT ONLY

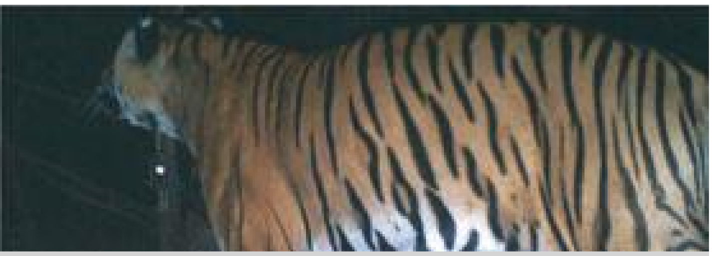

GBM-6 LEFT ONLY


GBM-7 RIGHT


GBM-7 LEFT


NSTR_GBM-8 RIGHT


NSTR_GBM-8 LEFT


GBM-9 LEFT ONLY


GBM_NSTR-10 LEFT ONLY


GBM_NSTR-11 RIGHT ONLY


GBM-12 RIGHT


GBM-12 LEFT

GBM-13 RIGHT

GBM-13 LEFT

GBM-14 RIGHT ONLY

GBM-15 LEFT ONLY

GBM-16 LEFT ONLY

NAGARJUNSAGAR SRISAILAM TIGER RESERVE, ANDHRA PRADESH & TELANGANA

20 Nos.

GVPA-1 RIGHT

GVPA-1 LEFT

GVPA_NSTR-2 RIGHT

GVPA_NSTR-2 LEFT

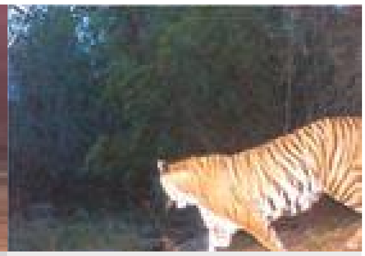
GVPA_NSTR 3 RIGHT

GVPA_NSTR 3 LEFT

GVPA-4 RIGHT

GVPA-4 LEFT

GVPA-5 RIGHT



GVPA-5 LEFT

GVPA-6 RIGHT

GVPA-6 LEFT

GVPA_NSTR-7 RIGHT

GVPA_NSTR-7 LEFT

GVPA-8 RIGHT

GVPA-8 LEFT


NSTR-1 RIGHT


NSTR-1 LEFT


NSTR-4 RIGHT


NSTR-4 LEFT


GBM_NSTR-11 RIGHT


GBM_NSTR-11 LEFT


GBM_NSTR-10 LEFT ONLY


NSTR-9 LEFT ONLY


NSTR-10 LEFT ONLY


NSTR_TL- 1 RIGHT


NSTR_TL- 1 LEFT


NSTR_TL- 2 RIGHT


NSTR_TL- 2 LEFT


NSTR_TL- 4 RIGHT


NSTR_TL- 4 LEFT


NSTR_TL- 5 RIGHT


NSTR_TL- 5 LEFT


NSTR_TL- 6 RIGHT


NSTR_TL- 6 LEFT


NSTR_TL-3 LEFT ONLY

SIMLIPAL TIGER RESERVE 5 Nos.


SIML-1 RIGHT


SIML-1 LEFT


SIML-2 RIGHT


SIML-2 LEFT


SIML-3 RIGHT


SIML-3 LEFT


SIML-4 RIGHT


SIML-4 LEFT


SIML-5 RIGHT


SIML-5 LEFT

SATKOSIA TIGER RESERVE 1 Nos.

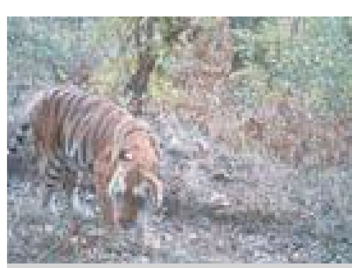

SATK-1 RIGHT


SATK-1 LEFT

PALAMAU TIGER RESERVE 2 Nos.


PALA-1 RIGHT


PALA-1 LEFT


PALA-2 RIGHT


PALA-2 LEFT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KAZI-1 RIGHT ONLY


KAZI-2 RIGHT ONLY


KAZI-3 RIGHT ONLY


KAZI-4 RIGHT ONLY


KAZI-5 RIGHT ONLY


KAZI-6 RIGHT ONLY


KAZI-7 RIGHT ONLY


KAZI-8 RIGHT ONLY


KAZI-9 RIGHT ONLY


KAZI-10 RIGHT ONLY


KAZI-11 RIGHT ONLY


KAZI-12 RIGHT ONLY

KAZIRANGA TIGER RESERVE

101 Nos.


KAZI-13 RIGHT ONLY


KAZI-14 RIGHT ONLY


KAZI-15 RIGHT


KAZI-15 LEFT


KAZI-16 RIGHT


KAZI-16 LEFT


KAZI-17 RIGHT


KAZI-17 LEFT

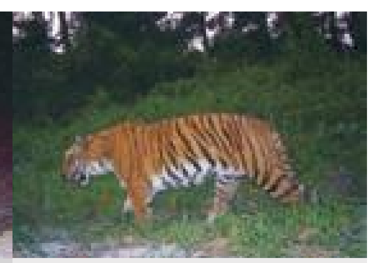

KAZI-18 RIGHT


KAZI-18 LEFT


KAZI-19 RIGHT


KAZI-19 LEFT


KAZI-20 RIGHT


KAZI-20 LEFT


KAZI-21 RIGHT


KAZI-21 LEFT


KAZI-22 RIGHT


KAZI-22 LEFT


KAZI-23 RIGHT


KAZI-23 LEFT


KAZI-24 RIGHT


KAZI-24 LEFT


KAZI-25 RIGHT


KAZI-25 LEFT


KAZI-26 RIGHT


KAZI-26 LEFT


KAZI-27 RIGHT


KAZI-27 LEFT


KAZI-28 RIGHT


KAZI-28 LEFT


KAZI-29 RIGHT


KAZI-29 LEFT


KAZI-30 RIGHT


KAZI-30 LEFT


KAZI-31 RIGHT

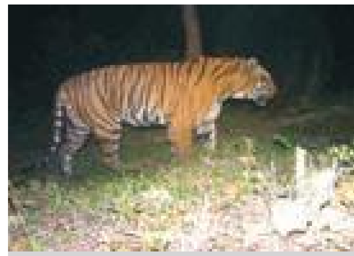

KAZI-31 LEFT


KAZI-32 RIGHT

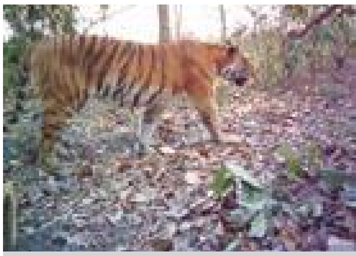

KAZI-32 LEFT


KAZI-33 RIGHT


KAZI-33 LEFT


KAZI-34 RIGHT


KAZI-34 LEFT


KAZI-35 RIGHT


KAZI-35 LEFT


KAZI-36 RIGHT


KAZI-36 LEFT


KAZI-37 RIGHT


KAZI-37 LEFT


KAZI-38 RIGHT


KAZI-38 LEFT


KAZI-39 RIGHT


KAZI-39 LEFT


KAZI-40 RIGHT


KAZI-40 LEFT


KAZI-41 RIGHT


KAZI-41 LEFT


KAZI-42 RIGHT


KAZI-42 LEFT


KAZI-43 RIGHT


KAZI-43 LEFT


KAZI-44 RIGHT


KAZI-44 LEFT

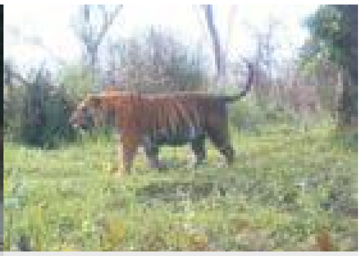

KAZI-45 RIGHT


KAZI-45 LEFT


KAZI-46 RIGHT


KAZI-46 LEFT


KAZI-47 RIGHT


KAZI-47 LEFT


KAZI-48 RIGHT


KAZI-48 LEFT


KAZI-49 RIGHT


KAZI-49 LEFT

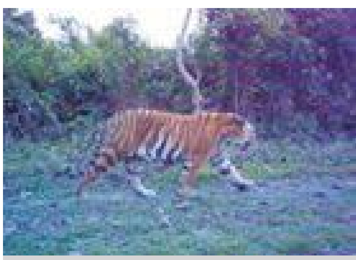

KAZI-50 RIGHT


KAZI-50 LEFT


KAZI-51 LEFT ONLY


KAZI-52 RIGHT

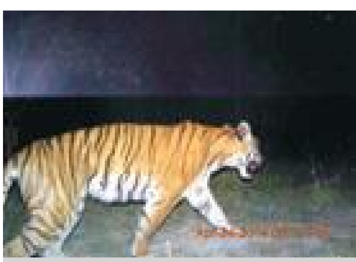

KAZI-52 LEFT


KAZI-53 RIGHT


KAZI-53 LEFT

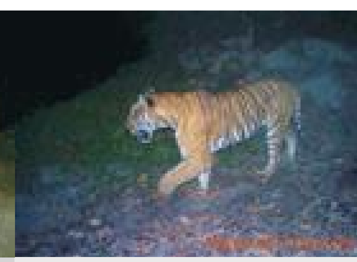

KAZI-54 RIGHT


KAZI-54 LEFT


KAZI-55 RIGHT


KAZI-55 LEFT

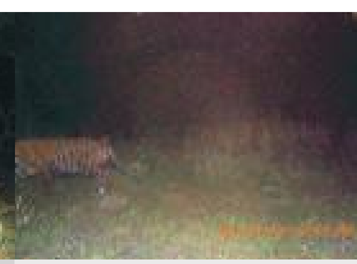

KAZI-56 RIGHT


KAZI-56 LEFT

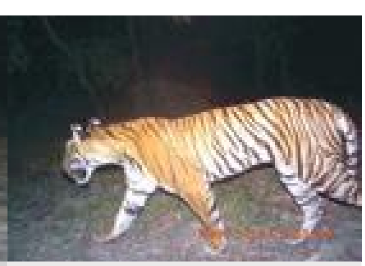

KAZI-57 RIGHT


KAZI-57 LEFT


KAZI-58 RIGHT


KAZI-58 LEFT


KAZI-59 RIGHT


KAZI-59 LEFT


KAZI-60 RIGHT


KAZI-60 LEFT


KAZI-61 RIGHT


KAZI-61 LEFT


KAZI-62 RIGHT


KAZI-62 LEFT


KAZI-63 RIGHT


KAZI-63 LEFT


KAZI-64 RIGHT


KAZI-64 LEFT


KAZI-65 RIGHT


KAZI-65 LEFT


KAZI-66 RIGHT


KAZI-66 LEFT


KAZI-67 RIGHT

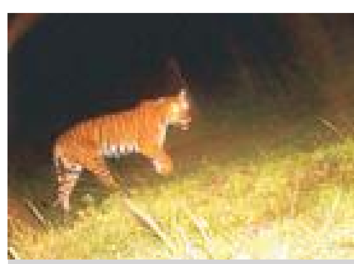

KAZI-67 LEFT

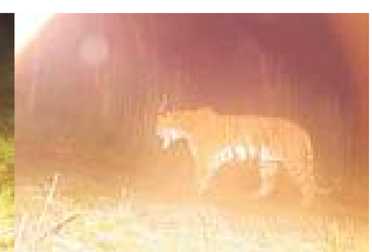

KAZI-68 RIGHT


KAZI-68 LEFT


KAZI-69 RIGHT


KAZI-69 LEFT

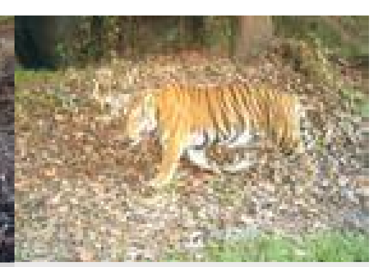

KAZI-70 RIGHT


KAZI-70 LEFT


KAZI-71 RIGHT


KAZI-71 LEFT


KAZI-72 RIGHT


KAZI-72 LEFT


KAZI-73 RIGHT


KAZI-73 LEFT


KAZI-74 RIGHT


KAZI-74 LEFT


KAZI-75 RIGHT


KAZI-75 LEFT


KAZI-76 RIGHT


KAZI-76 LEFT


KAZI-77 RIGHT


KAZI-77 LEFT


KAZI-78 RIGHT


KAZI-78 LEFT


KAZI-79 RIGHT


KAZI-79 LEFT


KAZI-80 RIGHT


KAZI-80 LEFT


KAZI-81 RIGHT


KAZI-81 LEFT


KAZI-82 RIGHT


KAZI-82 LEFT


KAZI-83 RIGHT


KAZI-83 LEFT


KAZI-84 RIGHT


KAZI-84 LEFT


KAZI-85 RIGHT


KAZI-85 LEFT


KAZI-86 RIGHT


KAZI-86 LEFT


KAZI-87 RIGHT


KAZI-87 LEFT


KAZI-88 RIGHT


KAZI-88 LEFT


KAZI-89 RIGHT


KAZI-89 LEFT


KAZI-90 RIGHT


KAZI-90 LEFT


KAZI-91 RIGHT


KAZI-91 LEFT


KAZI-92 RIGHT


KAZI-92 LEFT


KAZI-93 RIGHT


KAZI-93 LEFT


KAZI-94 RIGHT


KAZI-94 LEFT


KAZI-95 RIGHT


KAZI-95 LEFT


KAZI-96 RIGHT


KAZI-96 LEFT

KAZI-97 RIGHT

KAZI-97 LEFT

KAZI-98 RIGHT ONLY

KAZI-99 LEFT ONLY

KAZI-100 LEFT ONLY

KAZI-101 RIGHT ONLY

MANAS TIGER RESERVE 12 Nos.


MANS-1 RIGHT


MANS-1 LEFT


MANS-2 RIGHT


MANS-2 LEFT


MANS-3 RIGHT


MANS-3 LEFT


MANS-4 RIGHT

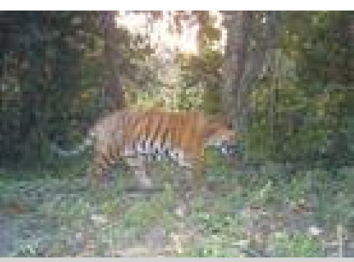

MANS-4 LEFT


MANS-5 RIGHT


MANS-5 LEFT


MANS-6 RIGHT


MANS-6 LEFT


MANS-7 RIGHT

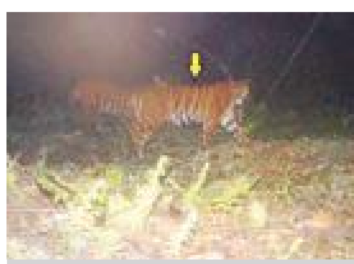

MANS-7 LEFT


MANS-8 RIGHT

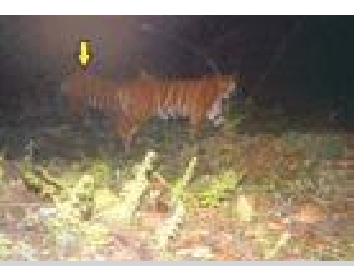

MANS-8 LEFT


MANS-9 RIGHT

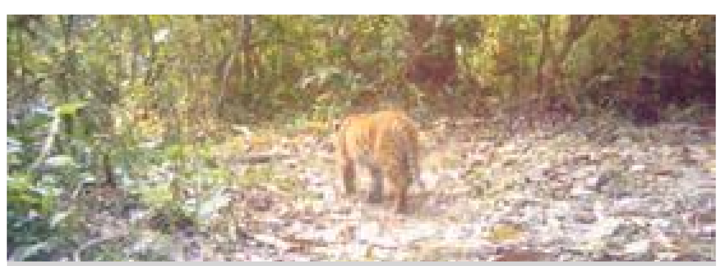

MANS-9 LEFT


MANS-10 RIGHT


MANS-10 LEFT


MANS-11 RIGHT


MANS-11 LEFT


MANS-12 LEFT ONLY

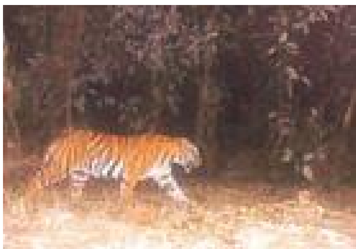
NAMERI TIGER RESERVE 7 Nos.


NAMR_PAKK-1 RIGHT


NAMR_PAKK-1 LEFT


NAMR-2 RIGHT


NAMR-2 LEFT


NAMR_PAKK-3 RIGHT


NAMR_PAKK-3 LEFT


NAMR-4 RIGHT


NAMR-4 LEFT


NAMR-5 RIGHT ONLY


NAMR-7 RIGHT ONLY


NAMR_PAKK-6 RIGHT


NAMR_PAKK-6 LEFT

ORANG TIGER RESERVE 17 Nos.

ORNG-1 RIGHT ONLY

ORNG-2 LEFT ONLY

ORNG-3 RIGHT

ORNG-3 LEFT

ORNG-4 RIGHT

ORNG-4 LEFT

ORNG-5 RIGHT

ORNG-5 LEFT

ORNG-6 RIGHT

ORNG-6 LEFT

ORNG-7 RIGHT

ORNG-7 LEFT

ORNG-8 LEFT ONLY

ORNG-9 RIGHT

ORNG-9 LEFT

ORNG-10 LEFT ONLY

ORNG-11 RIGHT

ORNG-11 LEFT

ORNG-12 RIGHT

ORNG-12 LEFT

ORANG TIGER RESERVE 17 Nos.

ORNG-13 LEFT ONLY

ORNG-14 RIGHT

ORNG-14 LEFT

ORNG-15 RIGHT

ORNG-15 LEFT

ORNG-16 RIGHT ONLY

ORNG-17 RIGHT ONLY

PAKKE TIGER RESERVE

6 Nos.


NAMR_PAKK - 1 RIGHT


NAMR_PAKK - 1 LEFT


PAKK - 2 RIGHT


PAKK - 2 LEFT


NAMR_PAKK - 3 RIGHT


NAMR_PAKK - 3 LEFT


PAKK - 4 RIGHT


PAKK - 4 LEFT


NAMR_PAKK - 6 RIGHT


NAMR_PAKK - 6 LEFT


NAMR_PAKK - 7 RIGHT


NAMR_PAKK - 7 LEFT

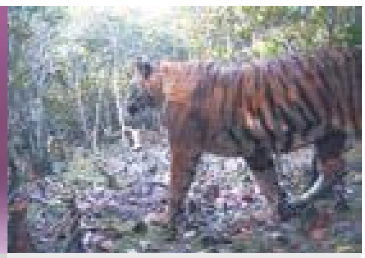

SUND-1 RIGHT


SUND-1 LEFT


SUND-2 RIGHT

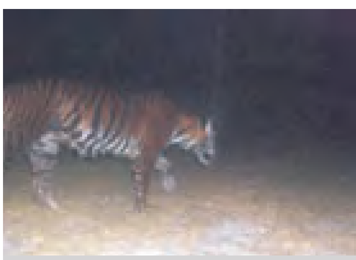

SUND-2 LEFT


SUND-3 RIGHT


SUND-3 LEFT

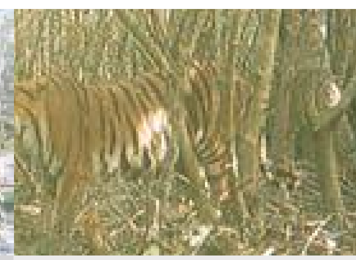

SUND-4 RIGHT


SUND-4 LEFT


SUND-5 RIGHT


SUND-5 LEFT


SUND-6 RIGHT


SUND-6 LEFT


SUND-7 RIGHT

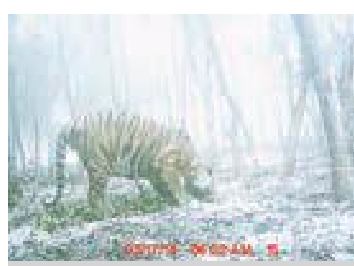

SUND-7 LEFT


SUND-8 LEFT


SUND-8 RIGHT


SUND-9 RIGHT

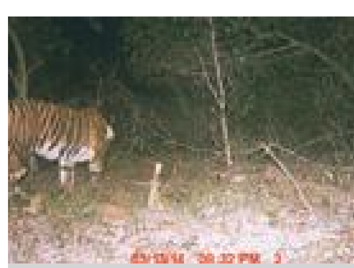

SUND-9 LEFT

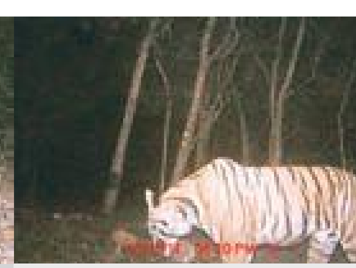

SUND-10 RIGHT


SUND-10 LEFT


SUND-11 RIGHT


SUND-11 LEFT


SUND-12 RIGHT


SUND-12 LEFT

SUNDARBAN TIGER RESERVE 62 Nos.


SUND-13 RIGHT


SUND-13 LEFT


SUND-14 RIGHT


SUND-14 LEFT

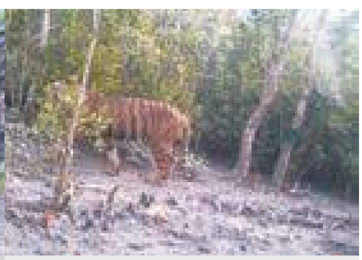

SUND-15 RIGHT


SUND-15 LEFT


SUND-16 RIGHT


SUND-16 LEFT


SUND-17 RIGHT

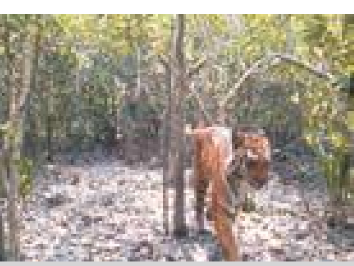

SUND-17 LEFT

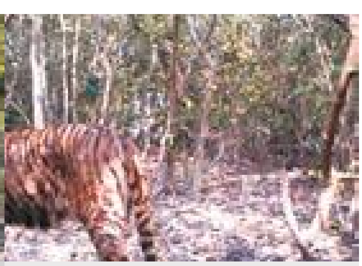

SUND-18 LEFT ONLY

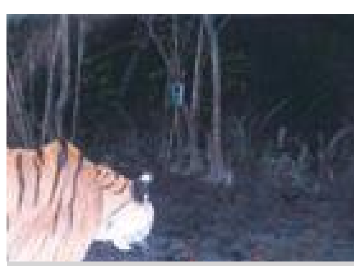

SUND-19 RIGHT


SUND-19 LEFT


SUND-20 LEFT ONLY

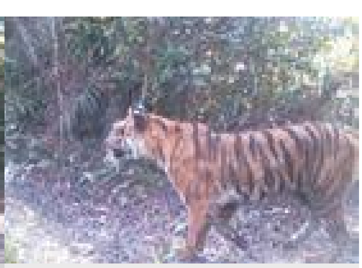

SUND-21 RIGHT


SUND-21 LEFT


SUND-22 RIGHT

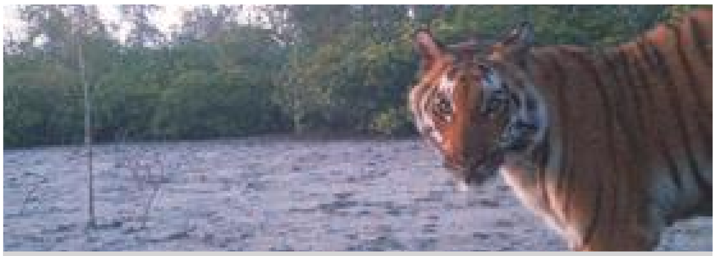

SUND-22 LEFT


SUND-23 RIGHT


SUND-23 LEFT


SUND-24 RIGHT


SUND-24 LEFT


SUND-25 LEFT ONLY

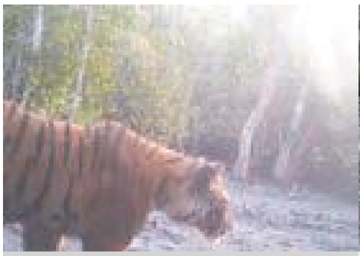

SUND-26 RIGHT


SUND-26 LEFT


SUND-27 RIGHT


SUND-27 LEFT

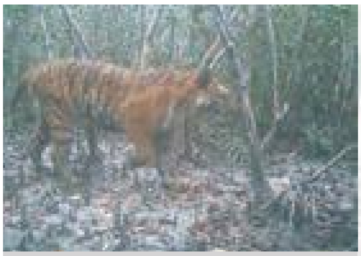

SUND-28 LEFT ONLY


SUND-29 RIGHT


SUND-29 LEFT


SUND-30 RIGHT


SUND-30 LEFT


SUND-31 RIGHT


SUND-31 LEFT


SUND-32 RIGHT


SUND-32 LEFT


SUND-33 RIGHT


SUND-33LEFT


SUND-34 RIGHT


SUND-34 LEFT


SUND-35 RIGHT


SUND-35 LEFT


SUND-36 RIGHT


SUND-36 LEFT


SUND-37 RIGHT

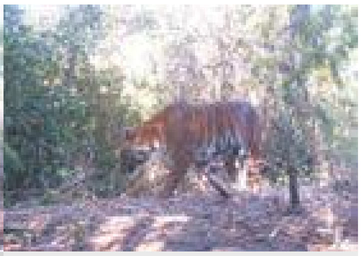
SUND-37 LEFT

SUND-38 RIGHT

SUND-38 LEFT


SUND-39 RIGHT

SUND-39 LEFT

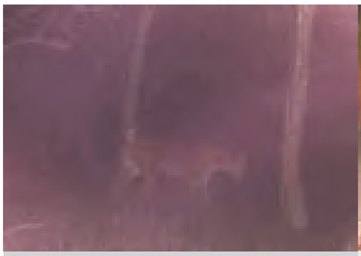
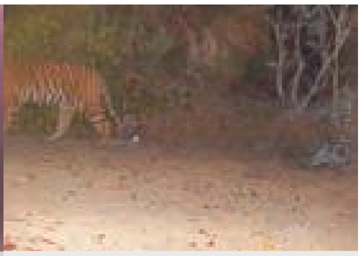
SUND-40 RIGHT

SUND-40 LEFT


SUND-41 LEFT ONLY

SUND-42 RIGHT

SUND-42 LEFT


SUND-43 RIGHT

SUND-43 LEFT

SUND-44 RIGHT

SUND-44 LEFT


SUND-45 RIGHT

SUND-45 LEFT

SUND-46 RIGHT

SUND-46 LEFT


SUND-47 RIGHT

SUND-47 LEFT

SUND-48 RIGHT

SUND-48 LEFT


SUND-49 LEFT ONLY


SUND-50 RIGHT


SUND-50 LEFT


SUND-51 RIGHT

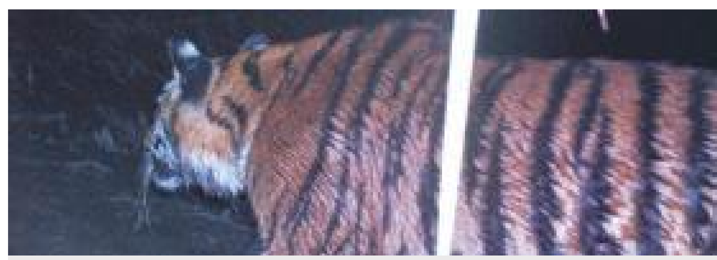

SUND-51 LEFT


SUND-52 RIGHT


SUND-52 LEFT

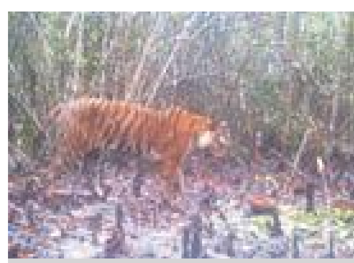

SUND-53 RIGHT


SUND-53 LEFT

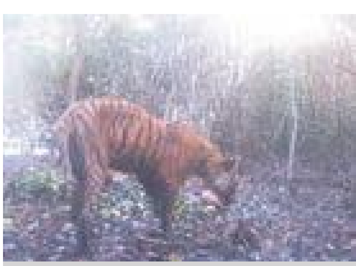

SUND-54 LEFT ONLY


SUND-55 RIGHT

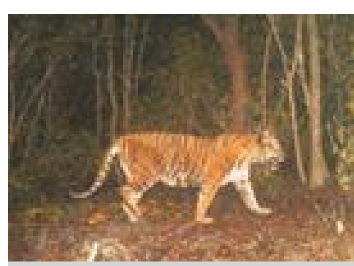

SUND-55 LEFT


SUND-56 RIGHT


SUND-56 LEFT

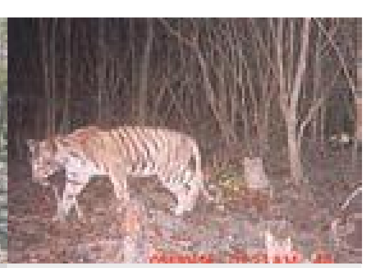

SUND-57 RIGHT


SUND-57 LEFT


SUND-58 RIGHT


SUND-58 LEFT


SUND-59 RIGHT


SUND-59 LEFT


SUND-60 RIGHT


SUND-60 LEFT

SUND-61 RIGHT ONLY

SUND-62 LEFT ONLY


NGHL-1 RIGHT


NGHL-1 LEFT


NGHL-2 RIGHT


NGHL-2 LEFT


NGHL-3 RIGHT


NGHL-3 LEFT


NGHL-4 RIGHT


NGHL-5 LEFT


NGHL-5 RIGHT


NGHL-5 LEFT


NGHL-6 RIGHT


NGHL-6 LEFT


NGHL-7 LEFT ONLY


NGHL-8 RIGHT


NGHL-8 LEFT


NGHL-9 RIGHT


NGHL-9 LEFT

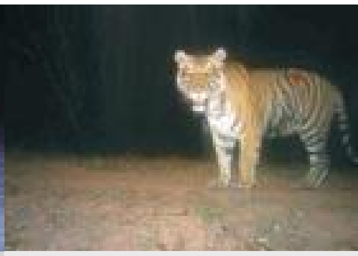

NGHL-10 RIGHT


NGHL-10 LEFT


NGHL-11 RIGHT


NGHL-11 LEFT


NGHL-12 RIGHT


NGHL-12 LEFT

NAGARHOLE TIGER RESERVE 77 Nos.


NGHL-13 RIGHT


NGHL-13 LEFT


NGHL-14 RIGHT ONLY


NGHL- 15 LEFT ONLY


NGHL-16 RIGHT


NGHL-16 LEFT


NGHL-17 RIGHT


NGHL-17 LEFT


NGHL-18 RIGHT


NGHL-18 LEFT


NGHL-19 RIGHT


NGHL-19 LEFT


NGHL-20 RIGHT


NGHL-20 LEFT


NGHL-21 RIGHT


NGHL-21 LEFT


NGHL-22 RIGHT ONLY


NGHL-23 LEFT ONLY


NGHL-24 RIGHT


NGHL-24 LEFT


NGHL-25 RIGHT


NGHL-25 LEFT


NGHL-26 RIGHT


NGHL-26 LEFT


NGHL-27 RIGHT


NGHL-27 LEFT

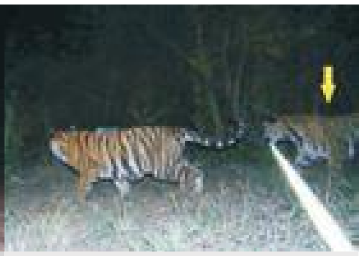

NGHL-28 RIGHT ONLY


NGHL-29 RIGHT ONLY


NGHL-30 RIGHT


NGHL-30 LEFT


NGHL-31 RIGHT


NGHL-31 LEFT


NGHL-32 LEFT ONLY


NGHL-33 RIGHT

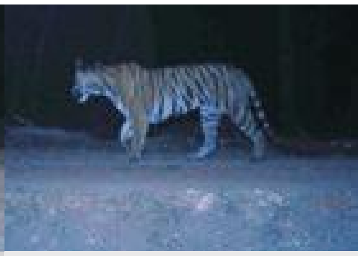

NGHL-33 LEFT


NGHL-34 LEFT ONLY


NGHL-35 RIGHT


NGHL-35 LEFT


NGHL-36 RIGHT


NGHL-36 LEFT

NGHL-37 RIGHT

NGHL-37 LEFT

NGHL-38 RIGHT

NGHL-38 LEFT

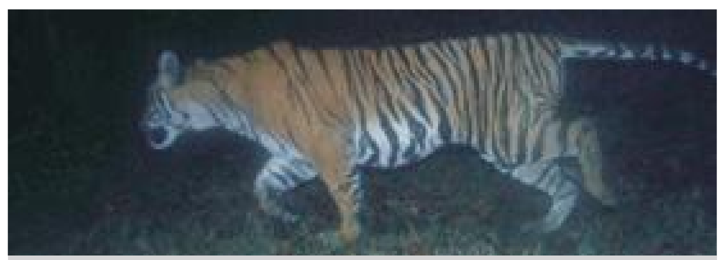
NGHL-39 RIGHT

NGHL-39 LEFT

NGHL-40 LEFT ONLY

NGHL-41 RIGHT

NGHL-41 LEFT



NGHL-42 LEFT ONLY

NGHL-43 RIGHT ONLY

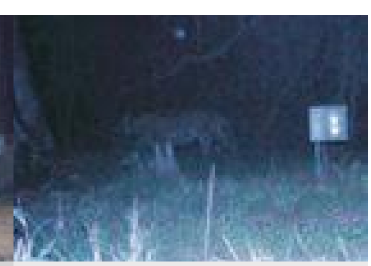
NGHL-44 RIGHT

NGHL-44 LEFT

NGHL-45 RIGHT

NGHL-45 LEFT

NGHL-46 RIGHT



NGHL-46 LEFT

NGHL-47 RIGHT

NGHL-47 LEFT

NGHL-48 RIGHT

NGHL-48 LEFT


NGHL-49 RIGHT


NGHL-49 LEFT


NGHL-50 RIGHT


NGHL-50 LEFT


NGHL-51 RIGHT


NGHL-51 LEFT


NGHL-52 RIGHT


NGHL-52 LEFT


NGHL-53 RIGHT


NGHL-53 LEFT


NGHL-54 RIGHT


NGHL-54 LEFT


NGHL-55 RIGHT


NGHL-55 LEFT


NGHL-56 RIGHT


NGHL-56 LEFT


NGHL-57 RIGHT


NGHL-57 LEFT


NGHL-58 RIGHT


NGHL-58 LEFT


NGHL-59 RIGHT


NGHL-59 LEFT


NGHL-60 RIGHT


NGHL-60 LEFT


NGHL-61 RIGHT


NGHL-61 LEFT


NGHL-62 RIGHT ONLY


NGHL-63 RIGHT


NGHL-63 LEFT


NGHL-64 RIGHT


NGHL-64 LEFT


NGHL-65 RIGHT


NGHL-65 LEFT


NGHL-66 RIGHT


NGHL-66 LEFT


NGHL-67 RIGHT


NGHL-67 LEFT


NGHL-68 RIGHT


NGHL-68 LEFT

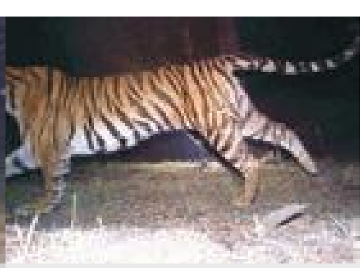

NGHL-69 RIGHT


NGHL-69 LEFT


NGHL-70 RIGHT


NGHL-70 LEFT


NGHL-71 RIGHT


NGHL-71 LEFT


NGHL-72 LEFT ONLY

NGHL-73 RIGHT

NGHL-73 LEFT

NGHL-74 RIGHT

NGHL-74 LEFT

NGHL-75 LEFT ONLY

NGHL-76 LEFT ONLY

NGHL-77 RIGHT

NGHL-77 LEFT

MUDUMALAI TIGER RESERVE

66 Nos.


MUD-1 RIGHT


MUD-1 LEFT


MUD-2 RIGHT


MUD-2 LEFT


MUD-3 RIGHT


MUD-3 LEFT


MUD-4 RIGHT


MUD-4 LEFT


MUD-5 RIGHT


MUD-5 LEFT


MUD-6 LEFT ONLY


MUD-7 RIGHT


MUD-7 LEFT


MUD-8 RIGHT

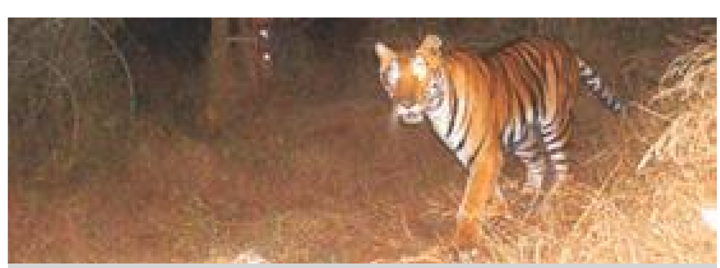

MUD-8 LEFT


MUD-9 RIGHT


MUD-9 LEFT


MUD-10 LEFT ONLY


MUD-11 RIGHT ONLY


MUD-12 LEFT ONLY


MUD-13 RIGHT


MUD-13 LEFT


MUD-14 LEFT ONLY


MUD-15 RIGHT

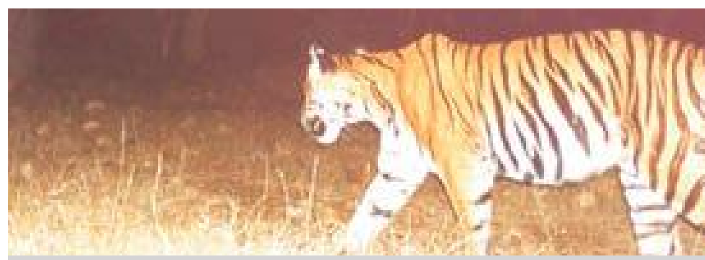

MUD-15 LEFT


MUD-16 RIGHT


MUD-16 LEFT


MUD-17 RIGHT


MUD-17 LEFT


MUD-18 LEFT ONLY


MUD-19 RIGHT


MUD-19 LEFT


MUD-20 RIGHT

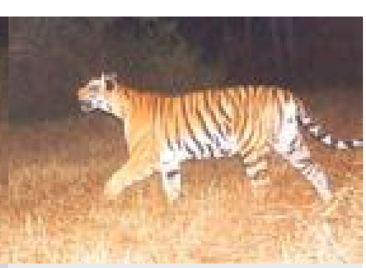

MUD-20 LEFT


MUD-21 RIGHT


MUD-21 LEFT


MUD-22 LEFT ONLY


MUD-23 RIGHT


MUD-23 LEFT


MUD-24 RIGHT


MUD-24 LEFT


MUD-25 RIGHT


MUD-25 LEFT


MUD-26 RIGHT


MUD-26 LEFT


MUD-27 RIGHT


MUD-27 LEFT


MUD-28 RIGHT


MUD-28 LEFT


MUD-29 RIGHT


MUD-29 LEFT


MUD-30 RIGHT

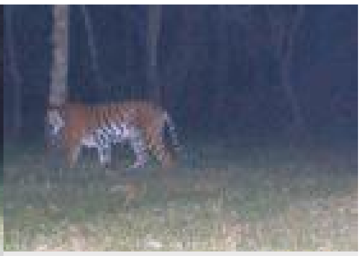

MUD-30 LEFT


MUD-31 RIGHT


MUD-31 LEFT


MUD-32 LEFT ONLY


MUD-33 RIGHT


MUD-33 LEFT


MUD-34 RIGHT


MUD-34 LEFT


MUD-35 LEFT ONLY

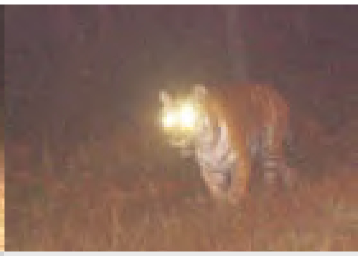

MUD-36 RIGHT


MUD-36 LEFT

MUD-37RIGHT

MUD-37 LEFT

MUD-38 RIGHT



MUD-38 LEFT

MUD-39 RIGHT

MUD-39 LEFT

MUD-40 RIGHT

MUD-40 LEFT

MUD-BPUR-41 RIGHT

MUD-BPUR-41 LEFT

MUD-42 RIGHT

MUD-42 LEFT

MUD-43 LEFT ONLY

MUD-44 LEFT ONLY

MUD-45 LEFT ONLY

MUD-46 RIGHT

MUD-46 LEFT

MUD-47 RIGHT

MUD-47 LEFT

MUD-48 LEFT ONLY

MUD-49 RIGHT

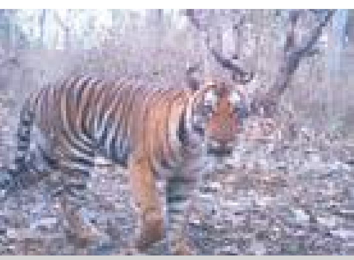
MUD-49 LEFT

MUD-50 LEFT ONLY

MUD-51 RIGHT

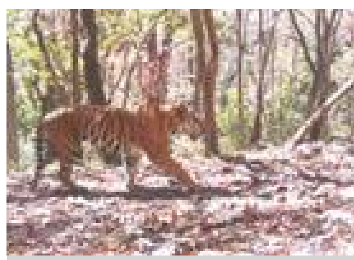
MUD-51 LEFT

MUD-52 LEFT ONLY

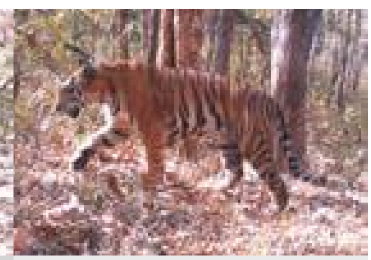


MUD-53 RIGHT

MUD-53 LEFT



MUD-54 RIGHT

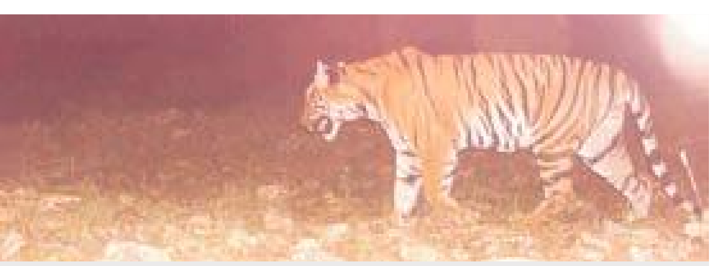


MUD-54 LEFT

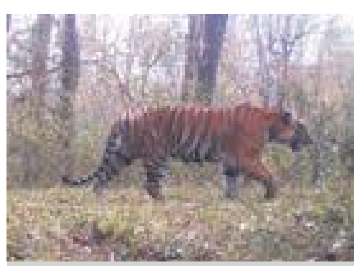
MUD-55 RIGHT

MUD-55 LEFT

MUD-56 LEFT ONLY

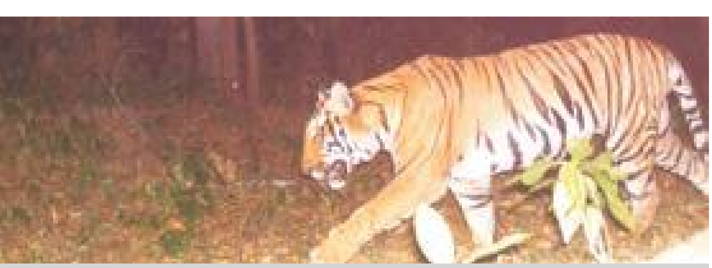


MUD-57 RIGHT ONLY

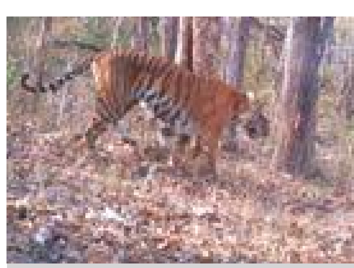


MUD-58 RIGHT

MUD-58 LEFT



MUD-59 LEFT ONLY



MUD-60 RIGHT

MUD-60 LEFT


MUD-61 RIGHT ONLY


MUD-62 RIGHT

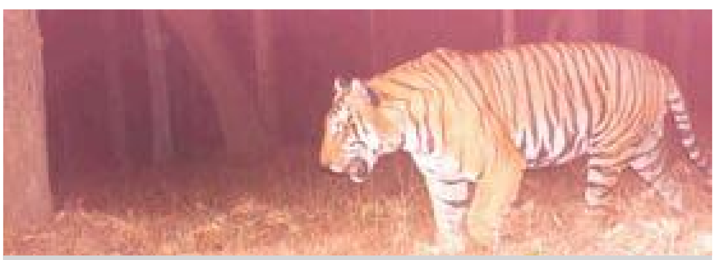

MUD-62 LEFT


MUD-WAYA-1 RIGHT


MUD-WAYA-1 LEFT


MUD-WAYA-2 RIGHT


MUD-WAYA-2 LEFT


MUD-WAYA-BPUR-1 LEFT ONLY


MUD-WAYA-BPUR-2 RIGHT


MUD-WAYA-BPUR-2 RIGHT

BANDIPUR TIGER RESERVE 96 Nos.


BPUR-1 RIGHT


BPUR-1 LEFT


BPUR-2 LEFT ONLY


BPUR-3 RIGHT


BPUR-3 LEFT


BPUR-4 RIGHT


BPUR-4 LEFT


BPUR-5 RIGHT ONLY


BPUR-6 LEFT ONLY


BPUR-WAYA-7 RIGHT


BPUR-WAYA-7 LEFT


BPUR-8 RIGHT ONLY


BPUR-9 RIGHT ONLY


BPUR-10 RIGHT


BPUR-10 LEFT


BPUR-11 LEFT ONLY


BPUR-12 RIGHT ONLY


BPUR-13 RIGHT ONLY


BPUR-14 RIGHT


BPUR-14 LEFT


BPUR-15 RIGHT


BPUR-15 LEFT


BPUR-16 RIGHT


BPUR-16 LEFT


BPUR-17 RIGHT ONLY


BPUR-18 RIGHT ONLY


BPUR-19 RIGHT ONLY


BPUR-20 RIGHT ONLY


BPUR-21 RIGHT ONLY


MUD-WAYA-BPUR-2 RIGHT ONLY


BPUR-23 RIGHT


BPUR-23 LEFT


BPUR-24 RIGHT ONLY


BPUR-25 RIGHT ONLY


BPUR-26 LEFT ONLY


BPUR-27 RIGHT


BPUR-27 LEFT


BPUR-28 RIGHT


BPUR-28 LEFT


BPUR-29 LEFT ONLY


BPUR-30 LEFT ONLY


BPUR-31 RIGHT


BPUR-31 LEFT


BPUR-32 RIGHT


BPUR-32 LEFT


BPUR-33 RIGHT


BPUR-33 LEFT


BPUR-34RIGHT


BPUR-34 LEFT


BPUR-35 RIGHT ONLY


BPUR-36 LEFT ONLY

BPUR-37 RIGHT

BPUR-37 LEFT

MUD_WAYA_BPUR-2 RIGHT ONLY

BPUR-39 LEFT ONLY

BPUR-40 RIGHT

BPUR-40 LEFT

BPUR-41 RIGHT ONLY

BPUR_WAYA-2 RIGHT

BPUR_WAYA-2 LEFT

BPUR-43 RIGHT

BPUR-43 LEFT

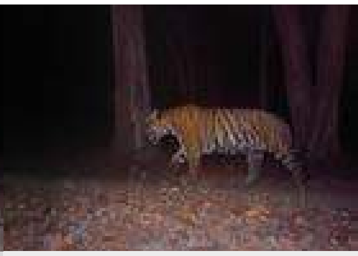
BPUR-44 LEFT ONLY

BPUR-45 LEFT ONLY

BPUR-46 RIGHT ONLY

BPUR-47 LEFT ONLY

BPUR-48 RIGHT



BPUR-48 LEFT


BPUR-49 RIGHT ONLY


BPUR-50 LEFT ONLY


BPUR-51 RIGHT


BPUR-51 LEFT

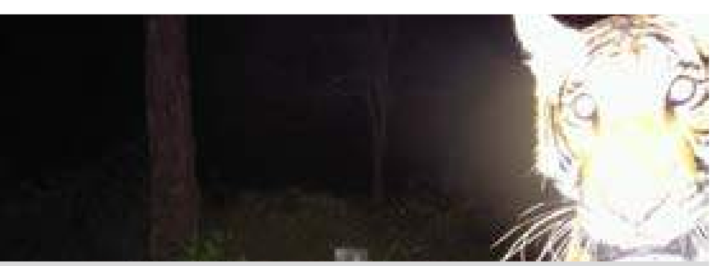

BPUR-52 LEFT ONLY


BPUR-53 LEFT ONLY


BPUR-54 LEFT ONLY


BPUR-55 RIGHT ONLY


BPUR-56 RIGHT ONLY


BPUR-57 LEFT ONLY


BPUR-58 LEFT ONLY


BPUR-59 RIGHT ONLY

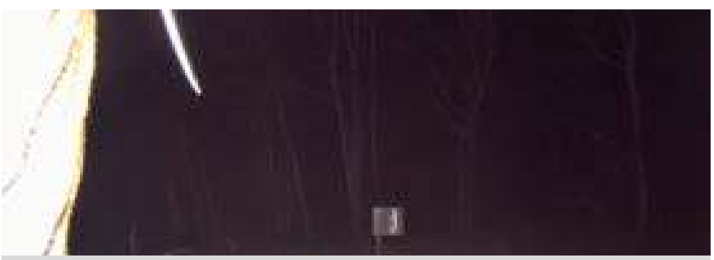

BPUR-60 LEFT ONLY


BPUR-61 LEFT ONLY


BPUR-62 LEFT ONLY


BPUR-63 LEFT ONLY


BPUR-64 RIGHT ONLY


BPUR-65 LEFT ONLY


BPUR-66 RIGHT ONLY


BPUR-67 RIGHT


BPUR-67 LEFT


BPUR-68 RIGHT


BPUR-68 LEFT


BPUR-69 RIGHT ONLY


BPUR-70 RIGHT ONLY


BPUR-71 LEFT ONLY


BPUR-72 RIGHT ONLY

BPUR-73 RIGHT ONLY

BPUR-74 RIGHT ONLY

BPUR-75 RIGHT

BPUR-75 LEFT

BPUR-76 LEFT ONLY

BPUR-77 LEFT ONLY

BPUR-78 RIGHT ONLY

BPUR-79 RIGHT ONLY

BPUR-80 RIGHT ONLY

BPUR-81 LEFT ONLY

BPUR-82 RIGHT ONLY

BPUR-83 RIGHT

BPUR-83 LEFT

BPUR-84 LEFT ONLY

BPUR-85 RIGHT ONLY

BPUR-86 RIGHT

BPUR-87 RIGHT ONLY


BPUR-88 LEFT ONLY


BPUR-89 LEFT ONLY


BPUR-90 RIGHT


BPUR-90 LEFT


BPUR-91 RIGHT ONLY


BPUR-92 RIGHT ONLY


BPUR-93 RIGHT ONLY


BPUR-94 RIGHT ONLY


BPUR-95 RIGHT


BPUR-95 LEFT


BPUR-96 RIGHT


BPUR-96 LEFT

SATHYAMANGLAM TIGER RESERVE

62 Nos.


SMTR-2 RIGHT


SMTR-2 LEFT


SMTR-3 RIGHT


SMTR-3 LEFT


SMTR-4 RIGHT


SMTR-4 LEFT


SMTR-5 RIGHT ONLY


SMTR-6 RIGHT


SMTR-6 LEFT


SMTR-7 RIGHT


SMTR-7 LEFT


SMTR-8 RIGHT ONLY


SMTR-NND-9 RIGHT


SMTR-NND-9 LEFT


SMTR-10 RIGHT


SMTR-10 LEFT


SMTR-11 RIGHT


SMTR-11 LEFT

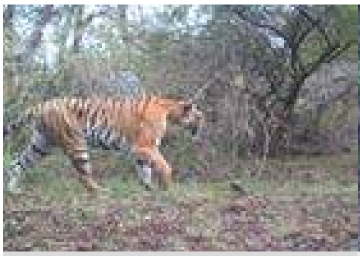

SMTR-12 RIGHT


SMTR-12 LEFT


SMTR-13 RIGHT


SMTR-13 LEFT

SMTR-14 RIGHT ONLY



SMTR-15 RIGHT

SMTR-15 LEFT

SMTR-16 RIGHT

SMTR-16 LEFT

SMTR-17 RIGHT ONLY

SMTR-18 RIGHT ONLY

SMTR-19 RIGHT

SMTR-19 LEFT

SMTR-20 RIGHT ONLY

SMTR-21 RIGHT ONLY

SMTR-22 RIGHT

SMTR-22 LEFT

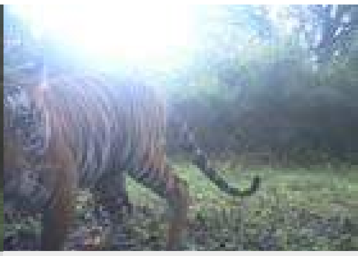
SMTR-23 RIGHT

SMTR-23 LEFT

SMTR-24 RIGHT

SMTR-24 LEFT

SMTR-25 RIGHT



SMTR-25 LEFT


SMTR-26 RIGHT


SMTR-26 LEFT


SMTR-NND-27 RIGHT


SMTR-NND-27 LEFT


SMTR-28 LEFT ONLY


SMTR-29 RIGHT ONLLY

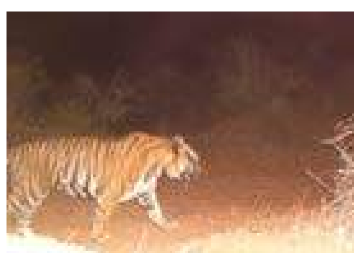

SMTR-30 RIGHT


SMTR-30 LEFT


SMTR-31 RIGHT ONLY


SMTR-32 RIGHT

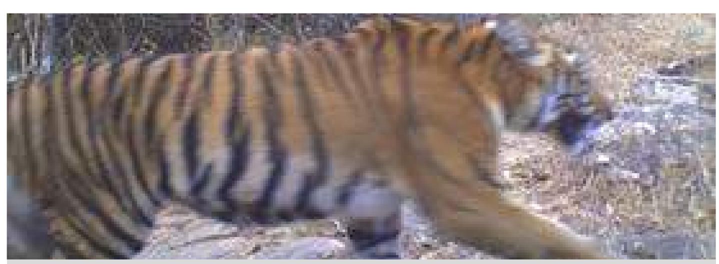

SMTR-32 LEFT


SMTR-33 RIGHT


SMTR-33 LEFT

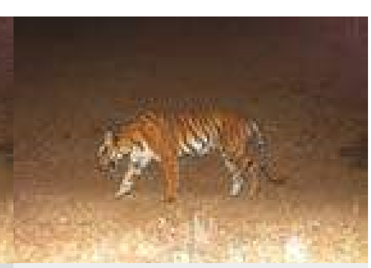

SMTR-34 RIGHT


SMTR-34 LEFT


SMTR-35 RIGHT ONLY


SMTR-37 RIGHT ONLY


SMTR-38 RIGHT


SMTR-38 LEFT


SMTR-39 RIGHT


SMTR-39 LEFT


SMTR-40 RIGHT


SMTR-40 LEFT


SMTR-41 RIGHT


SMTR-41 LEFT


SMTR-42 RIGHT


SMTR-42 LEFT


SMTR-43 RIGHT ONLY


SMTR-44 RIGHT


SMTR-44 LEFT


SMTR-45 RIGHT


SMTR-45 LEFT


SMTR-47 RIGHT


SMTR-47 LEFT


SMTR-48 RIGHT


SMTR-48 LEFT


SMTR-49 RIGHT


SMTR-49 LEFT


SMTR-50 RIGHT


SMTR-50 LEFT


SMTR-51 RIGHT


SMTR-51 LEFT


SMTR-52 RIGHT


SMTR-52 LEFT


SMTR-53 RIGHT


SMTR-53 LEFT


SMTR-54 LEFT ONLY


SMTR-55 RIGHT


SMTR-55 LEFT


SMTR-56 RIGHT


SMTR-56 LEFT

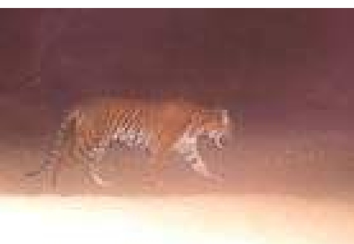

SMTR-57 RIGHT


SMTR-57 LEFT


SMTR-58 RIGHT ONLY


SMTR-59 RIGHT


SMTR-59 LEFT


SMTR-60 RIGHT


SMTR-60 LEFT


SMTR-61 RIGHT


SMTR-61 LEFT


SMTR-62 RIGHT ONLY


SMTR-63 LEFT ONLY

SMTR-64 RIGHT

SMTR-64 LEFT

SMTR-65 LEFT ONLY

NILGIRI NORTH DIVISION 47 Nos.


NND-1 RIGHT


NND-1 LEFT


NND-2 RIGHT


NND-2 LEFT

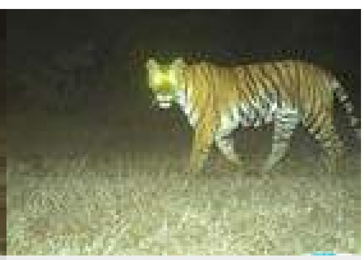

NND-3 RIGHT


NND-3 LEFT


NND-4 RIGHT


NND-4 LEFT


NND-5 RIGHT


NND-5 LEFT


NND-6 RIGHT


NND-6 LEFT


NND-7 RIGHT


NND-7 LEFT


NND-8 RIGHT


NND-8 LEFT


NND-9 RIGHT


NND-9 LEFT


NND-10 RIGHT


NND-10 LEFT


NND-11 RIGHT


NND-11 LEFT


NND-12 RIGHT


NND-12 LEFT


NND-13 RIGHT


NND-13 LEFT


NND-14 RIGHT


NND-14 LEFT


NND-15 RIGHT


NND-15 LEFT


NND-16 RIGHT


NND-16 LEFT


NND-17 RIGHT


NND-17 LEFT


NND-18 RIGHT


NND-18 LEFT

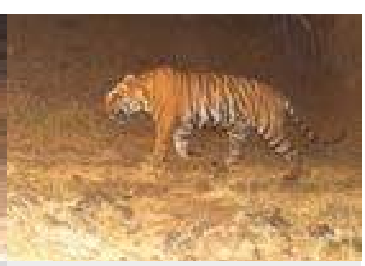

NND-19 RIGHT


NND-19 LEFT

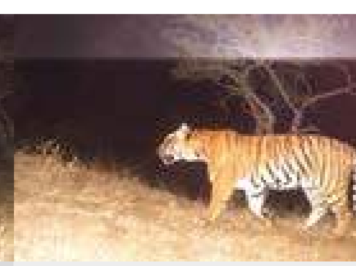

SMTR-NND-27 RIGHT


SMTR-NND-27 LEFT


NND-21 RIGHT


NND-21 LEFT


NND-22 RIGHT


NND-22 LEFT


NND-23 RIGHT


NND-23 LEFT


NND-24 RIGHT


NND-24 LEFT


NND-25 RIGHT

NND-25 LEFT

NND-26 RIGHT

NND-26 LEFT

NND-27 RIGHT

NND-27 LEFT

NND-28 RIGHT

NND-28 LEFT

NND-29 RIGHT

NND-29 LEFT

NND-30 RIGHT

NND-30 LEFT

NND-31 RIGHT

NND-31 LEFT

NND-32 RIGHT

NND-32 LEFT

NND-33 RIGHT

NND-33 LEFT

NND-34 RIGHT

NND-34 LEFT

NND-35 RIGHT

NND-35 LEFT

NND-36 RIGHT

NND-36 LEFT


NND-37 RIGHT


NND-37 LEFT


NND-38 RIGHT


NND-38 LEFT

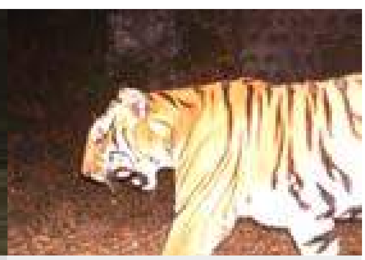

NND-39 RIGHT


NND-39 LEFT


NND-40 RIGHT


NND-40 LEFT


NND-41 RIGHT


NND-41 LEFT


NND-42 RIGHT


NND-42 LEFT

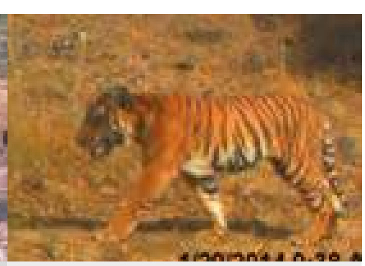

NND-43 RIGHT


NND-43 LEFT


NND-44 RIGHT

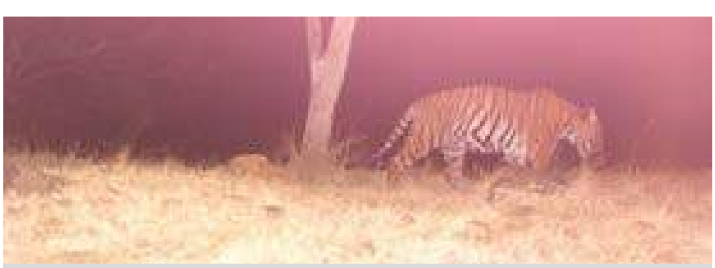

NND-44 LEFT


NND-45 RIGHT


NND-45 LEFT

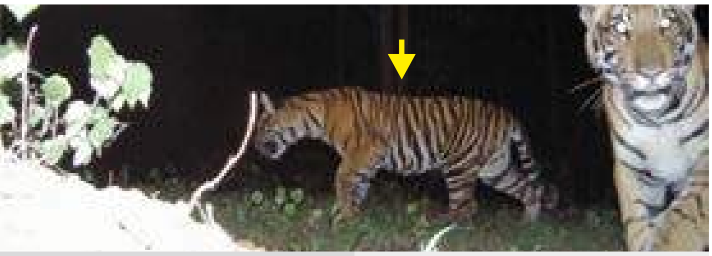

NND-46 RIGHT


NND-46 LEFT


SMTR-NND-9 RIGHT ONLY

WAYANAD WILDLIFE SANCTUARY

49 Nos.

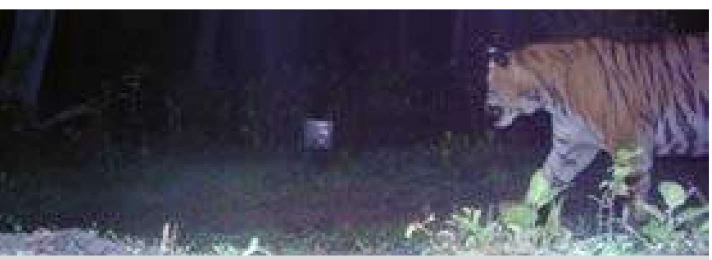


WAYA-1 LEFT ONLY

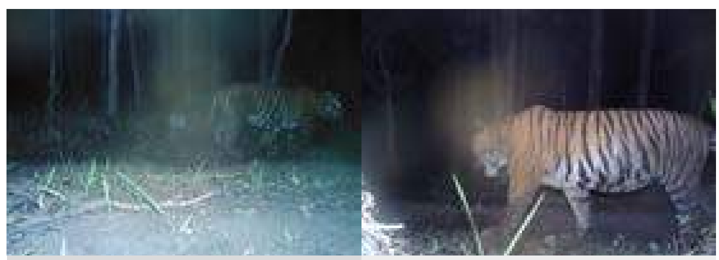
BPUR-WAYA-7 RIGHT | BPUR-WAYA-7 LEFT

WAYA-3 RIGHT | WAYA-3 LEFT

WAYA-4 RIGHT | WAYA-4 LEFT

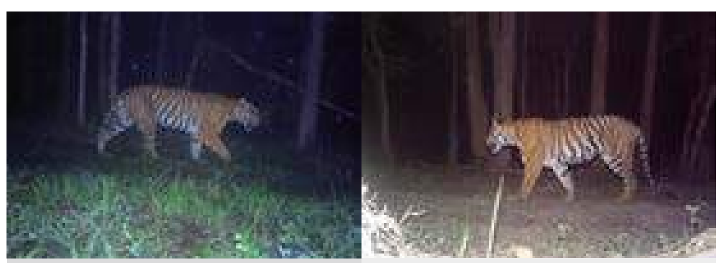


WAYA-5 LEFT ONLY

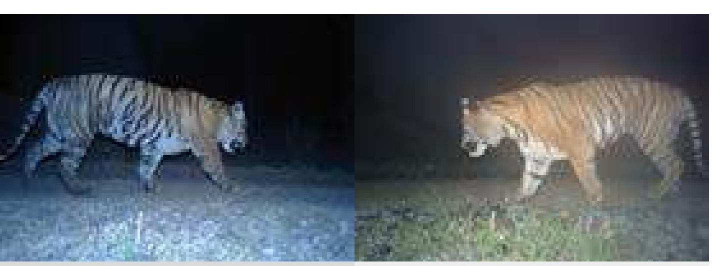


MUD_WAYA_BPUR-1 RIGHT | MUD_WAYA_BPUR-1 LEFT

WAYA-7 RIGHT ONLY



MUD_WAYA_BPUR-2 RIGHT | MUD_WAYA_BPUR-2 LEFT



WAYA-9 RIGHT | WAYA-9 LEFT

WAYA_BPUR-2 RIGHT | WAYA_BPUR-2 LEFT

WAYA-11 RIGHT | WAYA-11 LEFT

WAYA-12 RIGHT | WAYA-12 LEFT


WAYA-13 RIGHT


WAYA-13 LEFT


WAYA-14 LEFT ONLY


WAYA-15 RIGHT


WAYA-15 LEFT


WAYA-16 RIGHT


WAYA-16 LEFT


MUD_WAYA- 1 RIGHT


MUD_WAYA-1 LEFT


WAYA-18 RIGHT


WAYA-18 LEFT


WAYA-19 RIGHT ONLY


WAYA-20 RIGHT


WAYA-20 LEFT


MUD_WAYA-2 RIGHT


MUD_WAYA-2 LEFT


WAYA-22 RIGHT


WAYA-22 LEFT


WAYA-23 RIGHT

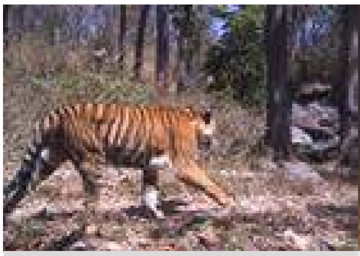

WAYA-23 LEFT


WAYA-24 RIGHT


WAYA-24 LEFT


WAYA-25 RIGHT


WAYA-25 LEFT


WAYA-26 RIGHT


WAYA-26 LEFT


WAYA-27 RIGHT ONLY


WAYA-28 RIGHT ONLY


WAYA-29 RIGHT ONLY


WAYA-30 RIGHT


WAYA-30 LEFT


WAYA-31 RIGHT ONLY


WAYA-32 RIGHT ONLY


WAYA-33 LEFT ONLY


WAYA-34 LEFT ONLY


WAYA-35 RIGHT


WAYA-35 LEFT


WAYA-36 LEFT ONLY


WAYA-37 RIGHT


WAYA-37 LEFT


WAYA-38 LEFT ONLY


WAYA-39 LEFT ONLY


WAYA-40 RIGHT ONLY


WAYA-41 RIGHT


WAYA-41 LEFT


WAYA-42 RIGHT ONLY


WAYA-43 RIGHT


WAYA-43 LEFT


WAYA-44 RIGHT


WAYA-44 LEFT

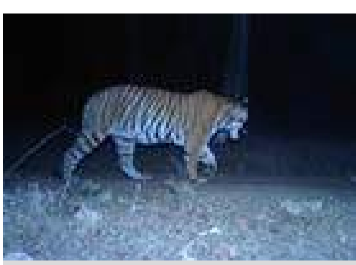

WAYA-45 LEFT ONLY


WAYA-46 RIGHT


WAYA-46 LEFT


WAYA-47 RIGHT


WAYA-47 LEFT


WAYA-48 RIGHT


WAYA-48 LEFT


WAYA-49 LEFT ONLY

BHADRA TIGER RESERVE 20 Nos.


BDRA-1 RIGHT BDRA-1 LEFT


BDRA-2 RIGHT BDRA-2 LEFT


BDRA-3 RIGHT BDRA-3 LEFT


BDRA-4 RIGHT BDRA-4 LEFT

BDRA-5 RIGHT ONLY

BDRA-6 RIGHT ONLY

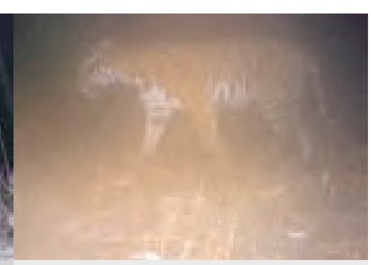

BDRA-7 RIGHT BDRA-7 LEFT

BDRA-8 RIGHT ONLY


BDRA-9 RIGHT BDRA-9 LEFT

BDRA-10 LEFT ONLY


BDRA-11 RIGHT BDRA-11 LEFT

BDRA-12 RIGHT BDRA-12 LEFT

BDRA-13 RIGHT ONLY

BDRA-14 LEFT ONLY

BDRA-15 RIGHT ONLY

BDRA-16 RIGHT

BDRA-16 LEFT

BDRA-17 RIGHT ONLY

BDRA-18 RIGHT ONLY

BDRA-19 RIGHT ONLY

BDRA-20 LEFT ONLY

BILIGIRI RANGASWAMY TEMPLE WILDLIFE SANCTUARY 62 Nos.


BRT-1 RIGHT


BRT-1 LEFT


BRT-2 RIGHT ONLY


BRT-3 RIGHT


BRT-3 LEFT


BRT-4 RIGHT


BRT-4 LEFT


BRT-5 LEFT ONLY


BRT-6 RIGHT


BRT-6 LEFT


BRT-7 RIGHT

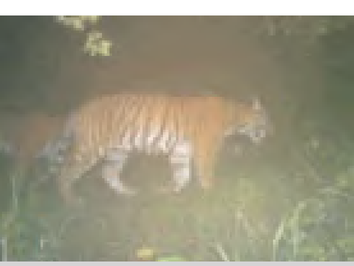

BRT-7 LEFT

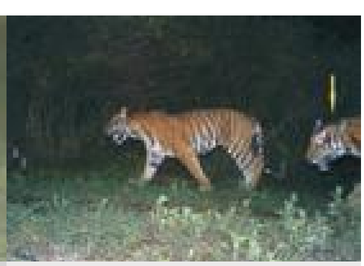

BRT-8 RIGHT


BRT-8 LEFT

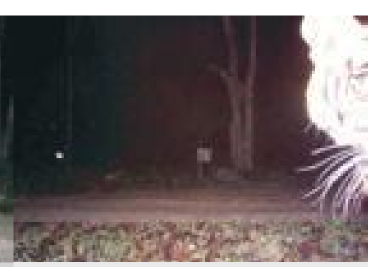

BRT-9 LEFT ONLY


BRT-10 LEFT ONLY


BRT-11 RIGHT


BRT-11 LEFT


BRT-12 RIGHT


BRT-12 LEFT

BRT-13 LEFT ONLY

BRT-14 RIGHT

BRT-14 LEFT

BRT-15 RIGHT

BRT-15 LEFT

BRT-16 RIGHT

BRT-16 LEFT

BRT-17 RIGHT

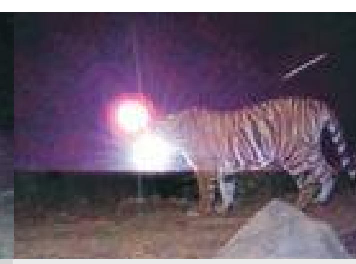
BRT-17 LEFT

BRT-18 LEFLT ONLY

BRT-19 RIGHT

BRT-19 LEFT

BRT-20 RIGHT



BRT-20 LEFT

BRT-21 RIGHT

BRT-21 LEFT

BRT-22 RIGHT ONLY

BRT-23 RIGHT

BRT-23 LEFT

BRT-24 RIGHT

BRT-24 LEFT

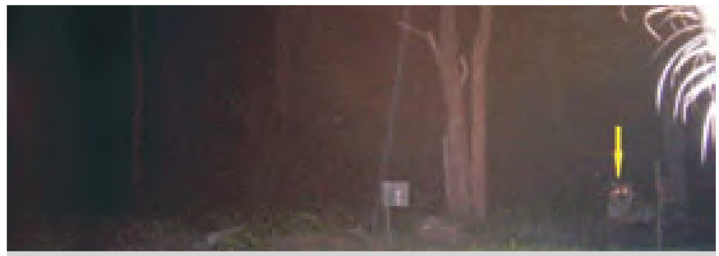

BRT-25 RIGHT


BRT-25 LEFT


BRT-26 LEFT ONLY


BRT-27 RIGHT


BRT-27 LEFT


BRT-28 LEFT ONLY

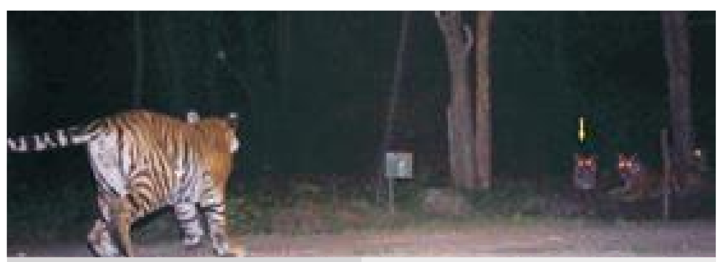

BRT-29 RIGHT


BRT-29 LEFT


BRT-30 RIGHT


BRT-30 LEFT


BRT-31 LEFT ONLY

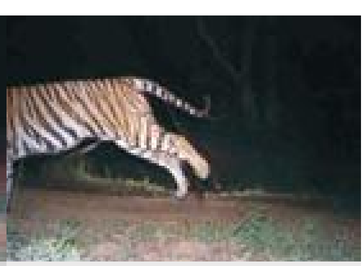

BRT-32 LEFT ONLY


BRT-33 LEFT ONLY


BRT-34 RIGHT

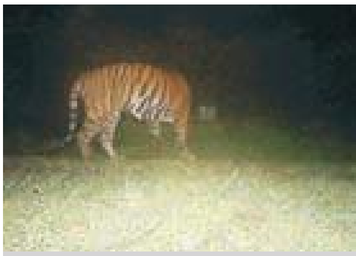

BRT-34 LEFT


BRT-35 RIGHT


BRT-35 LEFT


BRT-36 RIGHT


BRT-36 LEFT


BRT-37 RIGHT


BRT-37 LEFT


BRT-38 RIGHT


BRT-38 LEFT


BRT-39 RIGHT


BRT-39 LEFT


BRT-40 RIGHT


BRT-40 LEFT


BRT-41 RIGHT


BRT-41 LEFT


BRT-42 RIGHT


BRT-42 LEFT


BRT-43 RIGHT


BRT-43 LEFT


BRT-44 RIGHT


BRT-44 LEFT


BRT-45 RIGHT


BRT-45 LEFT


BRT-46 RIGHT


BRT-46 LEFT


BRT-47 RIGHT


BRT-47 LEFT


BRT-48 LEFT ONLY


BRT-49 RIGHT

BRT-49 LEFT

BRT-50 RIGHT

BRT-50 LEFT


BRT-51 RIGHT

BRT-51 LEFT

BRT-52 RIGHT

BRT-52 LEFT


BRT-53 RIGHT

BRT-53 LEFT

BRT-54 RIGHT

BRT-54 LEFT


BRT-55 RIGHT

BRT-55 LEFT

BRT-56 RIGHT

BRT-56 LEFT


BRT-57 LEFT ONLY

BRT-58 RIGHT

BRT-58 LEFT


BRT-59 RIGHT

BRT-59 LEFT

BRT-60 RIGHT

BRT-60 LEFT

BRT-61 RIGHT ONLY

BRT-62 RIGHT

BRT-62 LEFT

ANSHI-DANDELI TIGER RESERVE

3 Nos.

ANSI-1 RIGHT

ANSI-1 LEFT

ANSI-2 RIGHT

ANSI-2 LEFT

ANSI-3 RIGHT

ANSI-3 LEFT

ANAMALAI TIGER RESERVE

8 Nos.

ANMA-1 LEFT ONLY

ANMA-2 RIGHT

ANMA-2 LEFT

ANMA-3 RIGHT

ANMA-3 LEFT

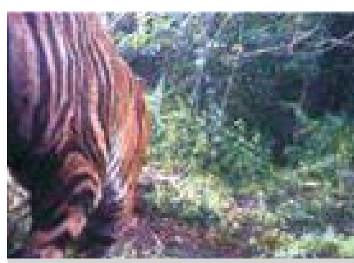
ANMA-4 RIGHT

ANMA-4 LEFT

ANMA-6 RIGHT ONLY

ANMA-7 LEFT ONLY

ANMA-9 LEFT ONLY



ANMA-10 RIGHT

ANMA-10 LEFT

PARAMBIKULAM TIGER RESERVE 14 Nos.

PRMB-1 RIGHT ONLY

PRMB-2 RIGHT

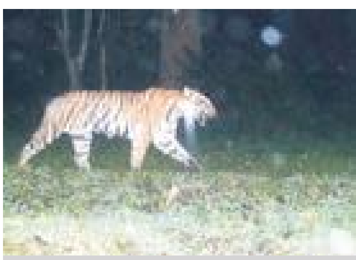
PRMB-2 LEFT

PRMB-3 RIGHT

PRMB-3 LEFT

PRMB-4 RIGHT

PRMB-4 LEFT



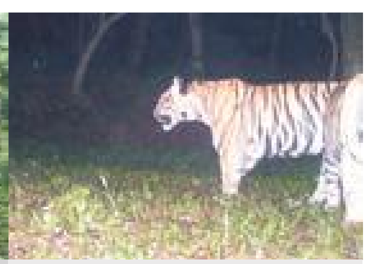
PRMB-5 RIGHT

PRMB-5 LEFT

PRMB-6 RIGHT

PRMB-6 LEFT

PRMB-7 RIGHT



PRMB-7 LEFT

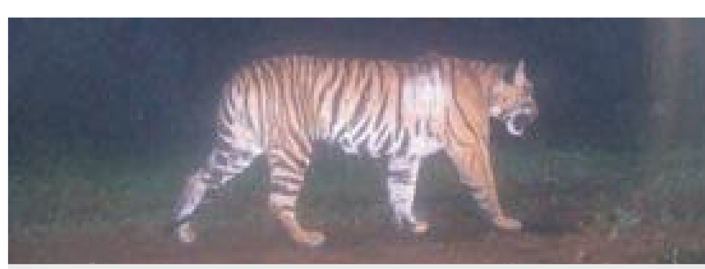
PRMB-8 RIGHT ONLY

PRMB-9 RIGHT ONLY

PRMB-10 LEFT ONLY

PRMB-11 RIGHT

PRMB-11 LEFT



PRMB-12 RIGHT ONLY

PRMB-13 RIGHT ONLY

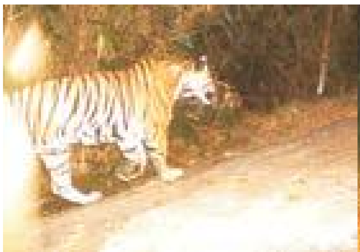
PRMB-14 RIGHT ONLY

KALAKAD-MUNDANTHURAI TIGER RESERVE

6 Nos.

KMTR-1 RIGHT

KMTR-1 LEFT



KMTR-2 RIGHT

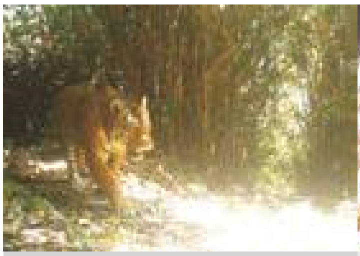
KMTR-2 LEFT

KMTR-3 RIGHT

KMTR-3 LEFT

KMTR-4 RIGHT ONLY

KMTR-5 RIGHT ONLY



KMTR-6 RIGHT

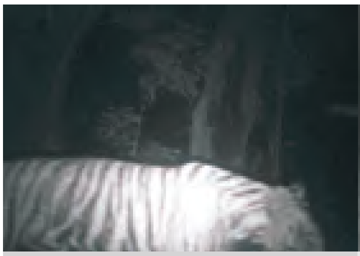
KMTR-6 LEFT

STATUS OF TIGERS CO PREDATORS AND PREY IN INDIA, 2014

PERIYAR TIGER RESERVE 22 Nos.


PRYR-1 RIGHT

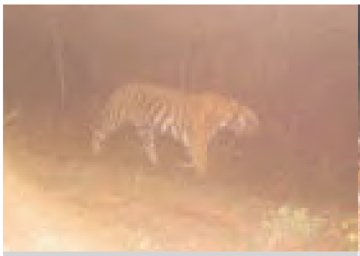

PRYR-1 LEFT


PRYR-2 RIGHT


PRYR-2 LEFT


PRYR-3 RIGHT


PRYR-3 LEFT


PRYR-4 RIGHT


PRYR-4 LEFT


PRYR-5 RIGHT


PRYR-5 LEFT


PRYR-6 RIGHT ONLY

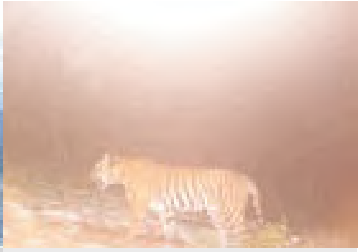

PRYR-7 RIGHT


PRYR-7 LEFT


PRYR-8 RIGHT


PRYR-8 LEFT


PRYR-9 RIGHT


PRYR-9 LEFT


PRYR-10 RIGHT


PRYR-10 LEFT


PRYR-11 RIGHT


PRYR-11 LEFT


PRYR-12 RIGHT


PRYR-12 LEFT


PRYR-13 RIGHT


PRYR-13 LEFT


PRYR-14 RIGHT ONLY


PRYR-15 LEFT ONLY


PRYR-16 LEFT ONLY


PRYR-17 RIGHT


PRYR-17 LEFT


PRYR-18 LEFT ONLY


PRYR-19 RIGHT


PRYR-19 LEFT


PRYR-20 LEFT ONLY


PRYR-21 RIGHT


PRYR-21 LEFT


PRYR-22 LEFT ONLY

The photographs in this album are contributed by the following organizations

LANDSCAPE	SITES	AGENCIES	LANDSCAPE	SITES	AGENCIES
SH&GP	Corbett	WII	CI&EG	Ramgarh	WWF
SH&GP	Terai East	WWF	CI&EG	Ranthambhore	WII
SH&GP	Dudhwa	WWF+UPFD	CI&EG	Sanjay Dubri	MPFD
SH&GP	Amangarh	WII	CI&EG	Sariska	WII
SH&GP	Haldwani	UKFD	CI&EG	Satkosia	OFD
SH&GP	Katarniaghat	WWF	CI&EG	Satpura	WII+MPFD
SH&GP	Rajaji	WII	CI&EG	Similipal	WII+OFD
SH&GP	Terai West	UKFD	CI&EG	Tadoba	WII
SH&GP	Valmiki	WWF	CI&EG	Tippeshwar	WCT
SH&GP	RamnagarFD	UKFD	CI&EG	Udanti Sitanadi	CGFD
SH&GP	Kishanpur	WWF	CI&EG	Umred	WII+WCT
SH&GP	Lansdowne	WII	NE&BFP	Kaziranga	WII+AARANYAK+WWF
SH&GP	Najibabad	WII	NE&BFP	Manas	WII+AARANYAK
SH&GP	Pilibhit	WWF	NE&BFP	Nameri	ASFD
SH&GP	Kalagarh	WII	NE&BFP	Orang	AARANYAK
CI&EG	Bor	WII+WCT	NE&BFP	Pakke	ARFD
CI&EG	Bandhavgarh	MPFD	WG	Anamalai	WWF
CI&EG	NSTR (GBM)	APFD	WG	Ansi Dandeli	CWS+WCS
CI&EG	Kailadevi	WWF	WG	Bandipur	CWS+WCS
CI&EG	Kanha	WII	WG	Bhadra	CWS+WCS
CI&EG	Kanha-Pench Corridor	WWF	WG	BR Temple WLS	CWS+WCS
CI&EG	Kuno	WII	WG	KMTR	TNFD
CI&EG	Melghat	WII	WG	Mudumalai	TNFD
CI&EG	Melghat Buffer	WRCS	WG	Nagarhole	CWS+WCS
CI&EG	Navegaon Nagzira	WCT	WG	North Nilgiri Divisions	WWF
CI&EG	NSTR	WII	WG	Parambikulam	KRFD
CI&EG	NSTR (GV Palli)	APFD	WG	Periyar	KRFD
CI&EG	Palamau	JFD	WG	SMTR	WWF
CI&EG	Panna	MPFD	WG	Wayanad	CWS+WCS
CI&EG	Pench (MH)	WCT	Sundarban	Sundarban	WII+WWF

ABBREVIATIONS:

SH&GP Shivalik Hills & Gangetic Plains
CI&EG Central Indian & Eastern Ghats
WG Western Ghats Landscape
NE&BFP North East Hills and Brahmaputra Flood Plains

WII Wildlife Institute of India
WCT Wildlife Conservation Trust
WWF World Wild Fund for Nature
WRCS Wildlife Research and Conservation Society
CWS Center for Wildlife Studies
WCS Wildlife Conservation Society

MPFD Madhya Pradesh Forest Department
APFD Andhra Pradesh Forest Department
JFD Jharkhand Forest Department
OFD Odisha Forest Department
CGFD Chhattisgarh Forest Department
UKFD Uttarakhand Forest Department
ASFD Assam Forest Department
ARFD Arunachal Pradesh Forest Department
TNFD Tamil Nadu Forest Department
KRFD Kerala Forest Department
UPFD Uttar Pradesh Forest Department

सत्यमेव जयते

भारतीय वन्यजीव संस्थान
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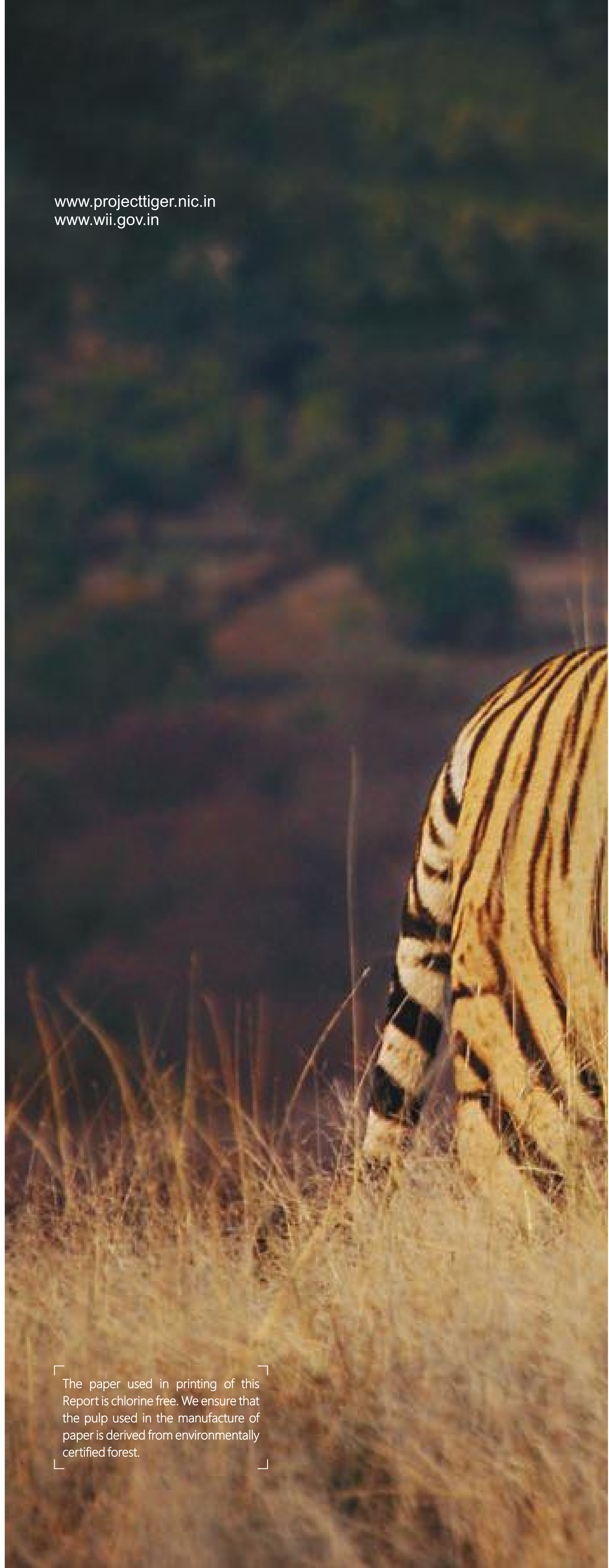

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