Status of Tiger and Prey Species in Panna Tiger Reserve, Madhya Pradesh:

capture-recapture and distance sampling estimates

Technical Report

[A component of ongoing WII-MPFD collaborative project and inputs in Phase IV of All India Tiger Population Monitoring Programme]

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

December 2013

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Panna Tiger Reserve, Madhya Pradesh Forest Department

Submitted to

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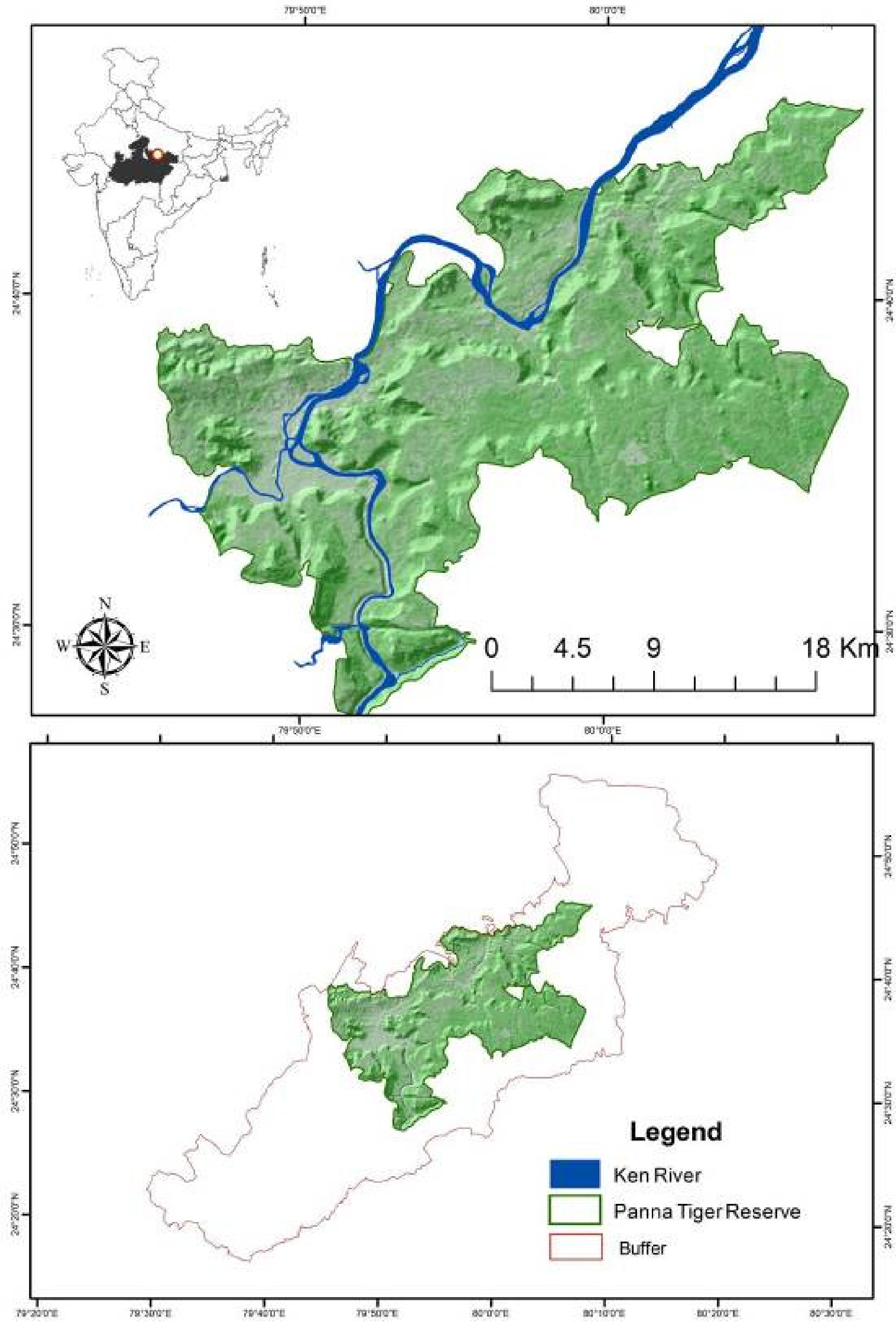
1 Introduction

1.1 Landscape Characteristics

Panna Tiger Reserve (PTR), with core area of 543 km^2 and about 1000 km^2 of buffer area, in north-central Madhya Pradesh (Figure 1) is located on the Vindhyan Range within the Biogeographic Province 6A Deccan Peninsula - Central Highlands (Rodgers et al. 2002). The habitat of PTR is configured by a step-like topography consisting of upper Talgaon Plateau (Panna Range), middle Hinauta Plateau (Hinauta Range) and lower Ken River Valley (Madla and Chandranagar Ranges), separated by steep and rocky escarpments of varying height upto ca.80m. The Ken River, which cuts through the Reserve from south to north and eventually joins the Yamuna in Uttar Pradesh, adds exceptional ecological and aesthetical values to the landscape (Figure 1). It is clearly an important lifeline for the Reserve's biodiversity and scores of human population surrounding the River. The geographical area of PTR falls in Panna and Chattarpur districts of the state of Madhya Pradesh, and has contiguous forests on either side of the area, thus placing the Reserve in landscape context, particularly against the backdrop that home range of large carnivores extend to these forests (Chundawat et al. 1999). The forest type in PTR is characteristic of tropical dry deciduous element (Meher-Homji 1990), formed by a mosaic of woodlands and grasslands, and a riparian community along the water courses. The woodland is dominated by teak, teak-mixed forest and bamboo, miscellaneous type, and drier strata are dominated by *Acacia-Zyzyphus*. As per Champion and Seth (1968), there are six forest types here; (1) Southern Tropical Dry Deciduous Teak Mixed Forest, (2) Northern Tropical Dry Deciduous Mixed Forest, (3) Dry Deciduous Scrub Forest, (4) *Annogeissus pendula* Forest, (5) Boswellia Forest, and (6) Dry Bamboo Brakes. Water is a limiting factor during this season, due to which, distribution of most faunal species is skewed around sparse water sources and artificial waterholes provided by the reserve management. The PTR is almost free from human occupation, and most of 14 village enclaves have been transformed into successional grasslands and there are only three villages remain in the core area and these are also being relocated.

Figure 1: Map of Panna Tiger Reserve (including proposed buffer)



1.2 Faunal Attributes

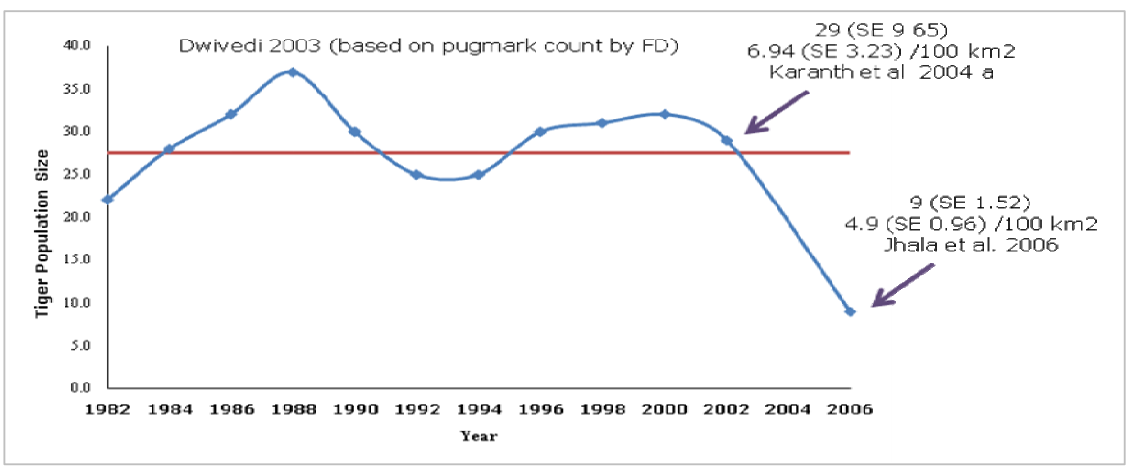
PTR is among the important Protected Area in the Central Indian Highlands complex, for its structural diversity and wide array of fauna, including 'the key species' Tiger. It is listed among the Regional Priority Tiger Conservation Landscape, which is defined as a low density habitat with moderate-high levels of threats (Sanderson et at. 2006). PTR also supports sizable population of Sloth Bear (*Melursus ursinus*). Other prominent carnivores are Leopard (*Panthera pardus*), Striped Hyena (*Hyaena hyaena*), Wild Dog (*Cuon alpinus*), Jungle Cat (*Felis chaus*) and Jackal (*Canis aureus*). The major ungulates that form prey for these carnivores are Sambar (*Cervus unicolor*), Chital (*Axis axis*), Nilgai (*Boselaphus tragocamelus*), Chinkara (*Gazella bennetti*), Four-Horned Antelope (*Tetraceros quadricornis*) and Wild Pig (*Sus scrofa*). The Common Langur (*Presbytis entellus*) is widespread, while Rhesus Macaque (*Macaca mullata*) is found only along the forest peripheries closer to human habitations. There are over 150 birds species in PTR, and the important breeding birds include Marshall's Iora (*Aegithina nigrolutea*), White-bellied Minivet (*Pericrocotus erythropygius*), Long-billed Vulture (*Gyps indicus*) and Striated Grassbird (*Megalurus palustris*) (Jayapal et al. 2007), besides a variety of Galliformes including Peafowl (*Pavo cristatus*), Painted Spurfowl (*Galloperdix lunulata*) and Painted Francolin (*Francolinus pictus*). The area also supports over 10 species of Reptiles, and over 50 species of fishes including two globally threatened Masheer species (*Tor tor*, *Tor putitora*), popularly known as 'King of Freshwater Fishes of India' (Johnson et al. 2012).

1.3 Chronicle of Tiger Status

PTR is known for its eventful conservation history for the last two decades. The area was initially recovered by village relocation program that allowed more space for tiger and other species to grow, and recently, tiger reintroduction program has facilitated recovery of tiger and the glory of the reserve. During formative years of PTR, tiger density was less than 3 tigers/100 km^2 and appeared to have increased to 7 tigers/100 km^2 during early 2000 (Karanth et al. 2004a). Tiger population in PTR was initially estimated based on pugmark technique, followed by camera trapping method including by the NTCA-WII All

Indian Tiger Monitoring Project in 2006 when the tiger population decline showed drastic decline (Figure 2). The results from these estimates indicated a mean population size of 25 tiger in PTR during these years. As per the equation of Karanth et al. (2004b), carrying capacity analysis of expected number of tiger in PTR based on prey density availability concurred with the population estimate of 2001/02 i.e. 7 tigers/100 km^2. Due to various reasons including poaching, the tiger population dwindled to almost none in the year 2009. In order to restore the population status, tiger population was reinforced initially with two female tigers from Bandhavgarh and Kanha Tiger Reserves during March 2009. However, once it became clear that there was no resident male in PTR and the population was functionally extinct (WII 2009/Ramesh et al. 2009), a full-fledged reintroduction program was conceived and is being implemented with credible success (MPFD and WII 2009). Subsequently, a male was caught in Pench Tiger Reserve and released in PTR in November 2009. The initial population of three animals (one male and two females) was supplemented with two hand-reared and semi-wild females from Kanha Tiger Reserve (Ramesh et al. 2011).

Figure 2: Chronology of population estimation of tiger in PTR during 1982 - 2006 (in 2008/09, it became functionally extinct with almost none)



These introduced animals have established in the new sites and three of the four females have yielded more than one litters in the last four years. However, it is important to understand the status of tiger and associated species (such as leopard and prey species) in terms of distribution and population size so as to understand the trajectory of these species assemblage in the reserve, which is the essence of NTCA's All India Tiger Population Estimation and Monitoring Project. Also, given the know population size, the estimates obtained here would offer insights for methodological issues related to small populations. Therefore, although tiger number was known in PTR, Phase-IV activities of the larger project was implemented jointly by Wildlife Institute of India research team and staff of PTR.

1.4 Objectives

The proposed report address the objectives of the Phase-IV of the NTCA project on monitoring tiger, co-predator and prey species, and is a part of the ongoing WII-MPFD collaborative project on 'Ecological Monitoring of Tiger in Panna Landscape, Madhya Pradesh'. The following were the specific objectives that are addressed in the present report;

(1) To obtain minimum number and density of large carnivores (tiger and leopard) based on photographic capture-recapture framework.

(2) To map occupancy of large carnivore (tiger, leopard and hyena) based on photographic capture rates.

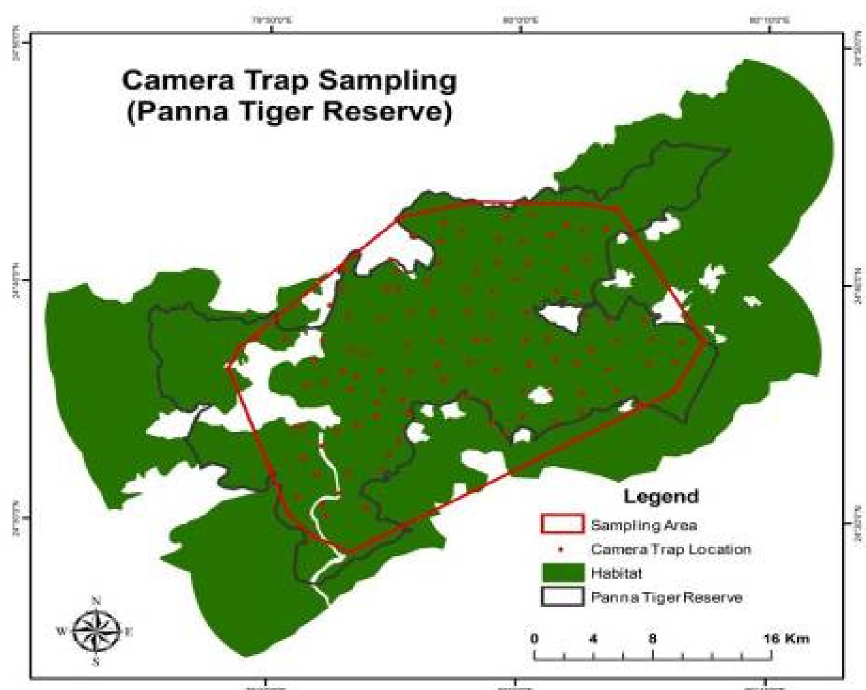
(3) To estimate population density of prey species based on distance sampling procedure.

2 Sampling Design and Methods

2.1 Photographic Capture-Recapture Sampling

Camera trap sampling design closely followed Karanth and Nicholas (2002) and was in line with the Phase IV protocol of All India Tiger Population Estimation and Monitoring Project (Jhala et al. 2011). The area has been gridded into 4 km^2 area (2 * 2 km cell) and deployment of camera traps were done in three blocks during summer of 2012 and winter of 2012/2013, and in entire area during summer 2013. During the block design, camera traps were deployed in 40 grids with 30 days of session for each block, accounting for 120 grids and 480 km^2 area (Figure 3). Choice and location of camera trap deployment are critical element in the photographic capture-recapture design. Cuddeback Attack cameras with Cantered Detection Technology was consistently used in the block design and one-time sampling design, as it provided the best results with clear picture on centre of the frame, ideally suited for such purposes. The area has been surveyed since 2008 and the field team is fully familiar with the areas of tiger use and strategic places. Therefore, locations could be carefully identified and were geo-referenced using GPS and mapped using ArcGIS 10 software.

Figure 3: Camera trap locations and effective sample area with habitat mask



In each of selected points, a pair of Cuddeback Attack camera traps (opposite side) were placed and monitored regularly. Placement of the camera traps was ensured such way that the flashes do not affect the opposite side camera pictures and obtain clear pictures of both flanks of the tiger. A total of 3600 trap nights in summer 2012 and winter 2012/13, and 7200 trap nights in summer 2013 were sampled using 120 pairs of camera traps. Pictures were regularly downloaded in field using portable netbook and were catalogued in WII base camp at Hinota. Subsequently, individual identification was done using standardized methods and creation of matrices were done based on both flanks of tiger and one side flank for leopard and hyena. The results for tiger has been presented for all the three time periods (summer 2012, winter 2012/13 & summer 2013), but for leopard and hyena, capture rates and population estimate for one season (summer 2012) has been given to provide an idea on the status of these co-predators.

Table 1: Details of camera trap sampling in three temporal periods

Camera Trap Session	From	To	Occasion
Summer 2012			
BLOCK-1	04-04-2012	03-05-2012	30days
BLOCK-2	08-05-2012	07-05-2012	30 days
BLOCK-3	15-06-2012	14-07-2012	30days
Winter 2012/13			
BLOCK-1	02-12-2012	31-12-2012	30days
BLOCK-2	07-01-2013	05-02-2013	30days
BLOCK-3	09-02-2013	10-03-2013	30days
Summer 2013			
Total Coverage	27-04-2013	25-06-2013	60 days

2.2 Occupancy Pattern of Tiger, Leopard and Hyena

In order to ascertain the spatial distribution and occupancy of tiger and co-predators, the photographic capture and recapture rates were used. Summer 2012 data was converted into individual tiger captured for each grid and the frequency of occurrence i.e. total number of capture-recapture of the species for each grid was assigned. The information was converted into discrete values and mapped using ArcGIS 10. The result was expected to present the pattern in spatially explicit form, so as to provide inputs for management strategies.

2.3 Prey Density Estimation

Ungulates and other prey species were estimated using line transect surveys in conjunction with distance sampling methods. A total 41 lines transects were laid across the PTR systematically along 4*4 grid cell. It was ensured that these transects covered all the important different habitats of prey species. These line transects vary in length between 1.85 km and 2.1 km, suited for efficient sampling for prey species in such habitats. Counts were done following distance sampling protocol (Buckland et al. 2001) and was analysed using Distance Ver.6 software (Thomas et al. 2009). Each transects was walked in the morning between 6:00 am and 8:30 am and was repeated for minimum of three times in both summer and winter seasons. The count included visual encounter of prey species along with group (cluster) size, sighting distance and sighting angles for each observation. Also prey species were classified as adult male, adult female, juvenile, or unknown. Data was analysed for individual species and for administrative units i.e. Range Boundary.

3 Results

3.1 Population Estimate of Tiger and Co-Predators

Camera trap data, converted into 'X matix', was subjected to Closure Test (Otis et al. 1978) in order to test for closure assumption. Results revealed that the dataset was amenable to closure assumption for all the sampling period [summer 2012, Z = 2.74441, p = 0.99697; winter 2012/13, Z = 2.85725, p = 0.99786 and summer 2013, Z = 0.10979, p = 0.54371]. In terms of capture history, 11 individual tigers were captured in summer of 2012 (3600 trap nights) and 2013 (7200 trap night), with total recaptures of 44 and 79 pictures respectively. However, in winter 2012/13 (3600 trap nights), 13 tigers with total recapture of 113 pictures were obtained.

Table 2: Summary of population estimates for tiger during summers of 2012 and 2013, and winter of 2012/13

Season	Model	Individual Tiger	Capture Probability	Population Size	Standard Error	95% CI
Summer 2012	Mh-Jacknife	11	0.12	12	2.93	12-29
	Mo-Null		0.13	11	0.45	11-11
Winter 2012/13	Mh-Jacknife	13	0.25	15	2.59	14-27
	Mo-Null		0.30	13	0.02	13-13
Summer 2013	Mh-Jacknife	11	0.12	11	1.00	11-11
	Mo-Null		0.12	11	0.07	11-11

Using Density software, these estimates were translated into 1/2MMDM density of 1.42/100 km^2 (SE 0.21) for summer 2012, while it was 1.16/100 km^2 (SE 0.08) for winter 2012/13 and 1.14/100 km^2 (SE 0.10) for summer 2013. Density estimate based on habitat masked Spatially Explicit Capture Recapture (SECR) model provided density estimates of 2.9/100 km^2 (SE 0.99) for summer 2012, 1.54/100 km^2 (SE 0.44) for winter 2012/13 and 1.59/100 km^2 (SE 0.50) for summer 2013.

Other co-predators, leopard and hyena, were photo-captured in all the seasons, but the estimates for summer 2012 could be obtained due to want of time for other sampling periods. The estimate for summer 2012 yielded, a minimum of 53 individual leopards and 102 hyenas, with total captures of 89 and 361 respectively for these two animals. These records provided SECR based density of 12.2/100 km^2 (SE 0.02) for leopard and 15.1/100 km^2 (SE 0.02) for hyena.

3.2 Spatial Pattern of Tiger, Leopard and Hyena Occupancy

Space use of tiger appears to be restricted, but it in increasingly expanding through the available habitat in the area. It is evident from the camera trap results obtained in summer 2012 when the space use was skewed towards few areas (Figure 4 and 5), while in recent years, it has expanded to most of the available habitats as discerned from radio-telemetry based home range mapping (Figure 6). The increasing population is only likely to occupy remaining unoccupied habitats. Leopard and hyena occupy widely in PTR and of these two species, hyena is more widely found, with intensive selection for certain areas (Figure 7 and 8).

Figure 4: Space use pattern of tiger in PTR (Summer 2012 camera trap results)

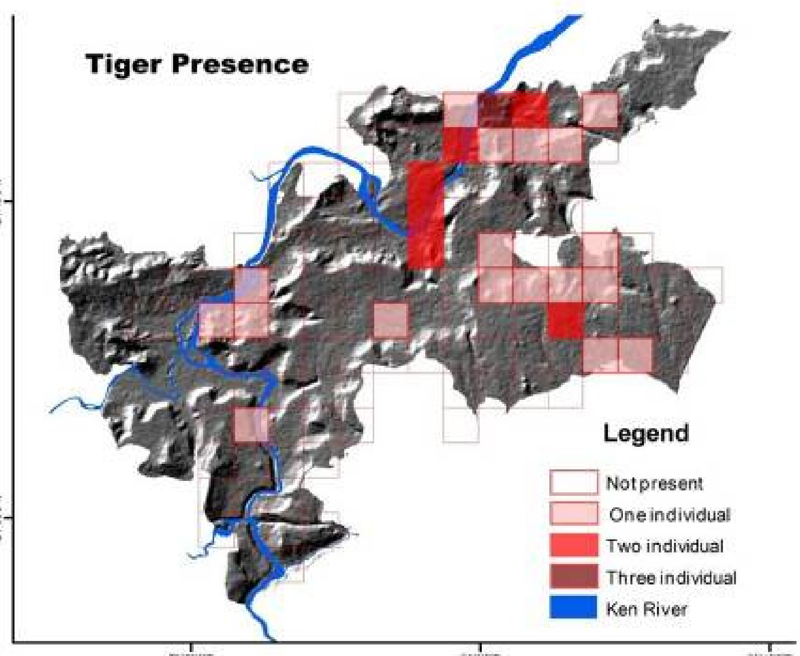


Figure 5: Intensity of use by tiger in PTR (Summer 2012 camera trap results)

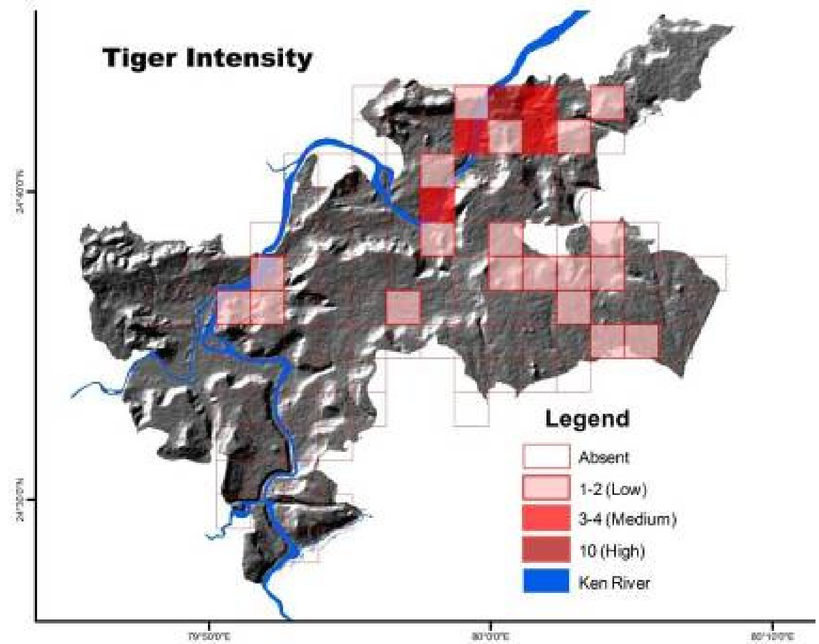


Figure 6: Recent occupancy pattern of tigers (2012/13 telemetry results)

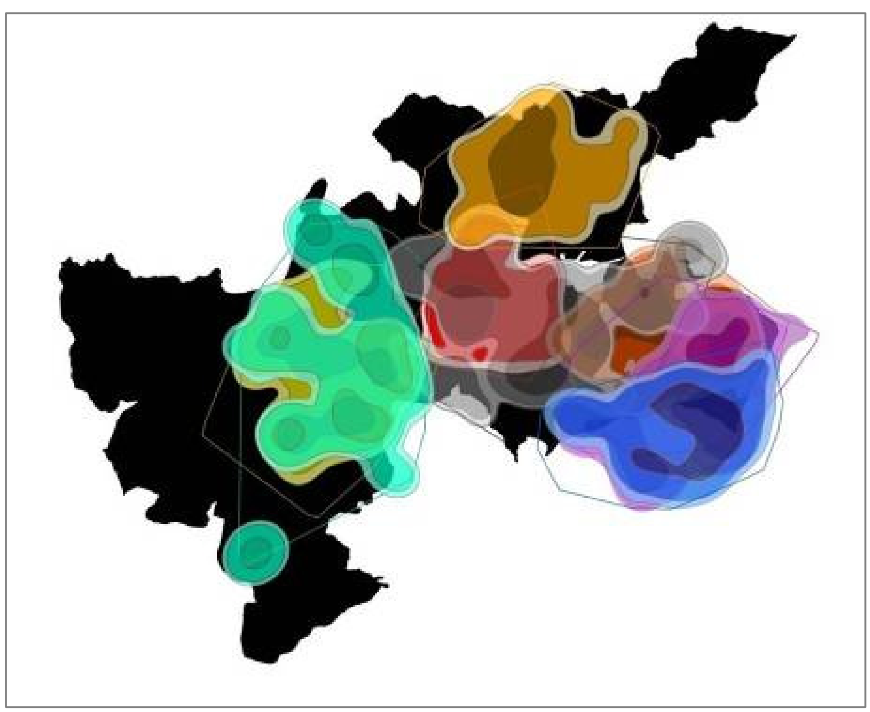


Figure 7: Space use pattern of leopard in PTR (Sum. 2012 camera trap results)

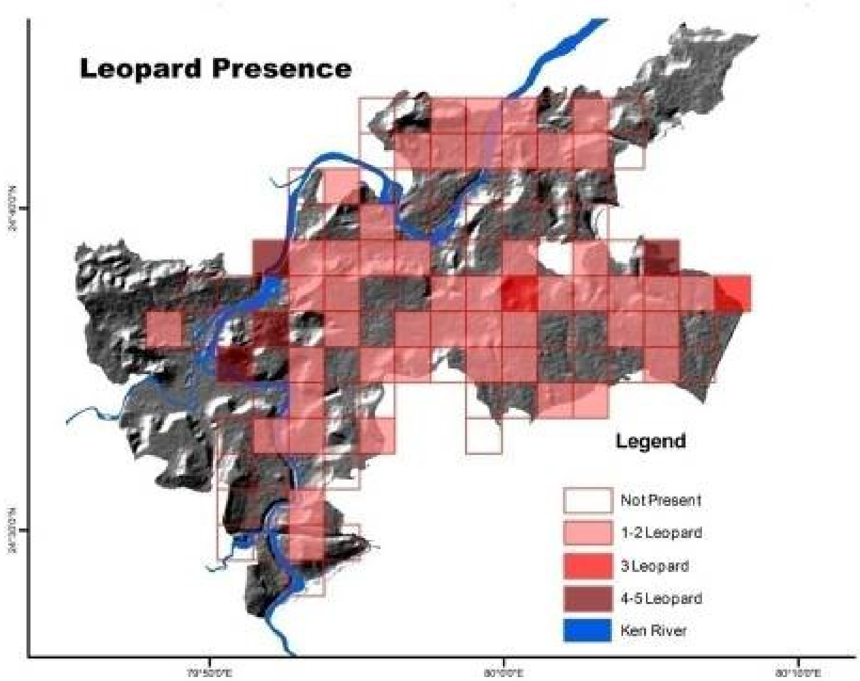
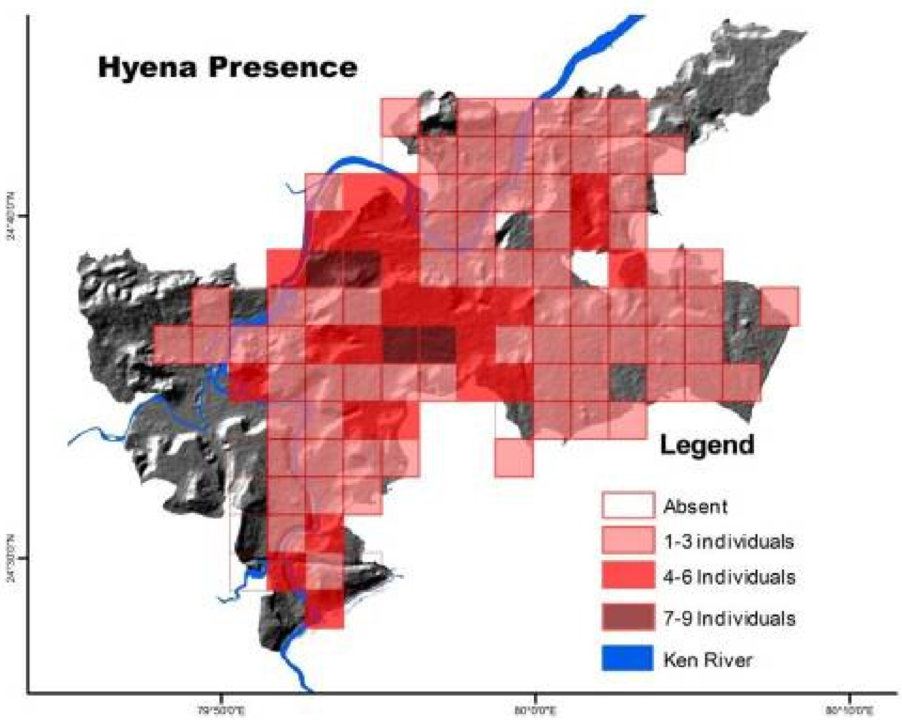


Figure 8: Space use pattern of hyena in PTR (Sum. 2012 camera trap results)



3.3 Prey Density

The prey species in PTR include sambar, chital, nilgai, wildpig, langur, peafowl, chinkara, chounsingha and cattle. However, density analysis could not be performed for chounsinga due to very low detections during the sampling periods. Table 3 and 4 provide density estimates for the prey species during winter 2012/13 and summer 2013 respectively. Based on the Standard Error for density estimates and CV of encounter rate, the estimates for langur, peafowl, sambar, chital and chinkara were reliable during winter, while the estimates for wild pig, nilgai and cattle were reliable in summer, although these variations could also explain seasonal habitat choice for these species. Of the ungulate species, the abundance ranking follows sambar>nilgai>wildpig>chital, although cattle scores the highest density, but occur in restricted areas (as reflected from high SE and CV) (Table 3 & 4). Density estimates obtained for different administrative units (i.e. Ranges) suggest that four ranges (Panna, Hinota, Madla and Gaharighat) have diverse prey species with reasonable abundance, while Chandranagar and Kishnagarh ranges are deprived of diversity and are dominated by nilgai (Table 5).

Table 3: Population estimates for prey species in winter 2012/13 in PTR

Species	Count	Selected Model	Estimated Individual Density (N/Km^2)	SE	Encounter Rate (N/Km)	CV %
Langur	41	Half normal cosine	<u>14.4</u>	<u>3.0</u>	0.3	12.4
Peafowl	28	Uniform cosine	<u>8.2</u>	<u>2.4</u>	0.4	23.9
Sambar	78	Hazard rate simple polynomial	<u>8.7</u>	<u>2.2</u>	0.5	17.7
Wild pig	18	Hazard rate cosine 5% right truncation	7.5	4.0	0.3	13.2
Chital	31	Negative exponential cosine 5% right truncation	<u>5.0</u>	<u>1.8</u>	0.4	20.5
Nilgai	72	Negative exponential cosine	9.5	1.9	0.4	12.6
Chinkara	11	Half normal simple polynomial*	<u>4.2</u>	<u>1.2</u>	0.2	18.0
Cattle	45	Hazard rate simple polynomial	118.8	62.7	0.5	22.1

* Model did not fit very well, perhaps due to low number of observations

Table 4: Population estimates for prey species in summer 2013 in PTR

Species	Count	Selected Model	Estimated Individual Density (N/Km^2)	SE	Encounter Rate (N/Km)	CV %
Langur	46	Half normal simple polynomial right truncation at 200m	23.2	4.5	0.5	12.3
Peafowl	40	Hazard right cosine*****	84.8	42.0	0.8	18.7
Sambar	50	Negative exponential cosine right truncation at 90m	16.0	4.6	0.5	16.8
Wild pig	17	Half normal simple polynomial	<u>6.1</u>	<u>2.0</u>	0.3	08.1
Chital	37	Uniform cosine right truncation at 50m	58.5	20.3	0.4	25.6
Nilgai	61	Negative exponential cosine right truncation at 127m	<u>7.7</u>	<u>1.9</u>	0.4	08.1
Chinkara	22	Negative exponential cosine right truncation at 53m	15.0	6.2	0.4	22.8
Cattle	21	Negative exponential cosine	<u>60.1</u>	<u>21.2</u>	0.3	14.0

***** Model did not fit very well, perhaps due to low number of observations

Table 5: Range wise population estimates for prey species in winter 2012/13

Species	Individual Density (Standard Error) in Ranges					
	Panna	**Hinota**	**Madla**	**Gaharighat**	**Chandranagar**	**Kishangarh**
Sambar	10.9(8.1)	6.5(3.0)	1.4(0.6)	11.6(5.8)	0.5(0.4)	2.3(1.5)
Nilgai	2.1(1.2)	2.2(0.9)	4.2 (2.2)	8.9(6.3)	20.1(12.4)	6.6(2.4)
Chital	1.4(0.9)	1.7(1.3)	3.0(1.6)	5.7(8.37)	*	*
Chinkara	*	*	2.0(1.0)	*	*	*
Wild pig	4.8(3.7)	1.6(1.9)	1.6 (1.1)	*	*	0.7(0.6)
Langur	10.5(4.6)	7.1(7.8)	10.7(7.0)	10.6 (7.1)	12.2(6.1)	3.4(3.0)
Peafowl	4.6(3.1)	*	0.6(0.4)	1.6(1.9)	*	*
Cattle	40.3(74.4)	*	85.3(58.3)	23.3(16.2)	118.0(99.5)	10.0(5.4)

**Too few or no records during sampling to compute density estimates for these species in these ranges.*

4 Inferences and Conclusion

The status of tiger and related species in Panna Tiger Reserve (PTR) should be seen in the context of population extinction and recovery of the species, following a full-fledged reinforcement and recovery programme for the species. It is pertinent to mention that PTR is also one of the few places in the country where monitoring of tiger and prey species are being carried out since 1995 by various people, and with tiger reintroduction project, a detailed monitoring including using VHF/GPS telemetry is being done. Began with three animals (one male and two females) translocated from other wild populations in 2009, and another two hand-reared and semi-wild females PTR in 2011, the population has now grown into 22 animals. Of these, 10 animals have been collared and nine are still being monitored based on radio-tracking. Therefore, in the context of Phase IV monitoring, PTR offers further insights since the population is known and population estimation procedures could be tested here. Nevertheless, establishing long-term monitoring is an important management activities and the results presented in this report would provide strong baseline for continuous monitoring.

Camera trap sampling captured 100% of the adult and sub-adult tiger in the populations in all seasons (*note: the population is known*), but there was variation in recapture rates, with higher in winter and lower in summer. This possibly relates to skewed distribution of the animal in summer months and the camera locations are static. Of the models, null model was selected in all the sampling period and Mh-Jacknife model had higher standard error and over estimated the population size. Null model selection is possible due to strict adherence to closer assumption and appropriate deployment of camera locations. Most studies choose Mh-Jacknife for the estimates and the results obtained here may provide specific insights as to whether or not the population size is over estimated. Density estimates based on 1/2MMDM provided tiger density of 1.14 to 1.42/100 km^2, while Maximum Likelihood Spatial Explicit Capture and Recapture methods provided density of 1.54 to 2.9/100 km^2. These estimates, if compared with home range of the tigers in Panna, appeared to yield lower estimate, except for one season when the density estimate was 2.9/100 km^2. Further analysis on this aspect would provide definitive answers to the variations in the observation and interpretation. The co-predators, leopard and hyena, have high density in PTR, and this is again related to diversity of prey species and habitat condition suited for co-occurrence of all these species. This is also reflected by the space use pattern of leopard and hyena. Spatial occupancy of tiger suggests that space use increases progressively and showing tendency towards occupancy in empty spaces. Leopard and hyena are well distributed in the sampled areas, indicating health of PTR in the larger contexts.

Prey population density in PTR is comparable with other similar habitats and the current estimate provide ca. 32 ungulates/km^2, dominated by Sambar, followed by nilgai, wildpig and chital. Cattle also constitute substantial biomass in the area. Although the estimate is slightly lower than the previous estimates obtained in PTR, it is within the Confidence Limit, and there, the prey density in PTR may be stated to be stable.

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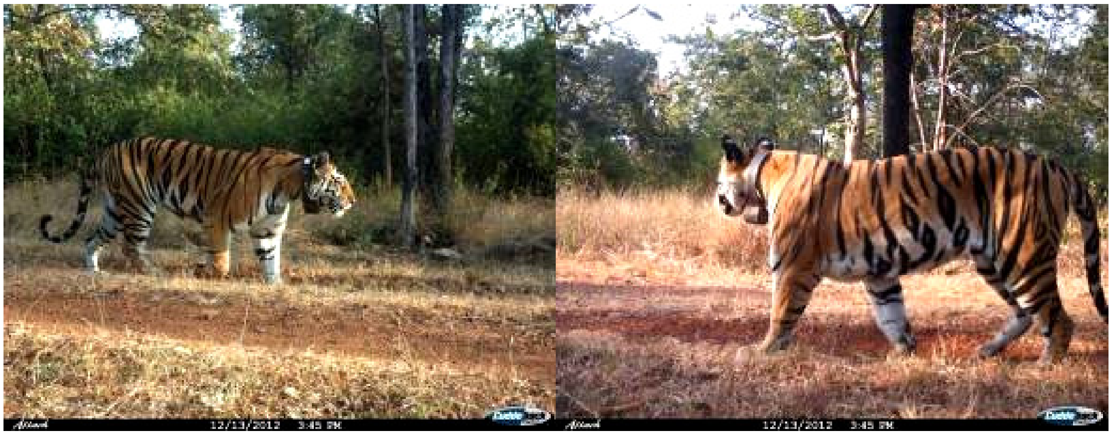
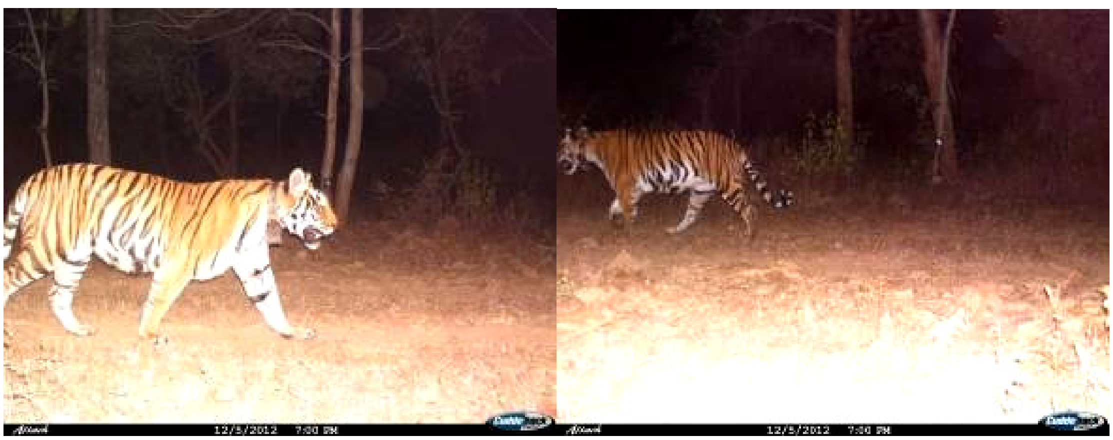
Annexure 1: Photographic ID of tiger in winter 2012/2013

T1 (T1)



T2 (T2)



T3 (T3)

T4 (T4)

T5 (T5)

T6 (P111)

T7 (P112)

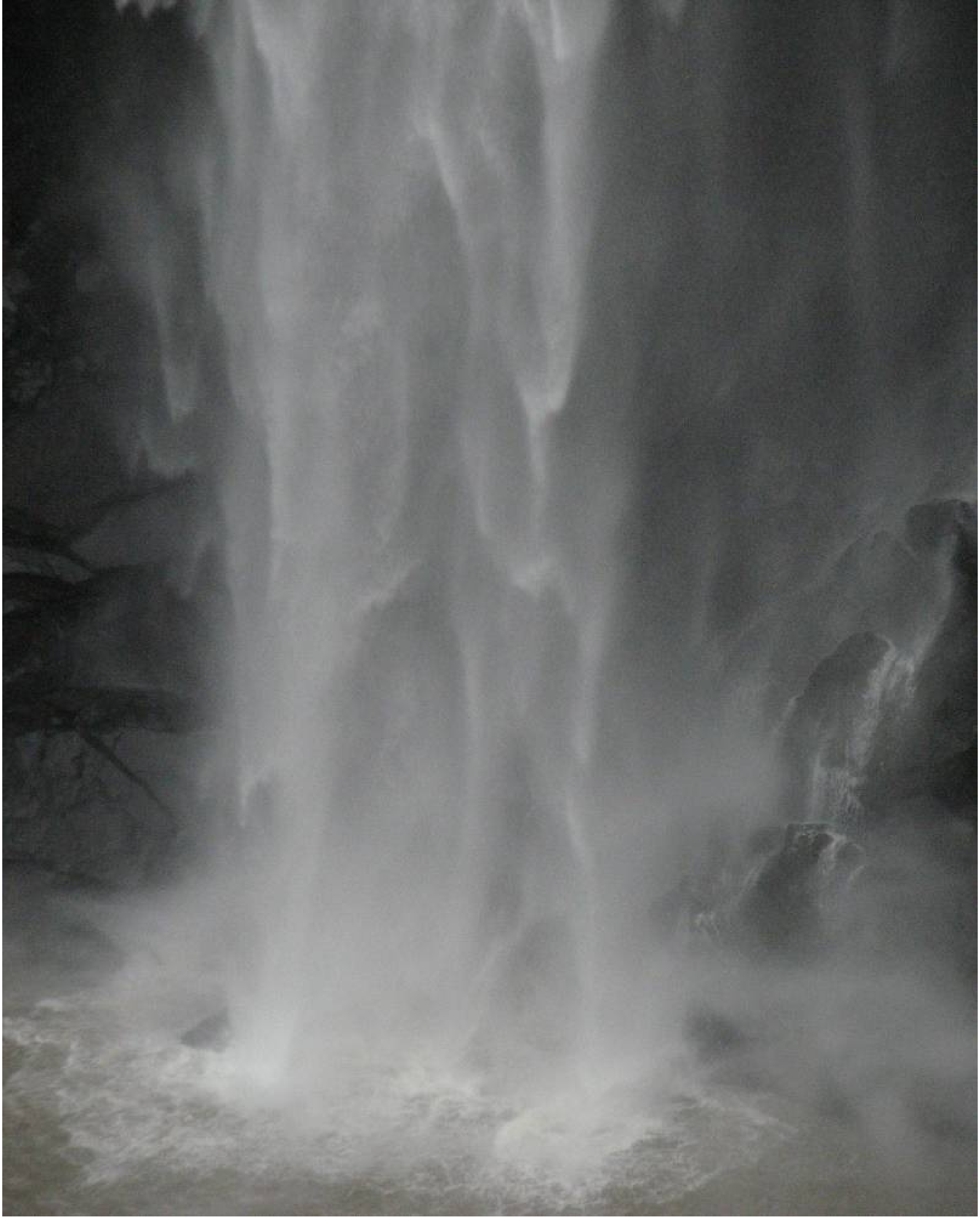
T8 (P212)

T9 (P213)

T10 (P411)

T11 (P412)

T12 (P212) & T13 (P222)



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