OCCASIONAL REPORT NO. 8

COUNTING STRIPES & CELLS

Assessing Tiger (*Panthera tigris*) Distribution and the Factors Influencing Tiger Occupancy in the Tadoba-Nagzira Corridor in Central India

Aditya Joshi, Vivek Tumsare, Prafulla Bhamburkar,
Rajendra Prasad Mishra and Rahul Kaul

2013

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Wildlife Trust of India

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PREFACE

Counting tigers is a conservationist's supposed best activity. However, estimating abundance in key corridors merely to pin point areas for conservation priority is lesser celebrated. WTI's decade old project to connect Tadoba-Andhari tiger reserves to the Nagzira Nawegaon tiger reserve in Maharashtra, and in fact, its work in many other corridors in the central Indian tiger landscape relies on such pin pointing. This work is a scientific assessment of connectivity based on predator and prey abundance along this critical connectivity. When WTI started its project in the corridor that lay between Nagzira and Nawegaon, the latter had no tigers left, with the last carnivores having been shot by a prominent local landowner. I had the privilege (if the use of the word is correct) to talk to him about his hunting days. Well into his eighties, the old man reminisced about the number of tigers he had killed, over a hundred if he were to be believed, and also regretted his past.

Two decades have passed since then and the WTI project along with actions by a few prominent conservationists in the region have focussed state and central attention on the corridor. Linear infrastructure mitigation measures have been started and are continuing. Livelihood work in village on the corridor have yielded some result. Most importantly, tigers have started returning to Nawegaon, which is the biggest conservation victory for the project.

This report, and a few others like it, however provided the scientific underpinning of the project. The circuit scape mapping allowed for precise interventions by the project team.

Vivek Menon
Executive Director

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EXECUTIVE SUMMARY

Most of the tiger range countries are putting substantial amount of conservation effort into tiger conservation, although most of these efforts are concentrated on few, relatively large Protected Areas (PA). India supports a large proportion of the global tiger population in less than seven percent of the global tiger habitat, most of which is fragmented. There is substantial area of forest outside the PA network, especially in central India; which needs to be surveyed for tiger presence. Good baseline data on presence of tigers outside PAs is essential to prioritize areas for conservation in a human-dominated landscape. Such data on distribution of tigers in the central Indian landscape is invaluable but unavailable.

The aim of this study was to generate the baseline data on distribution of tigers, the anthropogenic factors influencing tiger occupancy and habitat connectivity across one of the most important corridor in the central Indian landscape, the Tadoba-Nagzira corridor in order to do conservation action to secure it. To achieve these objectives we used grid-based sampling approach to collect data on tiger presence and anthropogenic factors that might influence tiger occupancy. Such data could allow identification of new habitats with potential for tiger and could potentially help in upgrading the legal protection status of these areas.

We detected tiger presence outside PAs; but as the distance from source PAs increases, tiger presence decreases. The major factors influencing tiger occupancy in the Tadoba-Nagzira corridor were presence of large prey species, disturbance, proportion of tiger habitat and livestock. Circuitscape results shows critical areas for restoration further strengthening this corridor. With appropriate actions this corridor has potential to not only facilitate tiger movement but also support resident tiger populations.

INTRODUCTION

Although recognized as the ambassador of wildlife conservation in India, the geographic range and number of tigers have decreased considerably in the last few decades. Growing human populations and developmental activities like highways, mines, power plants, dams etc. have all contributed to habitat loss and fragmentation in India (Karanth et al. 2009). Loss of habitat along with poaching of tigers and their prey have resulted in extensive range contraction of tiger populations globally; restricting them to 13 countries and occupying less than 7 percent of their global historical range (Sanderson et al. 2006). Tigers once occupied over 90 percent of the Indian subcontinent but within the last century their range has been estimated to have reduced by nearly 76 percent (Karanth et al. 2009, 2010). Dinerstein et al. 2007 estimated the current area occupied by tigers and compared it with occupancy estimates from last 10 to 100 years ago. The results showed a dramatic drop in tiger occupancy just over a decade ago and identify several causes of this decline and suggest a series of recommendations to curb the ongoing range collapse.

India with projected population of 1.4 billion at the dawn of 2025 (Dyson et al. 2005) still holds up a fair share of wild tiger population unlike any other tiger-bearing country. The potential tiger habitat in India as estimated varies from 100,000 km^2 (Jhala et al. 2008) to 250,000 km^2 (Sanderson et al. 2006). Tigers require large spaces (Karanth et al. 2004), but most of the protected areas are too small to harbor ecologically, demographically and genetically viable tiger populations over the long term (Woodroffe and Ginsberg 1998, Carroll and Miquelle 2006). Even these PAs are not safe for tigers, as learnt when intense poaching had eliminated all tigers from Panna and Sariska Tiger Reserve. Recently, areas surrounding PAs with tiger populations have received greater attention due to the increasing incidences of conflicts, evidence for importance of corridors and possibilities of PA expansion (Chundawat et al. 1999; Wikramanayake et al. 2004; Carroll and Miquelle, 2006; Sanderson et al. 2006; Ranganathan et al. 2008).

Western Ghats, Central India and the alluvial flood plains in the Himalayan foot hills support major tiger populations in India (Mondol et al. 2009 b). Although central India consists of important tiger habitats, this region has suffered a substantial loss of forest cover due to urbanization and development. A recent study by Joshi et al. (2013) provides evidence of long distance tiger-dispersal in the central Indian landscape and that the tiger connectivity is affected by human settlements, roads and presence of tiger-habitat. Kanha-Pench, Kanha-Nawegaon, Nagzira-Nawegaon, Tadoba-Nagzira, Tadoba-Kawal, and Melghat-Satpuda-Penchare some of the very important wildlife corridors in central India. The central Indian landscape is a matrix of forest and protected areas interspersed with different land use types. There are occasional reports of tiger sightings and cases of conflicts with domestic animals and people outside PAs. Some of the forest blocks between the PAs are suspected to have resident tiger populations. It is therefore important to assess the status of these forest fragments in terms of distribution and as corridors for tiger movement.

The knowledge of tiger occupancy outside protected areas is inadequate; such data could allow identification of new habitats with potential for tiger and could potentially help in upgrading the legal protection status of these areas. Accurate estimates of various population parameters are important for management and conservation; and strengthen the argument for protecting the remaining potential tiger habitats. Periodic monitoring of animal populations helps in setting specific management objectives and monitoring the success of conservation programme. Surveys of large landscapes can help identify habitat corridors, status of connectivity between source populations and routes used by dispersing tigers.

OBJECTIVE

The main goal of this project was to identify critical areas in the Tadoba-Nagzira corridor which are essential to maintain tiger-connectivity and/or which have potential to support resident tiger population.

The specific objectives of this project were to:

1. Determine the distribution of tigers in the Tadoba-Nagzira corridor.
2. Identify the factors influencing tiger occupancy in this landscape.
3. Assess tiger-connectivity based on habitat and occupancy.

Project area:

Tadoba-Andhari - Nagzira-Nawegaon Corridor

Tadoba-Nagzira corridor lies within administrative boundaries of five eastern-districts of the state of Maharashtra; with human population of around 1,04,53,660 (Census of India, 2011). Including the PAs, the corridor between Tadoba-Andhari Tiger reserve and Nagzira-Nawegaon has around 5500 km² of forested area passing through Chandrapur, Bramhapuri, Gadchiroli, Bhandara and Gondia forest divisions and runs parallel to the forest tracts in the state of Chhattisgarh.In this landscape, Kanha, Pench and Tadoba are classified as Class I Tiger conservation Landscapes (TCL) by Sanderson et al. (2006). Nagzira and Nawegaon fall under Class IV TCL due to lack of data on status of tigers, the rest of the study area falls under Class IV and Tiger Survey priority. The corridor between Tadoba Andhari Tiger Reserve and Nagzira-Nawegaon Wildlife Sanctuary holds a very strategic importance due to its geographic location; this area is an important part of global priority landscape for tigers, linking two main tiger-source populations in the central India landscape, the Tadoba Andhari Tiger Reserve and the Kanha Tiger Reserve.More than 75% of study site is outside Protected Areas.The corridor comprises of four PAs, Nagzira WLS, Nawegaon NP, Umred-Karhandla WLS and Tadoba-Andhari Tiger Reserve; apart from these PAs, recently new PAs have been declared like the New Nagzira WLS, Nawegaon WLS and Koka WLS which are also part of this corridor.

Majority of the area consists of tropical dry deciduous vegetation and monoculture plantations of timber trees. Some parts are dominated by Bamboo (*Dendrocalamus strictus*). Dominant tree species include *Anogeissus latifola, Butea monosperma, Diospyros melanoxylon*, *Emblica officinalis*, *Madhuca indica*, *Tectona grandis*, *Terminalia tomentosa*, *Lagerstroemia parviflora*, etc.

Nagzira and Tadoba-Andhari both have breeding tiger populations. Although these PAs provide their share of prey and habitat, the end is not sufficient enough to prevent Tiger population from isolation incase of lack of connectivity. Apart from PAs, rest of the areas lies with the Territorial division and the Forest Development Corporation of Maharashtra (FDCM). There are highways both National and State, railwaylines, mines, dams and associated long distance canals, and human settlements that are present in this corridor.

Conservation issues regarding wildlife-corridors are now gathering great momentum worldwide as fragmentations not only affect the movement and gene flow of large carnivores like tigers, but of also other species including herbivores

Fig. 1: Tiger pugmark in the Tadoba-Andhari TR

METHODS

a. Determining tiger-distribution and factors affecting tiger-occupancy

Population parameters such as abundance and density are difficult to assess over large landscapes due to logistical constraints (MacKenzie et al. 2006). Therefore the proportion of area occupied by the species is often used as a surrogate to assess its population status and distribution (MacKenzie et al. 2006) using simple surveys of animal presence based on easily detectable signs such as tracks, dung, etc.

Sampling design and data collection: Fig. 2 (in page# 22) shows the outlines of the study area with survey-grid overlaid on it. Each grid-cell measures188 km², considering that it encompasses the maximum home range of a tiger (adult male) (MacKenzie et al. 2006 and Karanth et al. 2008). Percentage of forest cover within each grid was calculated and grids with more than 10 km² forest cover or >10% forest cover were chosen for the survey (Karanth et al. 2008) as these are likely to harbor a female individual and also offer ample cover to a dispersing individual.

Depending on the percent forest-cover, the effort in terms of trails walked in each grid varied from 4 km (minimum) to 40 km (maximum) (Karanth et al. 2008). Tiger-signs and other covariate information such as disturbance indicators and correlates such as signs of prey were recorded along the trails; because tiger signs can be easily detected on trails (Karanth and Nichols 2002). Each of the 55 grids (Fig. 2 in pg# 22) was sampled and detection information on tiger presence and covariate information were recorded for every 100m segment. Temporal replicates are preferred for occupancy, but due to logistical constraints it is not feasible for most of the large scale surveys. Therefore spatial replicates are conducted across each site (Kendall and White 2009, Hines et al. 2010). Each grid was further divided into four sub-grids of equal area and all four were sampled.

Data Analysis

Occupancy models developed by Hines et al. (2010) which is refinement of the standard occupancy model by MacKenzie et al. (2002) were used for data analyses. The analyses were performed using program PRESENCE ver 6.2 (Hines 2006).

For estimating tiger-occupancy the data was clubbed into 1km segments. First, to understand the role of covariates in determining probability of detecting tiger-signs, probability of detecting tiger sign (Pt) was modelled based on covariates from global model, using Hines et al.(2010). Covariates used were: All prey species (AP), Large Prey (LP), Livestock (LVS), proportion of Habitat (PoH), Human Presence (HP) and Disturbance (DistB). The best model was selected based on Akaike Information Criterion (AIC).The covariates from the best model obtained in the above step for Pt were kept constant while running the occupancy models for tiger occupancy (ψ).

b. **Tiger-connectivity based on habitat and occupancy**

Using remotely sensed data in a Geographical Information System (GIS) framework the landscape was classified into two categories of forest and non-forest. Then the survey grids (188 km^2) were overlaid on the forest layer. Each grid was assigned the respective estimated value of ψ obtained from the best model based on AIC criterion.

Circuit theory was used to estimate amount of current flow, in this case amount of connectivity in the landscape using the program CIRCUITSCAPE ver 3.5.8 (McRae et al. 2008). The ψ values were used to create a resistance/conductance surface. The Protected Areas were used as nodes and maps of current flow were developed. Based on the net current-flow, critical areas for tiger connectivity were identified.

c. **Camera-trapping**

Opportunistic camera-trapping was done to obtain secondary data on tiger presence, possibly at individual level. Camera traps were deployed at locations where the chance of getting a tiger photograph was maximum; additionally camera-traps were placed on cattle-kills as the frequency of livestock depredation by tigers was quite high in particular sites.

Fig. 3: A leopard (Panthera pardus) roaming in the Tadoba-Andhari Tiger reserve.

RESULTS AND DISCUSSION

To understand the influence of various covariates on detection probability (Pt), several models were explored by keeping the covariate structure for ψ constant and changing the covariates for replicate level detection probability (Pt). Out of all the possible combinations, the top-ranked model showed that the combined influence of All Prey (AP), Livestock (LVS) and Proportion of Habitat (PoH) was highest on the detection probability with an AIC weight of 0.5848 (Table 1).

Keeping the covariate structure for Ptconstant, models for tiger occupancy (ψ) with varying covariate structure were explored. The model with covariate structure of combination of Large Prey (LP), Disturbance (DistB), Proportion of Habitat (PoH) and Livestock (LVS) emerged as the top-ranked model with AIC weight of 0.5854 (Table 2).

Table 1: Effect of covariates on tiger detection

Model	AIC	∆ AIC	AIC weight	Model Likeli hood	No. Of Para meters	-2*Log Like
ψ (AP + LVS +DistB + PoH),ϴ(.),ϴ’(.),pt(AP + LVS + PoH)	697.9	0	0.5848	1	8	681.9
ψ (AP + LVS +DistB + PoH),ϴ(.),ϴ’(.),pt(AP + LVS +DistB + PoH)	698.59	0.69	0.4141	0.7082	9	680.59
ψ (AP + LVS +DistB + PoH),ϴ(.),ϴ’(.),pt(AP + PoH)	710.61	12.71	0.001	0.0017	7	696.61
ψ (AP + LVS +DistB + PoH),ϴ(.),ϴ’(.),pt(AP + LVS)	717.51	19.61	0	0.0001	7	703.51
ψ (AP + LVS +DistB + PoH),ϴ(.),ϴ’(.),pt(AP)	717.84	19.94	0	0	6	705.84
ψ (AP + LVS +DistB + PoH),ϴ(.),ϴ’(.),pt(AP + DistBb)	719.44	21.54	0	0	7	705.44
ψ (AP + LVS +DistB + PoH),ϴ(.),ϴ'(.),pt(LVS)	747.67	49.77	0	0	6	735.67

ψ (AP + LVS +DistB + PoH),Ө(.),Ө'(.), pt(PoH)	749.65	51.75	0	0	6	737.65
ψ (AP + LVS +DistB+ PoH),Ө(.),Ө'(.), pt(DistBb)	749.91	52.01	0	0	6	737.91
ψ (AP + LVS+DistB+ PoH),Ө(.),Ө'(.), pt(LP)	750.3	52.4	0	0	6	738.3
ψ (AP + LVS +DistB+ PoH),Ө(.),Ө'(.), pt(DistBb + PoH)	750.42	52.52	0	0	7	736.42
ψ (AP + LVS +DistB+ PoH),Ө(.),Ө'(.), pt(DistBb + LVS+PoH)	750.85	52.95	0	0	8	734.85
ψ (AP + LVS +DistB + PoH),Ө(.),Ө'(.),pt(LP + LVS + PoH)	751.49	53.59	0	0	8	735.49
ψ (AP + LVS +DistB + PoH),Ө(.),Ө'(.),pt(LP + LVS +DistB + PoH)	751.98	54.08	0	0	9	733.98
ψ (AP + LVS +DistB + PoH),Ө(.),Ө'(.),pt(.)	25806.95	25109	0	0	9	25788.95

Table 2: Effect of covariates on tiger presence (ψ)

Model	AIC	∆ AIC	AIC weight	Model Likeli hood	No. Of Para meters	-2*Log Like
ψ(LP + DistB + PoH + LVS),Ө(.),Ө’(.), pi(AP+LVS+PoH)	695.78	0	0.5854	1	8	679.78
ψ(AP + DistB + PoH + LVS),Ө(.),Ө’(.), pi(AP+LVS+PoH)	697.9	2.12	0.2028	0.3465	8	681.9
ψ(AP + PoH + LVS),Ө(.), Ө’(.), pi(AP+LVS+PoH)	698.06	2.28	0.1872	0.3198	7	684.06

ψ(LP + HP + PoH + LVS),Ɵ(.),Ɵ’(.), pi(AP+LVS+PoH)	702.61	6.83	0.0192	0.0329	8	686.61
ψ(LP + PoH + LVS),Ɵ(.),Ɵ’(.), pi(AP+LVS+PoH)	705.43	9.65	0.0047	0.008	7	691.43
ψ(LP + DistB + PoH),Ɵ(.),Ɵ’(.),pi(AP+ LVS+PoH)	711.72	15.94	0.0002	0.0003	7	697.72
ψ(LP + PoH),Ɵ(.),Ɵ’(.), pi(AP+LVS+PoH)	712.2	16.42	0.0002	0.0003	6	700.2
ψ(LP + DistB + PoH + Goat),Ɵ(.),Ɵ’(.),pi(AP+ LVS+PoH)	713.21	17.43	0.0001	0.0002	8	697.21
ψ(AP + PoH),Ɵ(.),Ɵ’(.), pi(AP+LVS+PoH)	718.6	22.82	0	0	6	706.6
ψ(LP + HP),Ɵ(.),Ɵ’(.), pi(AP+LVS+PoH)	719.02	23.24	0	0	6	707.02
ψ(AP + DistB + H),Ɵ(.), Ɵ’(.),pi(AP+LVS+PoH)	719.42	23.64	0	0	7	705.42
ψ(AP + DistB),Ɵ(.),Ɵ’(.), pi(AP+LVS+PoH)	730.47	34.69	0	0	6	718.47
ψ(AP),Ɵ(.),Ɵ’(.),pi(AP+ LVS+PoH)	732.29	36.51	0	0	5	722.29
ψ(LVS),Ɵ(.),Ɵ’(.),pi(AP+ LVS+PoH)	737.53	41.75	0	0	5	727.53
ψ(LVS + PoH),Ɵ(.),Ɵ’(.), pi(AP+LVS+PoH)	738.25	42.47	0	0	6	726.25
ψ(DistB),Ɵ(.),Ɵ’(.), pi(AP+LVS+PoH)	739.05	43.27	0	0	5	729.05
ψ(PoH),Ɵ(.),Ɵ’(.), pi(AP+LVS+PoH)	739.06	43.28	0	0	5	729.06
ψ(DistB + PoH + LVS),Ɵ(.),Ɵ’(.),pi(AP+ LVS+PoH)	739.68	43.9	0	0	7	725.68
ψ(.),Ɵ(.),Ɵ’(.),pi(AP+ LVS+PoH)	25799	25103	0	0	5	25788.95

To understand the main factors influencing tiger occupancy in this landscape, we examined β-coefficient values for the covariates of the top-ranked model for ψ (Table 3). Disturbance (DistB) had a negative effect on tiger occupancy while Large Prey (LP) and proportion of tiger habitat (PoH) were positively correlated. Livestock (LVS) was positively correlated with tiger occupancy, which is not in concordance with other studies carried out on tiger occupancy.

Table 3: β coefficient values for covariates influencing tiger occupancy (ψ)

Sr. No.	Covariate	β coefficient	SE
1	LP	0.427326	0.151624
2	DistB	-1.373073	0.535989
3	PoH	0.081682	0.037667
4	LVS	4.20697	1.643816

The positive correlation of livestock with tiger occupancy can be explained by heavy dependence of tigers on cattle as prey. Compensation records reveal the degree of dependence of large carnivores on livestock in this landscape and raise some serious questions about the status of wild-ungulates in the areas outside PAs. Large number of cattle-kills by tiger and leopard along with low encounter rates of wild-ungulates suggest that these large carnivores are primarily feeding on livestock.Among all the forest divisions in this corridor, cattle depredation is highest in the Bramhapuri division.

Table 4: Compensation records for livestock depredation in Bramhapuri forest division

Year	Number of cattle-kills	Compensation amount in INR
2008-09	295	1408781
2009-10	305	1324063
2010-11	562	2586177
2011-12	506	2778325
2012-13	523	3061500

Fig. 4: Livestock depredation in Bramhapuri forest division

Site specific ψ values showing tiger occupancy for each grid cells reflects the nature of distribution of tiger occupancy across the corridor (Fig. 5 in pg# 23). It is clear that most of the areas with high tiger-occupancy are clustered around Tadoba and Nagzira.

Areas around TATR including buffer zone and Bramhapuri division show high tiger-occupancy. There is sudden drop in occupancy towards east of Bramhapuri in the Gadchiroli forest division (Fig. 6 in pg# 23) which continues up north till Nagzira where tiger occupancy again increases. This sudden drop in occupancy is mainly due to low number of large prey species. One major factor which could explain the low occupancy in Gadchiroli and Nawegaon is the long history of traditional hunting carried out by locals in these areas; although this is out of the purview of this study, it is worth exploring to understand its influence on large carnivores and their prey, in this landscape.

Critical areas

Simply looking at the forest cover, there are several gaps in the forest cover. The Circuitscape results help us to identify and prioritize areas which are important for maintaining connectivity. The map of the current flow (Fig. 7 in pg# 24) highlights breakages which would otherwise join key tiger areas. The forest boundaries (in green) overlaid on the Circuitscape map helps us to pinpoint exact locations of these pinch points.

Higher the current flow means higher connectivity. But there are areas with higher current flow but no forest cover, these are critical areas which need restoration and thus need to be given priority while planning conservation interventions.

There are four major zones where forest connectivity is severely affected and needs immediate attention. Out of these three locations, two locations are around the river Wainganga(Fig. 8 in pg# 24); one separating the South-Bramhapuri range (Bramhapuri Div.) from the Porla range (Gadchiroli Div.) are separating Pauni range (Bhandara Div.) and North-Bramhapuri range (Bramhapuri Div.) from Lakhandur range (Bhandara Div.) and Arjuni-Morgaon range (Gondia Div.).

Third disconnected zone is between Lakhandur range (Bhandara Div.), Arjuni-Morgaon range (Gondia Div.) and Adyal range (Bhandara Div.)

Fourth zone is between Adyal range (Bhandara Div.) and Kokka WLS.

Intact but narrow forest patches:

Intact but narrow patchesare highly prone to fragmentation given the heavy extractive pressures. Among several such linear patches in this corridor, there are two important ones.

First one is the forest starting from Gangasagar-heti beat in Talodhi range (Bramhapuri Div.) going towards Ghodazari reservoir in Nagbhid range (Bramhapuri Div.) and then going south to Govindpur Round (Talodhi range, Bramhapuri Div.), Nawargaon Round (Sindewahi range, Bramhapuri Div.) further connecting Palasgaon and Shioni range of Tadoba buffer.

The second such important connecting link is the Nagzira-Nawegaon corridor. This corridor is of prime importance in linking not only these two PAs but also TATR and PAs north of this corridor.

Camera trapping

Camera trapping was mostly concentrated in the Bramhapuri forest division. Due to limited resources we did opportunistic camera trapping; this involved, camera trapping on cattle-kills, water-holes and frequently used trails.

In all 27 individuals were identified (Annexure-1). Apart from these 27 individuals, tiger-cubs were photographed at three different locations. There was also an existing database of tiger photographs captures on cattle kills which was maintained by the Bramhapuri division since 2009. This dataset was filtered; compiled yearly and then unique individuals were identified. Each individual was given a unique ID and year wise capture locations were mapped to understand their movement patterns. The data shows that several adults captured in this season are previously photographed when they were cubs. 3 individuals have dispersed or move between Bramhapuri and TATR buffer. This is not in conjunction with the theory that areas outside Tadoba are just sinks; it shows that these areas outside PAs are also supporting breeding tigers.

Fig. 9: Camera trap picture of a tiger in Brahmapuri Forest Division

THREATS AND POSSIBLE SOLUTIONS

Increasing anthropogenic pressures, development activities, encroachment and hunting have resulted in habitat-fragmentation and decline in abundance and distribution of wild animals. Some notable threats posing serious damage to this tiger corridor and possible solutions to these problems are discussed here.

- **Thinning and degradation**: After fragmentation, major but highly underestimated threat to the corridors is the thinning of the forests, further leading to degradation.

    - ***Fuel-wood extraction*** is the main cause of forest-thinning. Local communities are highly dependent on forests for fuel-wood. Recently Maharashtra State Government has started implementing a scheme where communities adjacent to forests get LPG at subsidized rates. Although this scheme will have a positive effect but due to lack of enforcement measures on cutting of fuel-wood, this great scheme will not have the desired outcome.

      As of today with almost no check on the fuel-wood extraction, it is a free commodity. Apart from household use, the wood is in high demand in local markets and especially in Dhabas(roadside restaurants). The LPG scheme might have an effect on the household usage of the fuel-wood but it still it does not reduce the demand for fuel-wood; as it presents the opportunity to generate income from a free resource.

      Camera trap images reveal that large quantities of wood are transported on bicycles on almost daily basis. On several occasions same group of people were captured with cycle-loads of fuel-wood every day. With each cycle-load yielding about 250-300 Rs, it's an attractive business.

The solution for this problem is to take strict action against wood extraction no matter how small the quantity is. Major hurdle in implementation is that most of the extraction is carried out by women

Fig. 10: Fuelwood collection by women from the local community

and this needs well trained ladies-guards to take action on field. Most of the forest guards neglect this due to heavy interference of local politicians.

- ***Bamboo extraction*** is another activity which leads to forest-thinning (Fig. 11). Large quantities of bamboo are extracted to make bamboo-mats. These mats are then collected by a dealer at the rate of about 150 Rs/mat. These mats are mostly used to make house-compounds.

- ***Setting fire*** to the forest during collection of Tendu (*Diospyros melonoxylon*) leaves and Mahua (*Madhuca longifolia*) flowers is a common practice in these areas (Fig.12). These man-made fire leads to immense destruction and wipes out the undergrowth. These fires are set in the summer season which makes it difficult for wild ungulates to survive as whatever little undergrowth is present in the dry season gets burnt. Burning for Mahua is completely unnecessary; these fires are set to clean the area under the tree so the flowers can be collected easily. With a simple broom one can clear the area in less than 10 min. Tendu collectors believe that after fire new Tendu shoots grow which are of better quality and yield more. But recent field based experiments shows that even unburnt areas yield same quantities of Tendu leaves.

Fig. 11: Bamboo extraction by local villagers to make mats.

Fig. 12: Man-made fires in the forest to clean the area to collect Mahua flowers and Tendu leaves

• ***Monoculture and clear-felling***: Several reserve forests have been given out on lease to the Forest Development Corporation of Maharashtra (FDCM). Since 1974, large scale clear felling for teak plantation has been practiced by FDCM. Several areas where working of the FDCM is carried out are the areas used by tigers. Recently there was large scale timber extraction from the areas adjacent to the *Shinbodi* Lake in the *Sindewahi* range of the Bramhapuri division (Figure 13). This area is known for its tiger presence and has also supported breeding tigers. No tiger individual was recorded in this area due to heavy disturbance and destruction due to tree-felling.

Most of the compartments with mixed vegetation are converted into monoculture. Those areas where of low plantation success become scrub. Such degraded compartments where FDCM cannot generate revenue are given back to the territorial division and new better compartments are allotted. This can be compared to large scale *Jhum* cultivation.

Fig.13: Timber extraction from the areas adjacent to the Shinbodi Lake in the Sindewahi range of the Bramhapuri division

In future no new areas should be allotted for such activities. There is a need to change the ways of present working operations which reduces biodiversity and food availability for principal tiger-prey species. Areas with teak plantations, should be revived with native tree species. Bamboo and fruit-trees should also be given priority in the working plans. It is high time that new roles should be given to the FDCM, which will help meet conservation targets.

• ***Roads and railways***: With several villages being connected with metaled-road, there has been an increase in vehicular traffic even in remote forest areas leading to regular road-kills of wild-animals. Speed breakers and signboards on roads passing through areas with high tiger occupancy will help reduce mortalities but in future with increasing traffic, the only viable solution for mitigating effect of roads is to buid flyovers with sufficient height which will allow both the vehicles and animals to pass safely. National Highway 6, State Highway 9 and 233 are roads with heavy traffic which cut-across main forest linkages in this corridor (Fig. 14 in pg# 25). NH 6 on which is proposed to be expanded cuts the Nagzira-Nawegaon corridor. SH 9 cuts the prime linkage of the TATR with Bramhapuri division and SH 233 cuts the Bramhapuri – Umred-Karhandla corridor. With increase in vehicular traffic and road-connectivity, roads like the Sindewahi-Pathri road and Sindewahi-Gunjewahi road will pose serious threat in near future.

Upgradation of narrow gauge railways to broad-gauge like the Gondia-Chandrapur line will lead to increase in animal mortalities as it will lead to increase in train frequencies, speed and number of bogies. Strict implementation of speed limits on trains while passing through forest will help to reduce animal mortalities effectively.

• ***Dams and irrigation canals***: Human (Uma) river is one of the tributaries of the river Waingangā river passing through the TATR – Bramhapuri corridor. There was proposal to build a dam (Human Dam) at the edge of the TATR buffer near Piparda village (Fig.15 in pg# 25).This project has serious impact on this critical tiger habitat. Most important and fatal impact will be loss of habitat connectivity of Tadoba tiger population with Bramhapuri forest division. Submergence of critical forest land will also result in loss of biodiversity and space of residential tigers. Camera trapping data shows that 3 tigers are residential in the area which will be submerged and that 3 individuals have dispersed from Bramhapuri to TATR buffer on other side of this river; making it an important area for tiger connectivity.

There was lot of opposition for this project and the project was temporarily stopped as the irrigation department was unable to deposit the proposed Net Present Value (NPV) cost. Now as the area is partly under the limits of the TATR buffer, it will require prior permission from the standing committee of National Board for Wildlife (NBWL).

Vast stretch of forest-land has been diverted for the construction of the Gosekhurd irrigation canals. This canal start from the Gosekhurd dam on the Waingangā river near the Umred-Karhandla WLS and pass through the forest bifurcating the Bramhapuri division into 3 fragments (Fig. 16 in pg# 26). Till the canal reaches the Bramhapuri it splits in to two, the Right Bank Canal (RBC) and the Left Bank Canal (LBC) both running in the north-south direction through the forest. These canals are deep with steep concrete walls which is a death trap for wild animals. There has been already a case of tiger getting trapped in the canal and several other animals. Safe crossing-paths should be created for wild-animals at regular intervals. These bridges should be sufficiently wide for animals to be comfortable to use them.

- ***Hunting***: Hunting of herbivores poses a continuous threat. The occupancy results show that the presence of prey species is critical for tiger-occupancy. Snares are set regularly for catching hare and nets are used to catch wild-pig (Fig. 17). These activities go unnoticed but have a profound effect on abundance of wildlife. During the survey several snares and nets were detected. Effective patrolling and training in law and enforcement should be given to the staff of the Territorial divisions.

- ***Mines***: Mines situated in critical forest corridors cause irreparable damage to the habitat. Infrastructure developed around the mines leads to chain of activities which causes fragmentation and disturbance. Coal mining on the northern side of TATR near Khadsangi, mining for ore

Fig. 17: Snares placed on forest trails for Hares; many times Chital or Sambar gets trapped in such traps.

near the Deulgaon and Dongar-Sawangi villages in the Armori range of Gadchiroli, stone quarries near the Kanpa-Tempa village in the Nagbhid range of Bramhapuri, mining near Asolamendha reservoir in the Sindewahi range of Bramhapuriare some of the mines in critical areas important for tiger-connectivity (Fig. 18 in pg# 27&28).

Mines near the Deulgaon and Dongar-Sawangi villages in the Armori range of Gadchiroli are on the hill which connect Bramhapuri and Gadchiroli divisions and is one of the prime areas identified by the Circuitscape analysis.

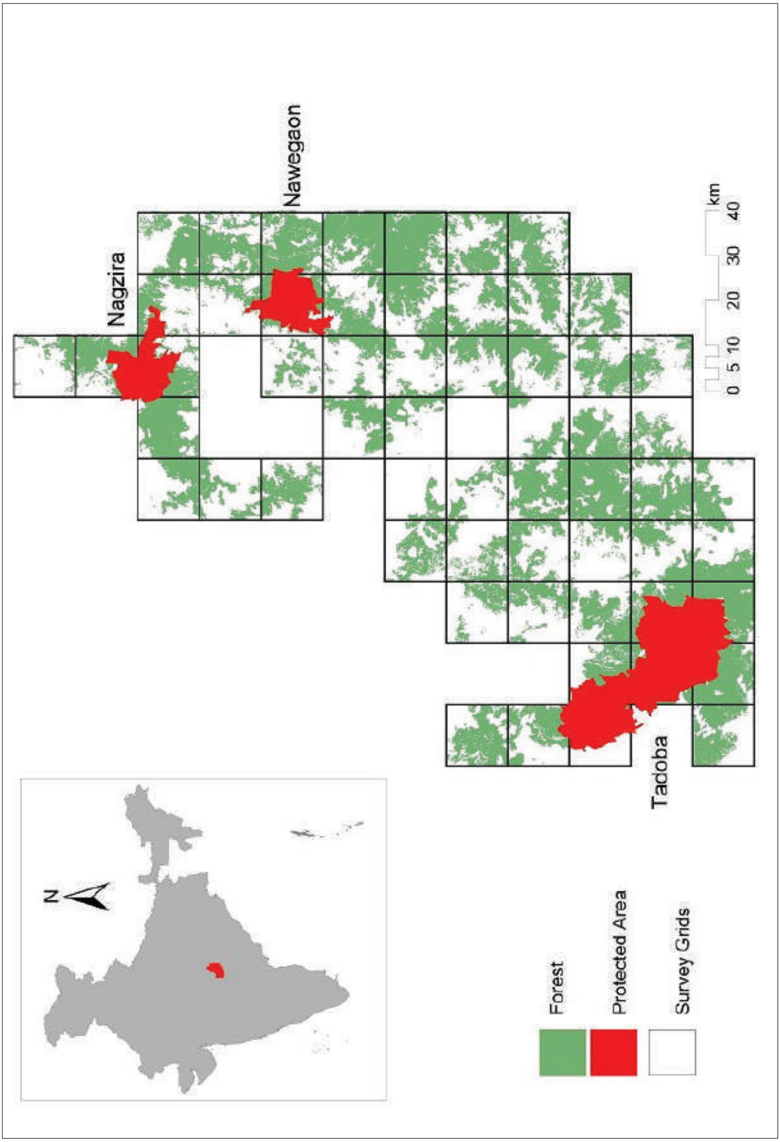

Fig.2: Study area with survey grids, with each grid-cell measuring 188 km²

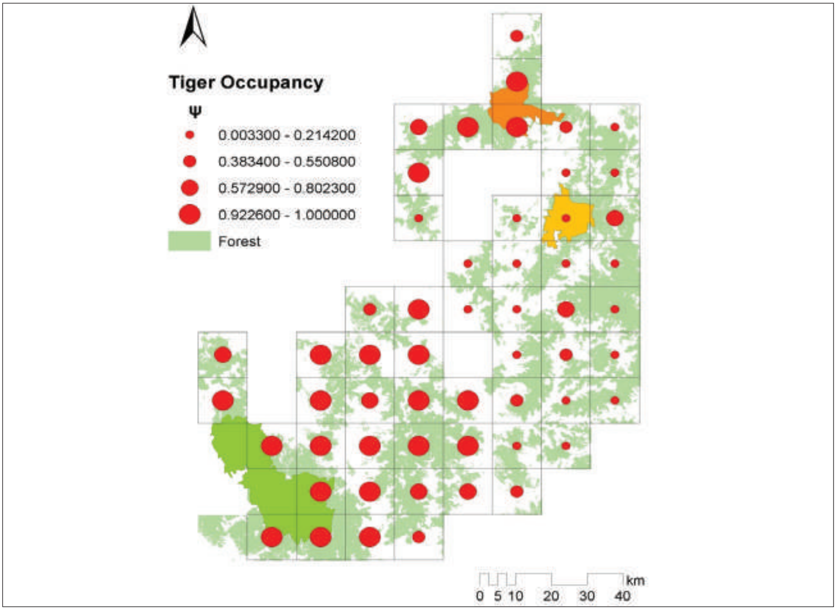

Fig.5: Map showing tiger-occupancy for individual sites (grid-cells)

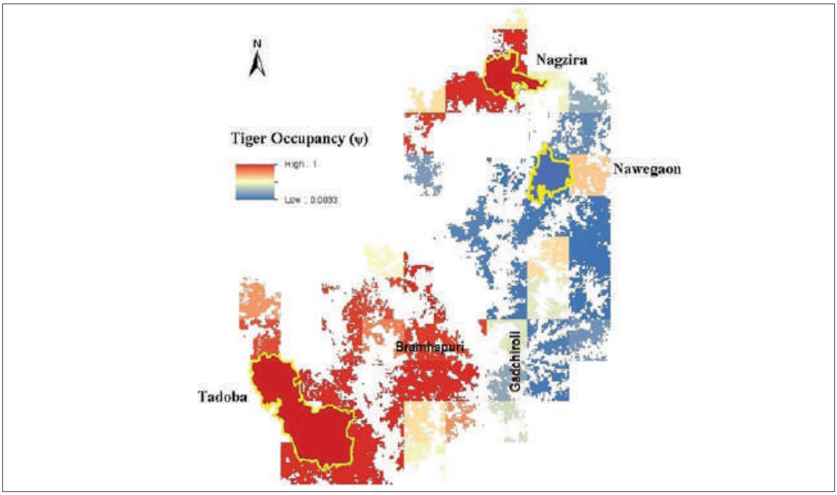

Fig. 6: Map showing forests with high and low tiger-occupancy.

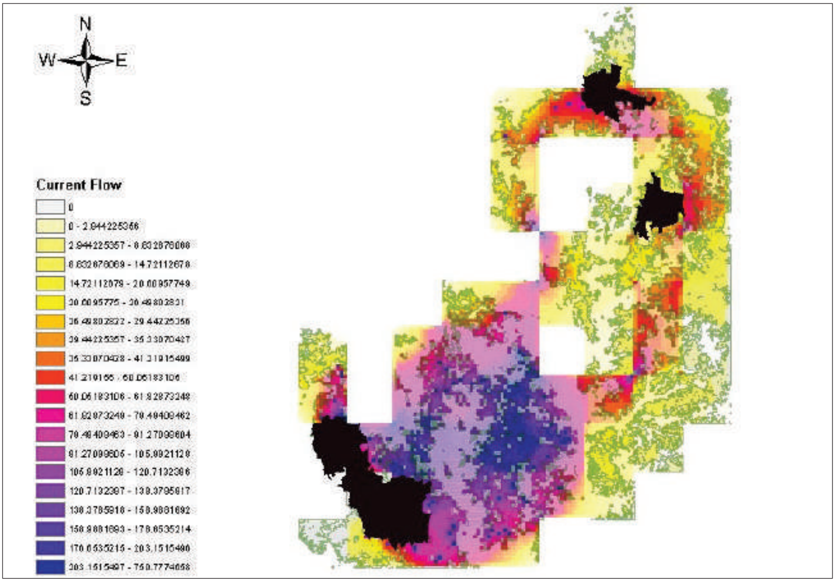

Fig.7: Map showing current flow along with forest boundaries

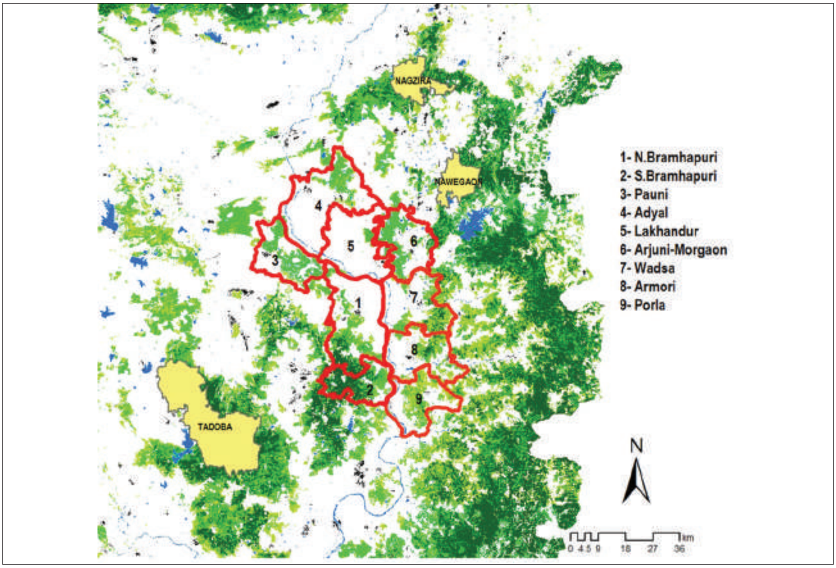

Fig.8: Map showing Critical zones

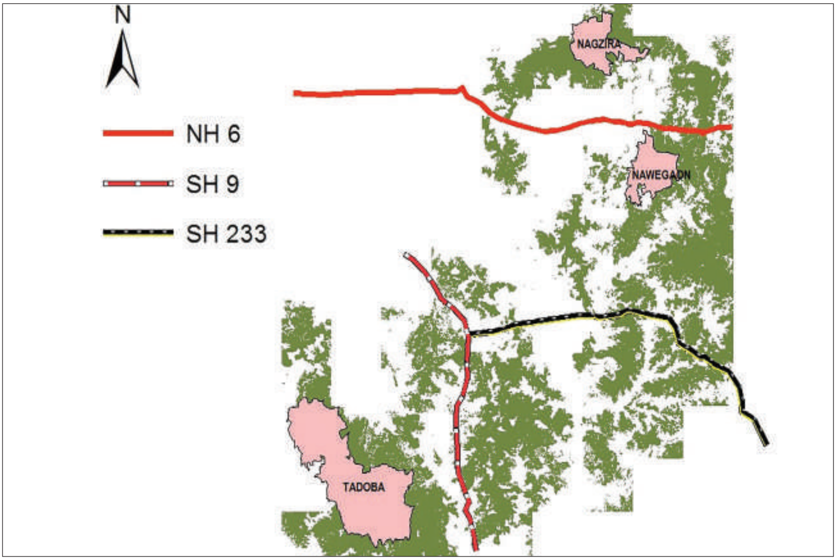

Fig.14: Map depicting National Highway 6, State Highway 9 and 233 with Heavy traffic which cut-across main forest linkage in this corridor in the Sindewahi range of the Bramhapuri Forest Division

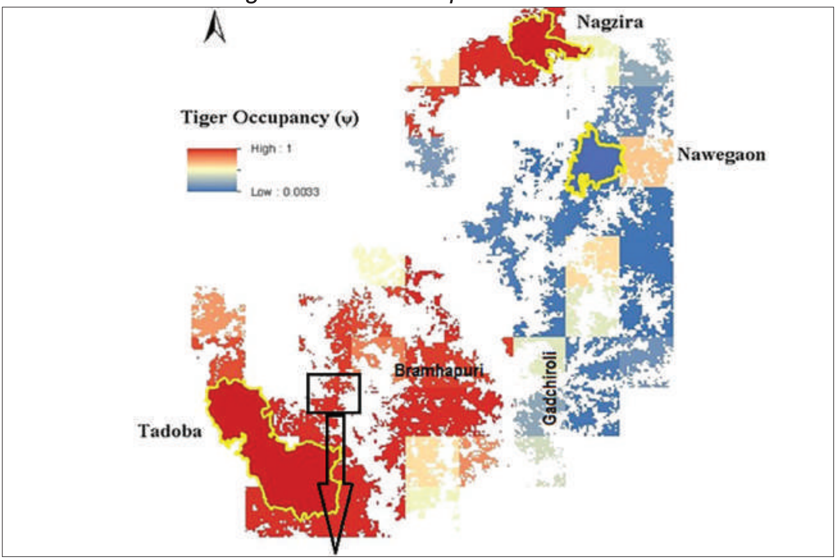

Fig.15: Map depicting proposed Dam to be built on Tadoba-Andhari TR buffer near Piparda village

Fig.15a: Google map depicting proposed Dam to be built on Tadoba-Andhari TR buffer near Piparda village

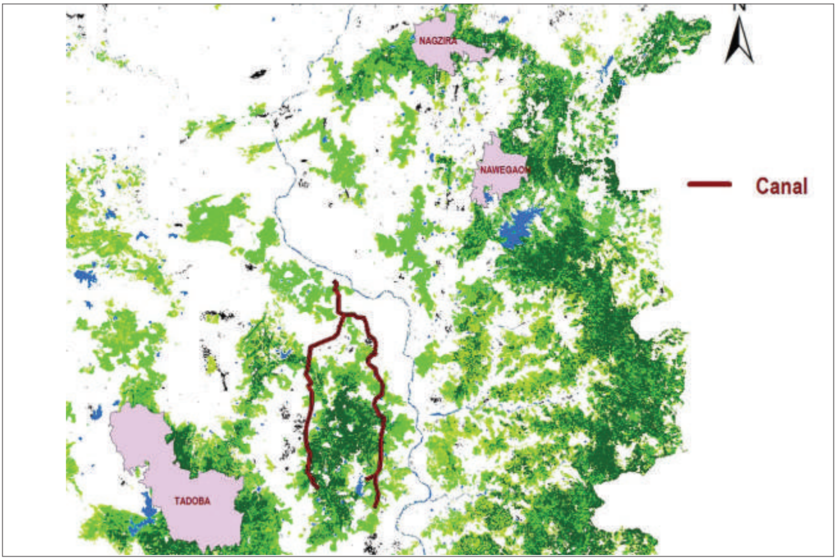

Fig.16: Map showing Gosekhurd irrigation canals

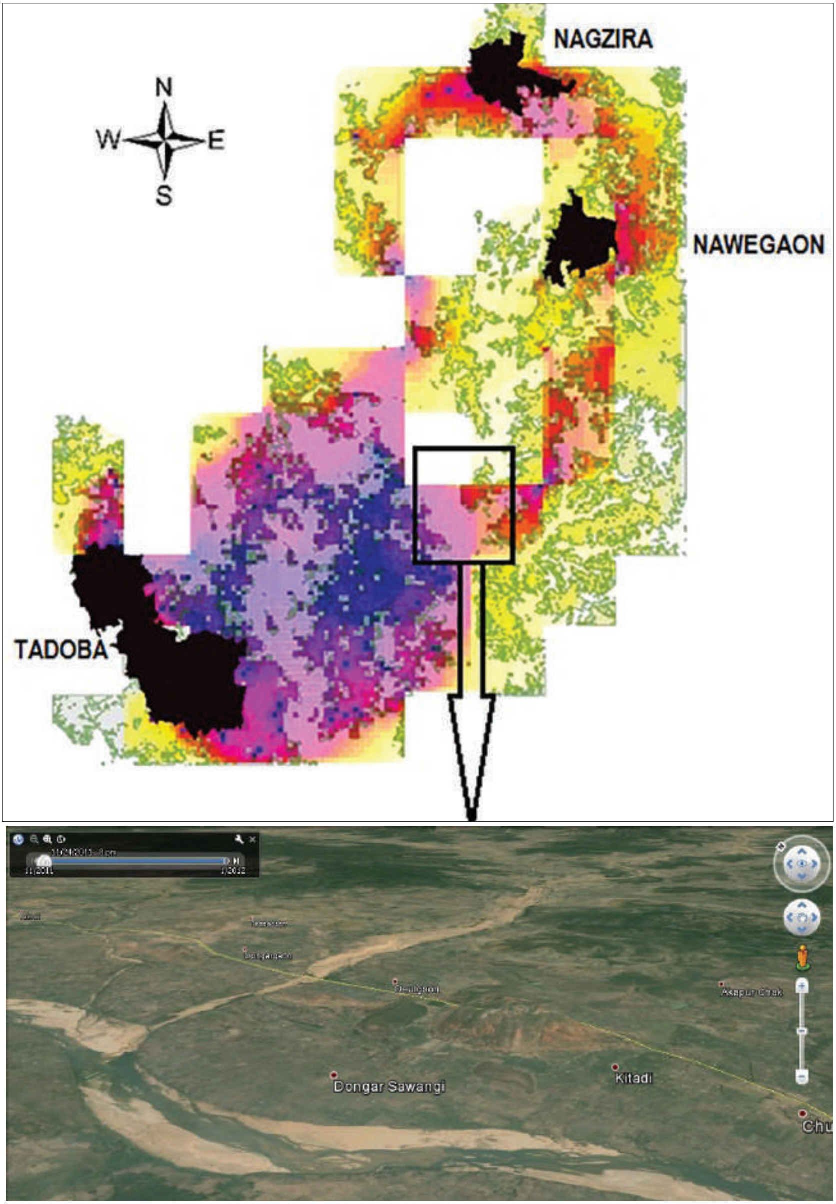

Fig.18: Map depicting mines situated in critical forest corridors

Google map depicting mines situated in critical forest corridors

THE WAY FORWARD

The future of this corridor depends on the physical connectivity of the forests, availability of prey and effective protection. Check on linear developments like roads and irrigation canals are essential. Practical and effective mitigation measures need to be taken to maintain the functional connectivity of the corridor.

Initiation of afforestation programs and strict action against encroachment and fuel-wood extraction will have a positive effect on tiger habitat. Critical areas showing breakage in forest connectivity should be given priority and measures should be taken to fill these gaps wherever possible.

Declaring new PAs or conservation reserves like the area around Ekara in South Bramhapuri range and area around Ghodazari reservoir in Nagbhid range will be key for long-term survival of these tiger-populations.

As tigers in this corridor are highly dependent on livestock, proper and timely relief is essential to avoid any retaliation from locals. Availability of principal tiger-prey species is important to reduce livestock dependence and increase tiger population in this landscape.

Regular and scientific monitoring of tigers is a key to measure the success of conservation interventions and management decisions. Maintaining a database of individuals helps to track individuals over several years and understand how they use the landscape.

Other than effective monitoring, there is a need to train the territorial-staff in law and enforcement techniques. It is important to equip them with essential kits required to effectively patrol their areas and boost their morale.

With two tiger-source PAs on each end, presence of forest patches in-between and areas with breeding tigers outside PAs; this corridor presents a unique opportunity to conserve tigers at a landscape level.

Other corridors in this landscape should be explored to understand their potential and new tiger bearing areas can be identified. If we are to achieve the target of doubling the tiger numbers, it's only through such corridors that we might even have a chance of achieving it.

A tiger cub near a waterbody in the Tadoba-Andhari TR

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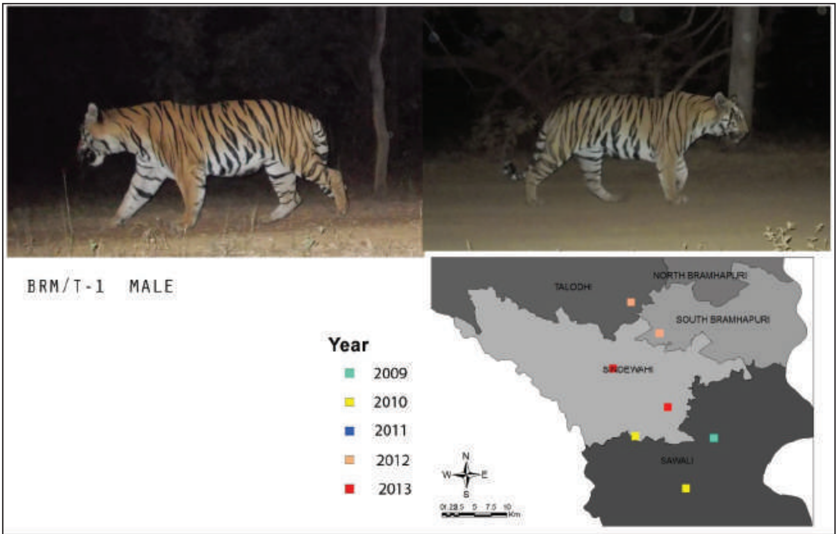
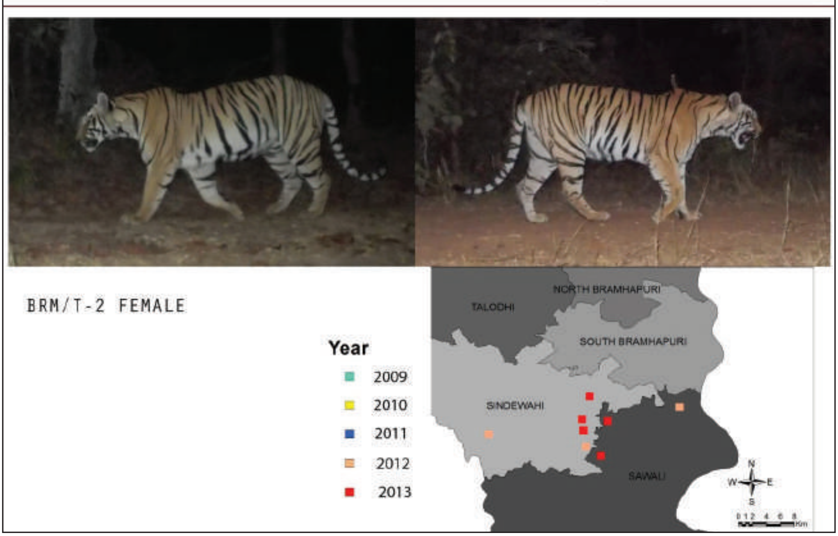
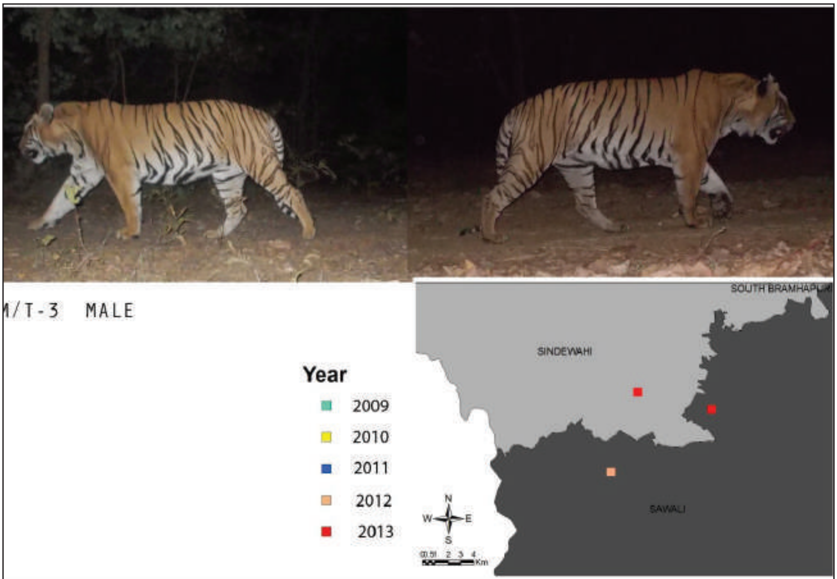
ANNEXURE - I

Camera trap pictures of tigers in Bramhapuri Forest Division



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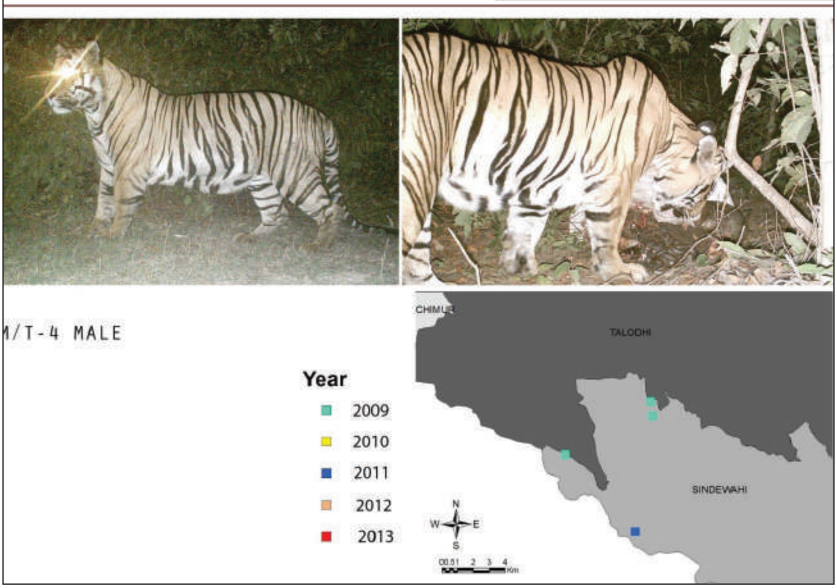
/T-4 MALE
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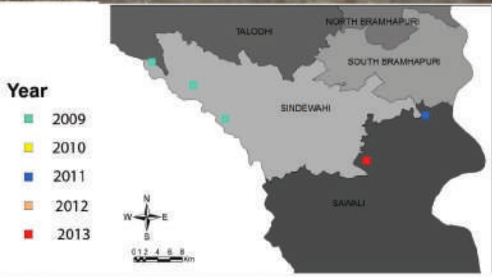
BRM/T-5 FEMALE



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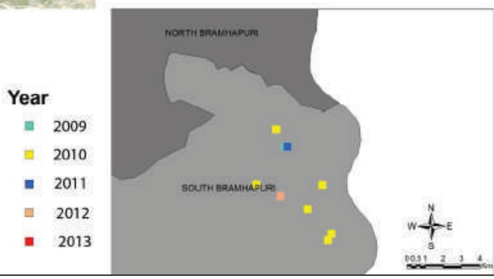
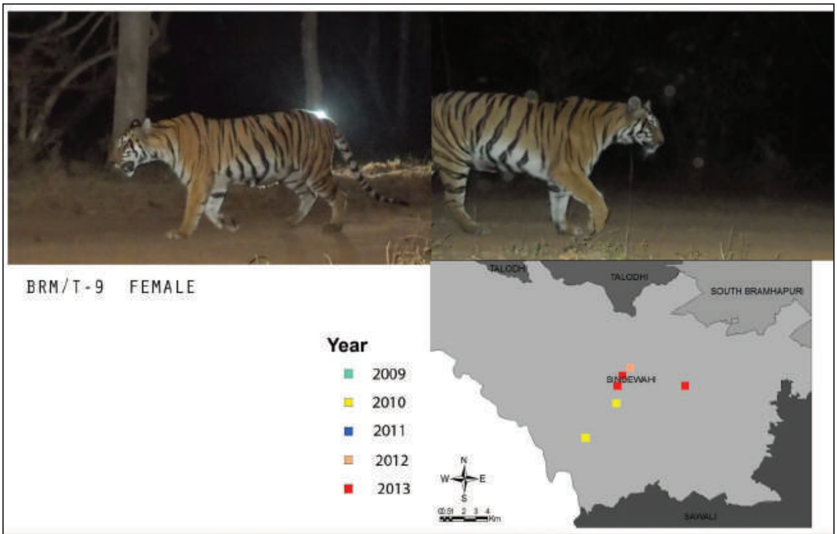
MOTHER OF BRM/T-19

BRM/T-7 MALE

BRM/T-8 FEMALE
MOTHER OF BRM/T-27

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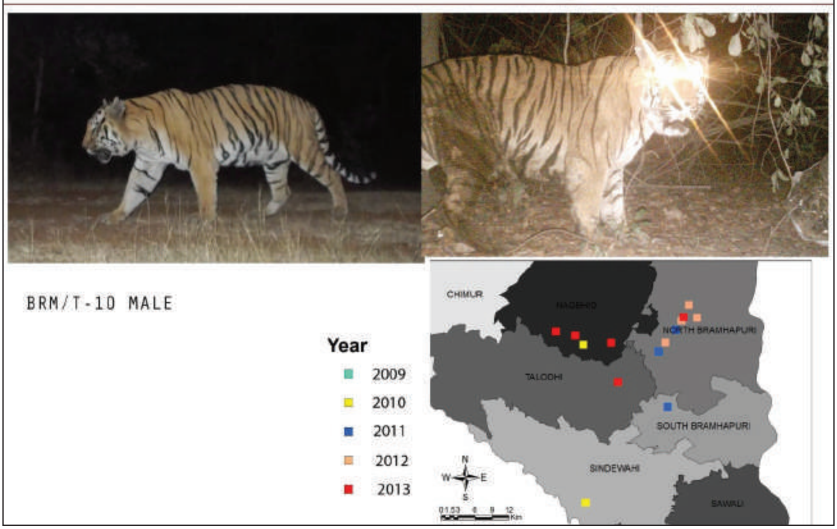
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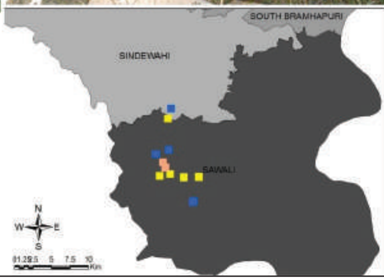

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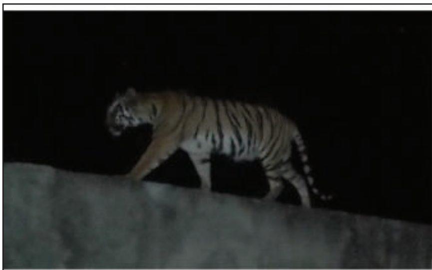
BRM/T-14 FEMALE
RANGE OVERLAPS WITH
PALASGAON (TADOBA BUFFER)



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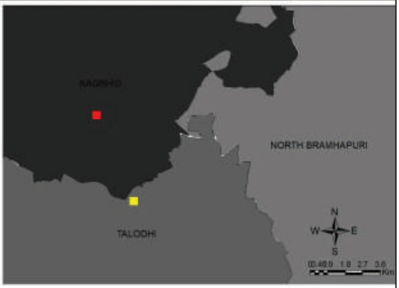

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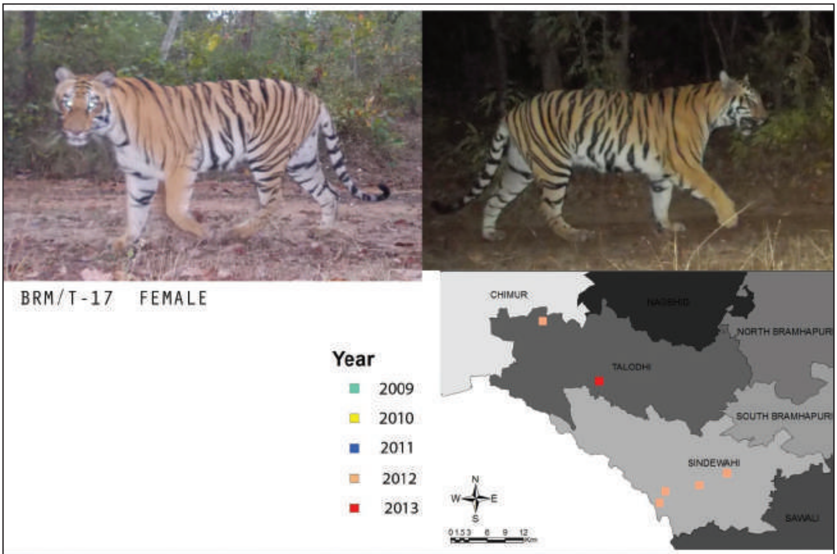
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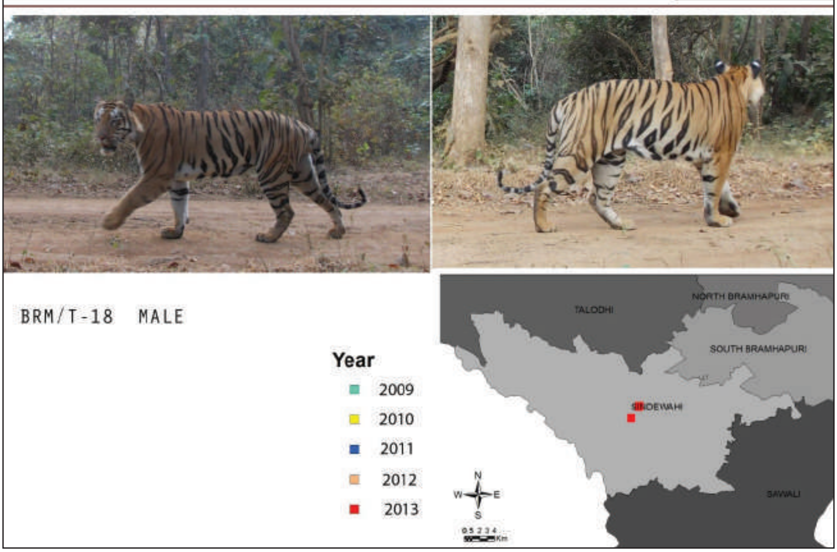
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BRM/T-19 FEMALE

OFFSPRING OF BRM/T-6

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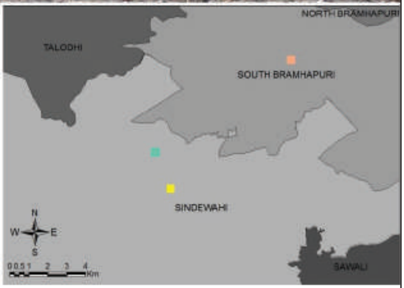

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BRM/T-21 FEMALE

BRM/T-22 MALE

BRM/T-23

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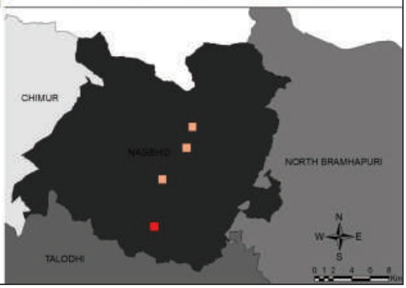
BRM/T-24 FEMALE
KALA



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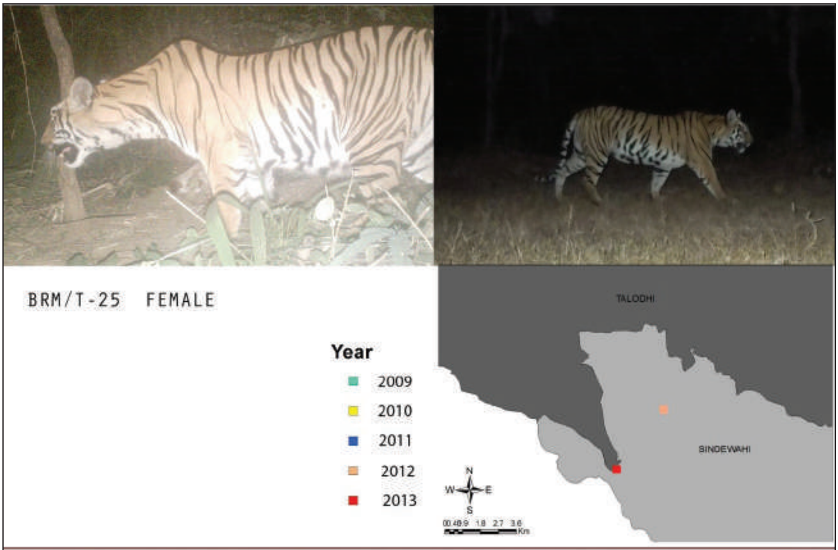
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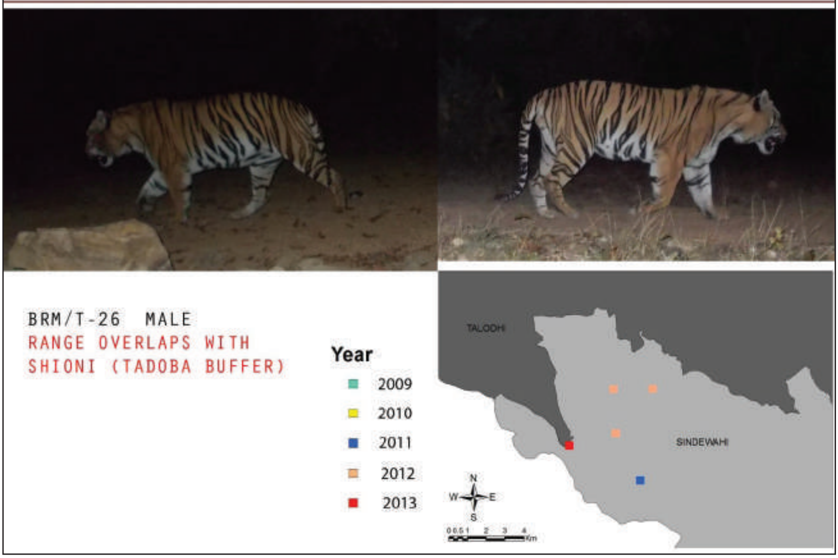
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RANGE OVERLAPS WITH
SHIONI (TADOBA BUFFER)
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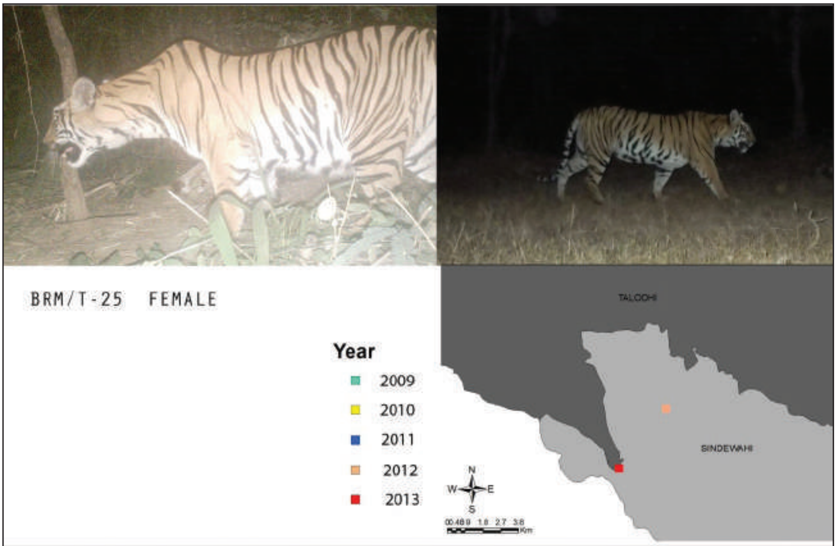
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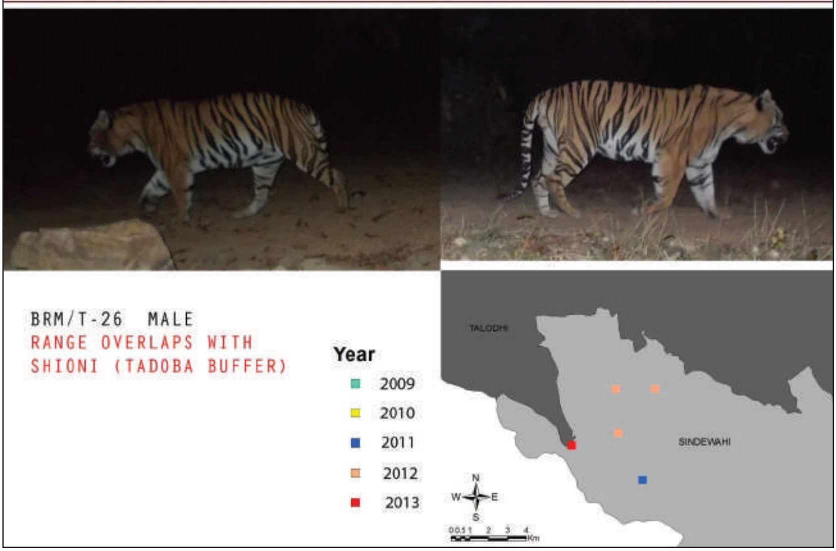
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RANGE OVERLAPS WITH
SHIONI (TADOBA BUFFER)
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BRM/T-27 FEMALE
OFFSPRING OF BRM/T-8

CUBS OF BRM/T-9
2013

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A. OCCASIONAL REPORTS

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Impact assessment around the Jarawa tribal reserve, middle and south Andaman Islands

Captive Concerns:
Health and management of captive elephants in Jaipur

Jumbo Express:
A scientific approach to understanding and mitigating elephant mortality due to train accidents in Rajaji National Park.

Fair Concern:
Health and management of captive elephants in Sonpur

Elephant in Exile:
A rapid assessment of the human-elephant conflict in Chhattisgarh

Ganesha to Bin Laden:
Human-elephant conflict in Sonitpur district of Assam

Healing Touch:
Health and management of captive elephants at Kaziranga elephant festivals

Dog and Bull:
An investigation into carnivore-human conflict in and around Itanagar Wildlife Sanctuary, Arunachal Pradesh

Against the Current:
Otters in the river Cauvery, Karnataka

Making Way
Securing the Chilla-Motichur Corridor to protect elephants of Rajaji National Park

Silent Stranglers:
Eradication of mimosa in Kaziranga National Park, Assam

Living at the Edge:
Rapid survey for the endangered Ladakh urial (*Ovis vignei vignei*) in Leh district of Ladakh Trans-Himalaya

Search for Spectacle:
A conservation survey of the Phayre's leaf monkey (*Tranchypithecus phayrei*) in Assam and Mizoram

Sighting Storks:
Status and distribution of Greater adjutant storks (*Leptoptilos dubius*) in the Ganga and Kosi river floodplains near Bhagalpur, Bihar

Bait and Watch:
Popularization of alternatives to dolphin oil among fishermen for the conservation of the Ganges river dolphin (*Plantanista gangetica*) in Bihar

No Mast Kalandar:
The beginning to the end of dancing with bears

Awaiting Arribadda:
Protection of Olive Ridley turtles (*Lepidochelys olivacea*) and their nesting habitats at Rushikuliya rookery, Orissa

Living with Giants:
Understanding human-elephant conflict in Maharashtra and adjoining areas

Crane Capital:
Conservation strategy for Sarus Crane (*Grus antigone*) habitat in Etawah and Mainpuri Districts, Uttar Pradesh

Deadly Tracks:
A scientific approach to understanding and mitigating elephant mortality due to train hits in Assam

Carnivore Conflict:
Support provided to leopards involved in conflict related cases in Maharashtra

India at the International Whaling commission:
A policy document on India's involvement in the IWC 1981-2003

Hunt for Hangul
Establishing the presence of hangul outside Dachigam National Park, J&K

Bear Necessities
A swcientific approach to understand and mitigate Human Sloth Bear conflict in Madhya Pradesh

B. CONSERVATION ACTION REPORTS

Beyond the Ban:
A census of Shahtoosh workers in Jammu & Kashmir

Biodiversity, Livelihoods and the Law:
The case of the 'Jogi Nath' snake charmers of India

Goats on the Border:
A rapid assessment of the Pir Panjal markhor in Jammu & Kashmir distribution, status and threats

The Ground Beneath the Waves : (2 Volumes)
Post-tsunami impact assessment of wildlife and their habitats in India

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Rehabilitation of Asiatic black bears in Arunachal Pradesh

Mountain Migrants:
Survey of Tibetan Antelope (*Pantholops hodgsonii*) and Wild Yak (*Bos grunniens*) in Ladakh, Jammu & Kashmir, India

Predator Alert:
Attacks on humans by leopard and Asiatic black bear in the Kashmir valley – Analysis of case studies and spatial patterns of elevated conflict

Turning the Tide:
The campaign to save Vhali, the Whale Shark (*Rhincondon Typus)* in Gujarat

Tiger Country:
Helping Save Bhutan's Natural Heritage

Daring to Restore:
Coral Reef Recovery in Mithapur

Gujarat's Gentle Giants:
Conservation of Whale Shark (*Rhincodon typus*) in Gujarat

A Dance to Forget:
The story of the eradication of Sloth Bear dancing from India

Safe Passage, Safe Habitation
Securing the Thirunelli-Kudrakote Elephant Corridor through Voluntary Relocation

Living with the Wild
Mitigating conflict between Humans and Big Cat species in Uttar Pradesh

Back from the Brink
Recovering the Wild Buffalo (*Babalus Arnee*) population in Central India

C. CONSERVATION REFERENCE SERIES

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Studies in wildlife rehabilitation

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Elephant corridors of India

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Responding to poisoning in Asian elephants – A field guide

Commentaries on Wildlife Law:
Cases, statutes & notifications

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Ecology and conservation of Asian elephants in Kameng elephant reserve, Arunachal Pradesh

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Conserving the forest and wildlife of the Bodoland Territorial Council

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Conserving the forest of Garo Hills with elephant and gibbon as flagships

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Crane Constituencies:
Important Sarus Wetland sites in the Agricultural Landscape of Easter Uttar Pradesh

Right of Passage (2nd Edition)
Elephant Corridors of India

D. **Institutional**

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An international campaign to save the endangered Tibetan Antelope

Tiger Bridge:
Nine days on a bend of the Nauranala

Emergency Relief Network Digest 2005 – 2006

Emergency Relief Network Digest 2006 – 2007

Action Tiger:
(Edition 1, 2, 3 and 4th)
Tiger action plans of 13 tiger range countries - 2014

National Bear Conservation and Welfare Action Plan 2012

Born to be Wild:
Commemorating a decade of Wildlife Rescue and Rehabilitation

Tigers of North Kheri:
A collection of short stories and articles penned by Ashok Kumar

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The National Chambal Sanctuary (NCS) is India's only tri-state riverine Sanctuary and is the breeding ground of endangered Indian Skimmers (*Rynchops albicollis*). Past scientific projects reported that low water flow conditions in the river made way for predators like dogs and jackals resulting in egg/chick predation, as well as unintentional trampling by cattle and human movement. Recognizing that effective protection of nests and chicks required constant monitoring, a WTI Rapid Action Project was implemented to pilot a nesting-island protection programme involving members of the local community, State Forest Department and conservationists. This Occasional Report covers the project activities which resulted in two Indian Skimmer nesting sites being protected, where 42 nests were active with 54 Indian Skimmer fledglings.

Wildlife Trust of India

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