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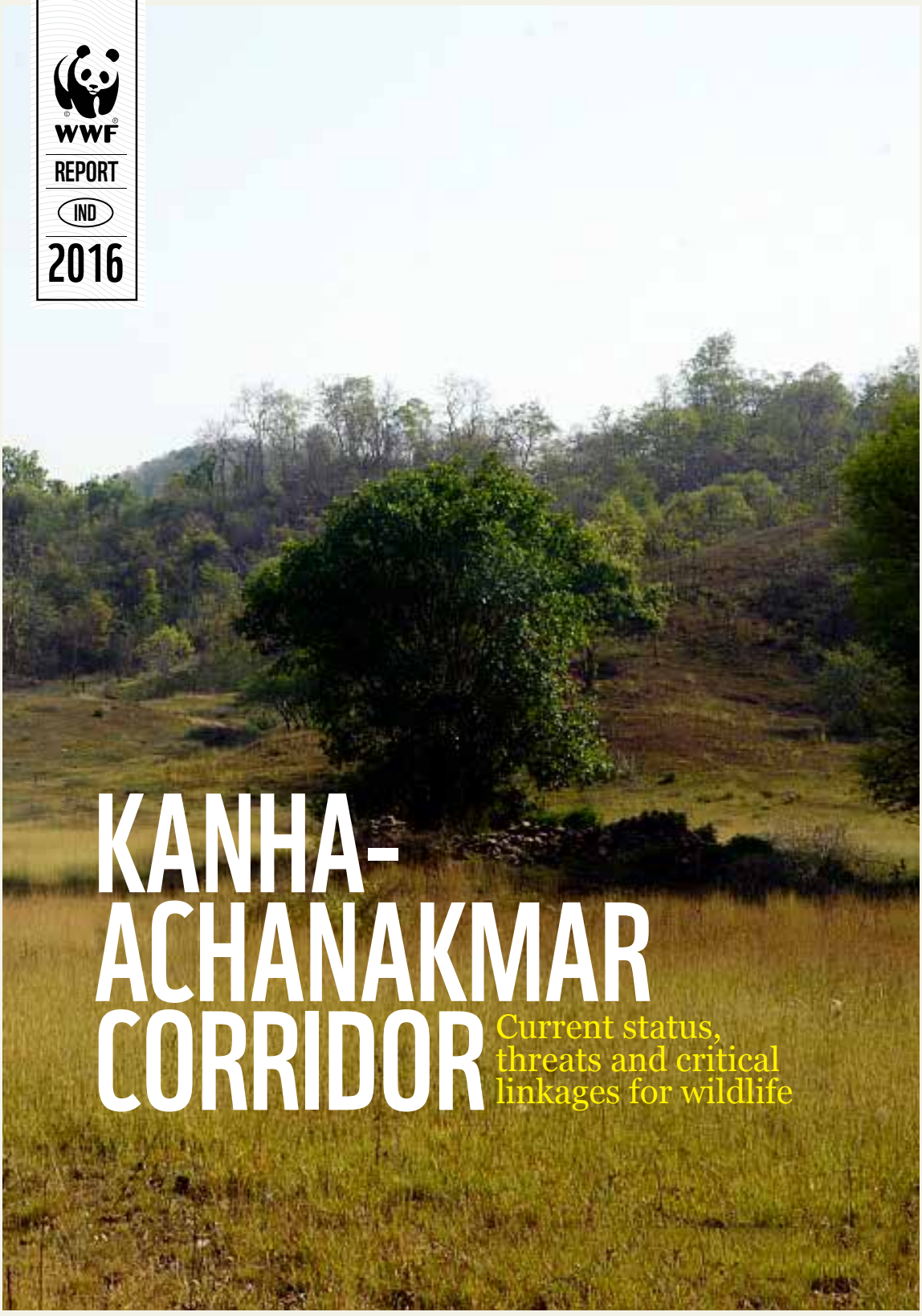
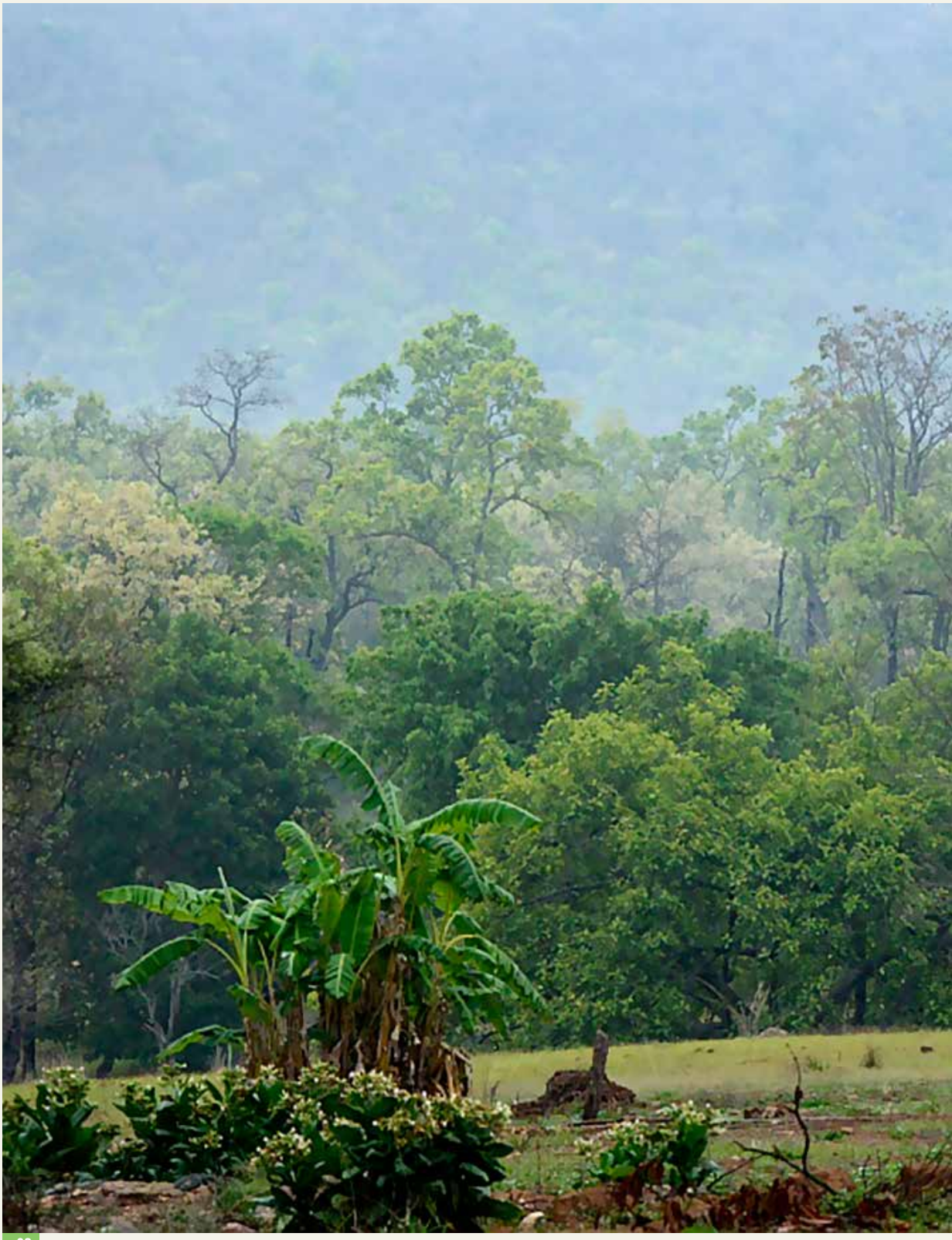
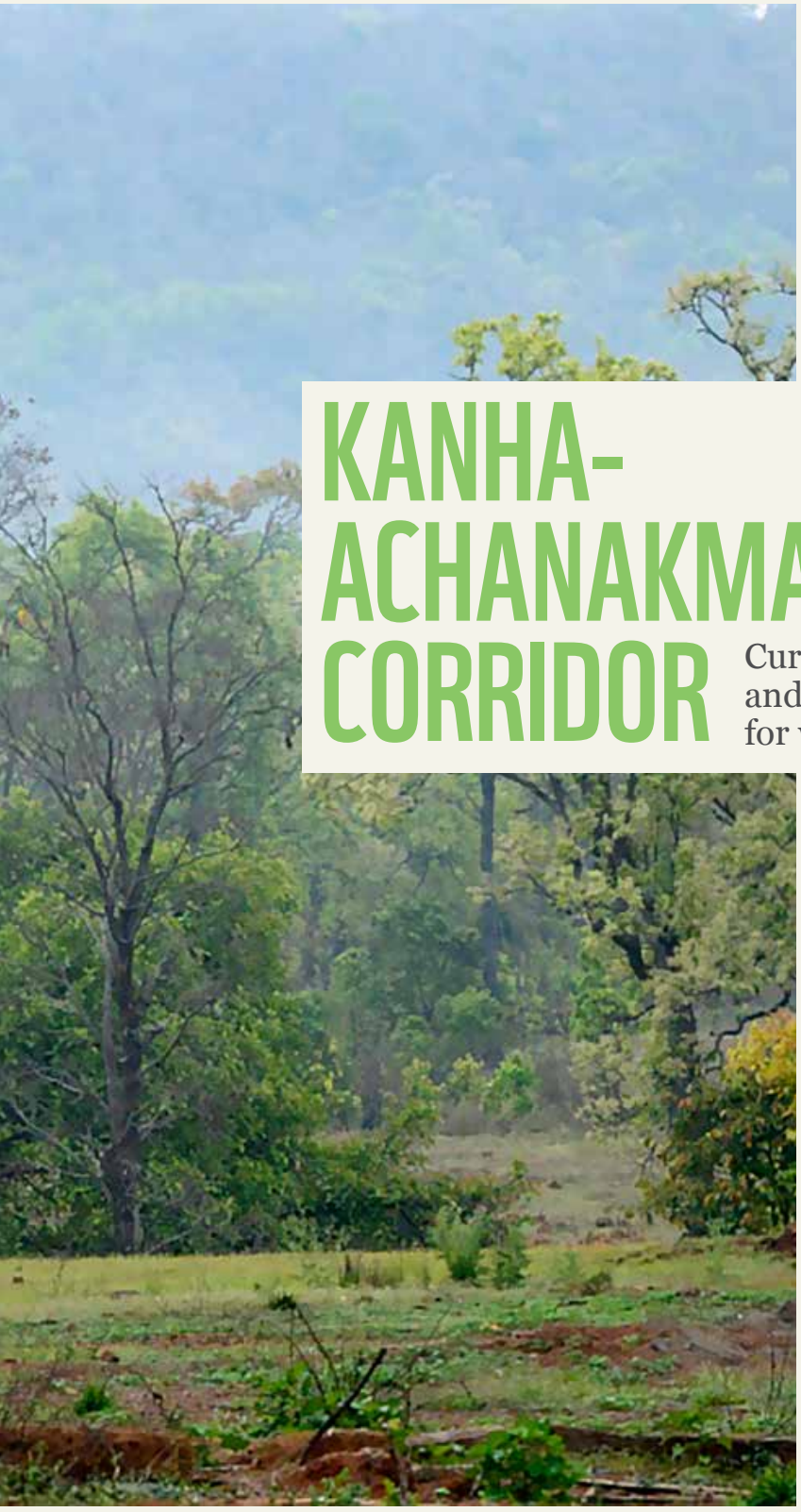


KANHA-ACHANAKMAR CORRIDOR

Current status, threats and critical linkages for wildlife





KANHA-ACHANAKMAR CORRIDOR

Current status, threats and critical linkages for wildlife

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FOREWORD

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Foreword

The report on Kanha-Achanakmar Corridor stating its current status, threats and critical linkages for wildlife is done by WWF. The report describes about the details of area in corridors in Satpuda Maikal Landscape, human population in corridor, Tiger occupancy and distribution of other carnivore species, prey availability, critical linkages along corridor, threats in corridor and to wildlife. This information will help in the management of wildlife in protected area and help in mitigation of man-animal conflict. It will also boost tourism in the Tiger Reserve. The study made is commendable.

(महेश गागड़ा)

(Mahesh Gagda)

TABLE OF CONTENTS

ACKNOWLEDGEMENT

We would like to offer our sincere gratitude to Principal Chief Conservators of Forest (Wildlife), of Chhattisgarh and Madhya Pradesh Forest Department, Shri B N Duwedi, IFS and Shri Narendra Kumar, IFS for permitting us to conduct the study. We are also grateful to Mr. Tapesh Jha, IFS, Former Field Director, and Mr. Matheswaran V., IFS, Deputy Director Achanakmar Tiger Reserve and Mr. J. S. Chauhan, IFS, Former Field Director, Kanha Tiger Reserve for collaborating and providing all necessary support in conducting this survey. We would further like to thank all the Divisional Forest Officers (DFOs) of forest divisions of Kanha Tiger Reserve Buffer, East Mandla, Dindori, Kawardha, Bilaspur and Mungeli for enabling the field-work involved in this study.

The study would not have been possible without the support of frontline staffs of forest divisions, who helped us in our survey and took care of logistics during the field work. We offer our sincere gratitude to all of them.

We are thankful to the field assistants of WWF-India's Satpuda Maikal Landscape (SML) team - Jitendra Jangde and Ratnesh Dholpuriya; and interns – Himanshu Rawal and Nilaykant Saraf, for assisting us in the field surveys. It would not have been possible to cover the study area within the limited time and resources without their help. Our sincere gratitude goes out to field officers- Sujit Sonwani, Kamal Thakur, and Parasram Balmiki for their expert help.

We are grateful to colleagues from WWF-India, particularly Mr. Yash Shethia, Associate Director, Species & Landscapes programme; Dr. Jimmy Borah, Senior Coordinator, Tiger Conservation

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SUMMARY

The Pench-Kanha-Achanakmar complex holds a functional metapopulation of tigers in Central India and connects the Pench Tiger Reserve (TR), Kanha TR and Achanakmar TR mainly through forested corridors. The long term sustenance of this complex completely depends on maintaining the corridor connectivity vital for gene flow between the TRs. The Kanha – Achanakmar corridor (KAC) within this complex ensures eastward connectivity for the Kanha-Pench source population, which harbours 215 tigers, through the Phen Wildlife Sanctuary onward to Achankamar TR and even beyond to Bandavgarh TR.

The report evaluates the status of the Kanha-Achanakmar corridor (KAC), specifically focussing on establishing its functionality i.e. the movement and use by tigers and other large mammals. Also an effort has been made to identify robust but potentially vulnerable linkages (better forest habitats; minimum fragmentation; functionally connected) and linkages that are gravely threatened (potential to be rapidly converted to a situation rendering these not conducive to wildlife movement, and thus requiring immediate attention) within this corridor.

KAC administratively comprises three forest divisions in the state of Madhya Pradesh (Kanha buffer, East Mandla and Dindori) and four forest divisions in the state of Chhattisgarh (Achankamar TR buffer, Kawardha, Bilaspur and Mungeli). The corridor is 107 km long and width varies between 27 km to 65 km at different places. A total of 4300 sq km consisting of 199 beats and 43 grids (10 x 10 sq km) was surveyed for detecting signs of tigers; other major carnivore species (leopard, sloth bear); ungulate prey species (chital, sambar, nilgai, barking deer and wild pig) as well as of human presence and use.

Tiger signs were evident over 39% of the area i.e. around 1677 sq km; the encounter rate of these signs was 0.048 signs/km. The encounter rate of leopards was found to be 0.281 signs/km and sloth bear signs being 0.336 signs/km. Livestock was seen in 148 beats while humans were encountered in 108 beats. Signs of prey were found in 148 beats. Additionally, challenges impacting the functionality of this corridor were also assessed in brief e.g. development projects such as roads, dams and mining and are also discussed in the report.

The study identified Block A (Chilpi and Bhoramdeo Ranges of Kawardha Forest Division), Block B (Mawai, Sijhora, Garhi, Motinala ranges falling under divisions of Kanha Buffer, Phen wildlife sanctuary and parts of East Mandla) and Block E (Maniyari range of Achanakmar Tiger Reserve and Karanjiya East and West range of Dindori Forest Division) as currently robust but potentially vulnerable linkages while Blocks C (Taregaon range of Kawardha Forest Division) and Block D (South Samnapur, Bajag and Karanjiya East and West range of Dindori Forest Division and under Pandariya West and East range) were found to be threatened.

The study thus helps in identifying areas which need immediate action for not only maintaining but also restoring corridor connectivity including incorporation of appropriate mitigation measures to ensure that developmental projects do not become barriers to the movement of wildlife. It is hoped that the results of this study serve as an important baseline for the future monitoring of the corridor and towards preparing a long term corridor conservation plan.

INTRODUCTION

The concept of landscape connectivity has received increasing recognition as a key strategy to maintain a viable ecosystem (Merriam 1984, Tischendorf & Fahrig 2000), to support wildlife populations, to protect biodiversity and to facilitate adaptation for wildlife species in the face of anthropogenic pressures and climate change (Rudnick *et al.* 2012). With an ever increasing human population, there has been a rapid conversion of land for resource extraction, for urban and agricultural resources which has profoundly impacted the physical, chemical and biological character of landscapes (Rudnick *et al.* 2012). This shift of large habitat blocks into fragments not only changes the size of habitat patches and alters other landscape features such as patch geometry and the amount of edge habitat (Saunder *et al.* 1991) but also affects ecological processes at many spatial scales (Simberloff 1988, Kareiva 1990, Soule & Gilpin 1991). The issues of fragmentation, habitat degradation and habitat loss which has either reduced or broken the connectivity of landscapes are therefore widely recognized as major drivers of the present global biodiversity crisis (Rudnick *et al.* 2012). Among others, habitat fragmentation has particularly affected habitat of large bodied organisms that have large home range requirements like tigers (*Panthera tigris*) and other carnivores (Lovejoy *et al.* 1983, Harris 1984).

With increasing fragmentation, the Protected Areas (PAs) are now becoming separated and embedded within matrices of human land-use (Johnsingh *et al.* 2004, Wikramanayake *et al.* 2004, Ranganathan *et al.* 2008). The long-term survival of wildlife species can therefore be ensured only through maintaining viable populations within connected habitats. For maintaining such habitats it is vital that large, continuous landscapes are preserved

(Karanth 1991, Nowell & Jackson 1996). Restoration and inclusion of corridors has become one of the popular landscape strategies for mitigating the effect of habitat fragmentation (Hilty *et al.* 2006). The corridors thus need to be included in the conservation plans for all habitat areas to sustain long term conservation of wildlife species and to increase the connectivity of small isolated patches.

Recognizing the importance of corridors for the long term survival of wildlife populations, there has been considerable advocacy for planning dispersal wildlife corridors in recent years. Well-established corridors in India, for e.g. the Kanha-Pench corridor in central India support good tiger populations; of about 120 tigers (Jhala *et al.* 2011). Another example comes from the Terai Arc Landscape, which spans the base of the Himalayan foothills in northwestern India and southern Nepal. Conservationists are working to restore, reconnect, and manage wildlife corridors to link 12 important wildlife reserves and national parks that harbor wild tigers across the 49,000 km² landscape (Wikramanayake *et al.* 2004; Dinerstein *et al.* 2007). The Kosi River corridor connects the Corbett Tiger Reserve and the forests of Ramnagar Forest Division. This corridor serves as a vital link between the source population of tigers in Corbett and the adjoining forest areas and enables them to move across. A study has demonstrated the functionality of the Kosi River corridor with reference to tigers. It also recorded 20 other wild mammal species crossing the corridor in search of new territory or resources (Anwar *et al.* 2014). In order to support long term wildlife populations, it is imperative not only to maintain these functional corridors but also to identify new potential connectivity within a landscape complex.

Pench-Kanha-Achanakmar (PKA) is one such complex that is a continuous forest patch between three meta-populations of Pench, Kanha and Achanakmar Tiger Reserves (TRs). It's thus very crucial to provide space to dispersing animals like tigers and other large carnivores between these habitats (Jhala *et al.* 2011). Studies have already documented the genetic extent of this patch (Sharma *et al.*

2012, 2013; Joshi *et al.* 2013; Yumnam *et al.* 2014). This complex harbors a huge population of around 215 tigers within these TRs (Jhala *et al.* 2011). Kanha-Achanakmar Corridor (KAC) connecting Kanha Tiger Reserve (KTR) and Achanakmar Tiger Reserve (ATR) is significant for providing wildlife an opportunity to disperse in the PKA complex. Understanding the functionality of the corridor is crucial to determine the potential for survival of tigers in the region with regard to the opportunity it provides to tigers for dispersal this report presents the outcomes of the survey carried out to assess the use of this corridor by tigers and other associated animals.

CORRIDORS IN SATPUDA MAIKAL LANDSCAPE

Bounded by the Aravalli Range in the north west, the Satpuda Range in the south, the Odisha hills in the south east and Chota Nagpur plateau in the north east, the Central Indian landscape is a globally recognized area for tiger conservation with potential for long term persistence of the species (Walston *et al.* 2010; Jhala *et al.* 2011; Sharma *et al.* 2012). It is an important bio-geographic province (Rodgers *et al.* 2002) and one of the six landscape complexes for tiger conservation in India (Jhala *et al.* 2011). The central Indian landscape is host to one of the largest concentrations of tiger populations with around 22% of the world population and 30% of India's tiger population (Jhala *et al.* 2015).

The Satpuda-Maikal landscape (SML) in the Central Indian highlands has been classified as a global-priority Tiger Conservation Landscape (TCL) for its significant potential in providing habitat for long term survival of tigers (Dinerstein *et al.* 2007). SML, situated along the Satpuda and Maikal hill ranges encompasses an area of about 118,113 km^2, and is part of states of Madhya Pradesh, Chhattisgarh and Maharashtra (Jena *et al.* 2014). With six tiger reserves and four important corridors, the landscape is home to 283 tigers (Jhala *et al.* 2014). The northern part of this landscape is dominated by the *Shorea robusta*, *Anogesius* sp. and *Acacia* sp.

interspersed with several miscellaneous species. While the southern part has a drier forest with *Tectona grandis* as the major species. The landscape is also home to the second largest watershed of India comprising of Narmada, Son, Pandu, Kanhar, Rihand, Bijul, Gopad and Banas rivers (Gopal and Shukla, 2001).

Within this landscape there are complexes of patchily connected TRs that are essential for the long term survival of the species in the region. The major corridors present within landscape include Kanha-Pench, Kanha-Achanakmar, Satpuda-Melghat and Satpuda-Pench (Fig 1).

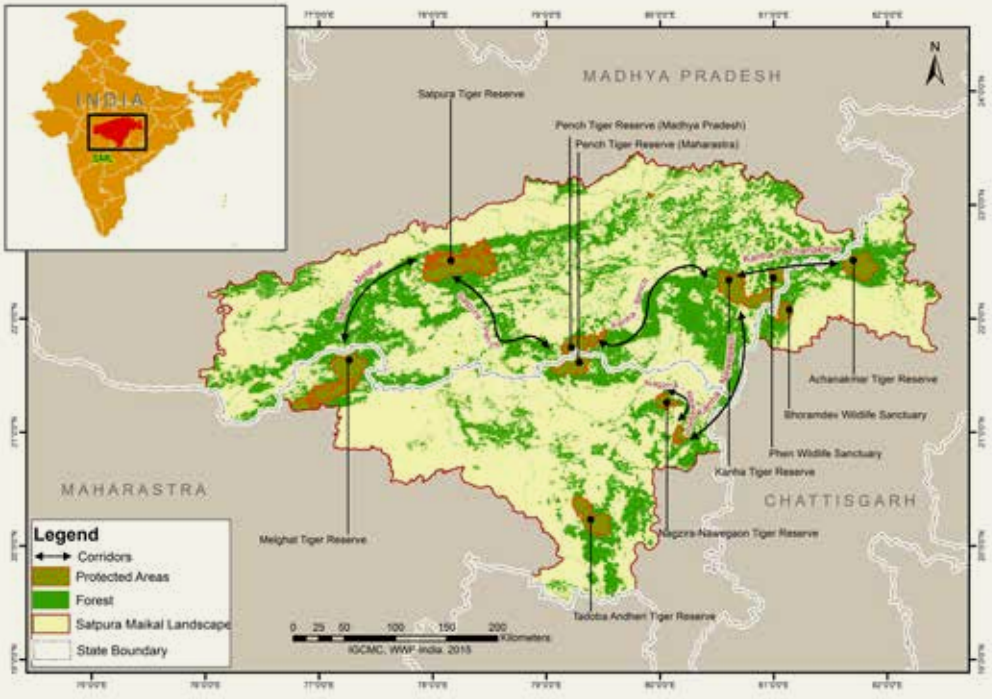

Figure 1. Major Corridors of Satpuda Maikal Landscape

Apart from these corridors in Satpuda Maikal Landscape, the Kanha-Navegaon-Nagzira-Tadoba corridor is also important in terms of connectivity between different source sites. The forest of Balaghat connects the Kanha tiger population to the southern tiger populations of Maharashtra (in Nagzira-Navegaon and Tadoba TRs).

Tiger habitats in central India which had been historically connected (Yumnam *et al.* 2014) and largely contiguous owing to its huge forest cover (Mondol *et al.* 2009), are now under threat from rapid infrastructural development and urbanization which endangers the long term meta-population persistence (Yumnam et al 2014). In spite of being threatened, the landscape continues to support a good population of tigers and importantly allows gene flow between most of these population clusters (Jhala *et al.* 2011).

OBJECTIVES OF STUDY

The main objective of the study was to evaluate the status of the Kanha-Achanakmar corridor, specifically focused on establishing its functionality in facilitation of movement and use by tigers and other large mammals. This also included identification of critical linkages in this corridor.

DESCRIPTION OF THE AREA

KANHA-ACHANAKMAR CONNECTIVITY

The Kanha-Achanakmar corridor is significant for sustenance of the Achanakmar tiger population and for meta-population of Kanha–Achanakmar (KA) complex. The corridor area administratively comes under three forest divisions of Madhya Pradesh (Kanha buffer, East Mandla and Dindori) and four forest divisions of Chhattisgarh (ATR buffer, Kawardha, Bilaspur and Mungeli). The corridor is almost 107km long while its width varies from around 27 km to 65 km in different places (Fig 2). The terrain is mostly hilly and undulating with almost all the dense and good forest patches restricted to the hilly slopes. The forest type is tropical dry deciduous with Sal (*Shorea robusta*) being the most dominant tree species in the corridor. Other major forest types recorded from the area are *Shorea-Terminalia-Adina*, *Shorea-Buchanania-Cleistanthus* and *Terminalia-Anogeissus Cleistanthus* clusters (Champion and Seth 1968).

The major carnivores reported from the KAC are tiger, leopard (*Panthera pardus*) and sloth bear (*Melursus ursinus*). The order herbivora is represented by chital (*Axis axis*), sambar (*Rusa unicolor*), nilgai (*Boselaphus tragocamelus*), gaur (*Bos gaurus)* and barking deer (*Muntiacus muntjac*). Other common faunal species are wild pig (*Sus scrofa)*, jackal (*Canis aureus*) and common langur (*Presbytis entellus*). The area also supports rich avifauna.

HUMAN POPULATION IN THE CORRIDOR

As per Qureshi *et al.* (2014), there has been an increase in human population from 26,017 to 29,910, almost 14% within a decade in the corridor area. The population estimated was however based on least cost pathway area and it included only 62 villages. During the survey, it was observed that the whole corridor patch had around 280 villages signifying that the population could be larger and which definitely adds on to the gravity of the situation.

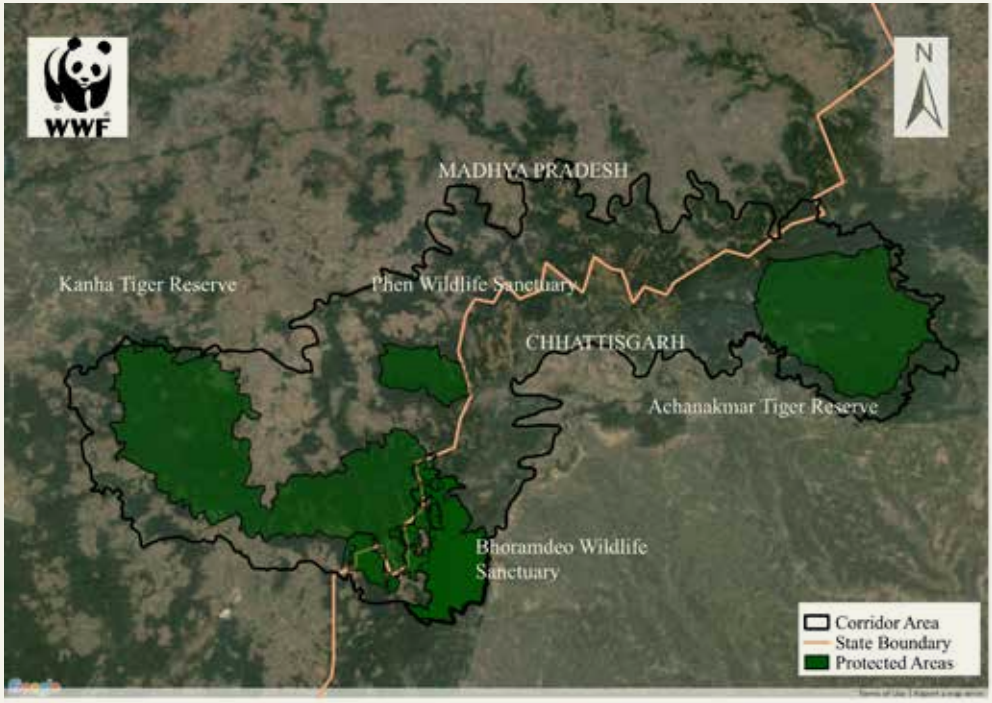

Figure 2. Map of Kanha-Achanakmar Corridor (KAC) area

DATA COLLECTION

Surveys were carried out in buffer areas of both the tiger reserves, Kanha and Achanakmar, territorial divisions of East Mandla and Dindori in Madhya Pradesh, and Kawardha, Mungeli and Bilaspur in Chhattisgarh, and within Phen and Bhoramdeo wildlife sanctuaries over a five month period from January to May, 2015.

Occupancy Survey

For the occupancy surveys, 10x10 km^2 size grids were superimposed initially on the map of KAC. It resulted in 43 grids within the corridor area (Fig 3), which were then sampled for occupancy and use by tigers, other major carnivore species, ungulate prey species as well as of human presence and use. Survey was undertaken for detecting carnivore signs in spatially replicated segments within each of the 43 grids. A total of 4300 km^2, which consisted of 199 beats (beats are the smallest administrative units of forest department) within the 43 grids, was intensively surveyed. Fresh signs of tigers, leopards, sloth bears and major ungulate prey species (chital, sambar, nilgai, barking deer and wild pig) in KAC were identified and recorded by observers in each beat falling under the corridor. The survey also recorded human presence along with ungulate prey presence and their use within the sampling area. For accounting prey presence, pellets and footmarks were recorded at every 200m, while for recording human use, four parameters were taken into account along the survey-signs of wood cutting and lopping; presence of people and livestock. General information on forest types and terrain type was also recorded. All the parameters were considered as covariates affecting occupancy. Overall, the number of spatial replicates in a grid (sampling effort) varied from four to eight while the total kilometer walked varied from 4 to 9.5 km, depending on the extent of available habitat within the grid. Areas within a beat were systematically sampled and searched for tiger signs, starting with the area most likely to have tiger

presence(e.g. trails, ridgelines, roads, river and stream beds) within each grid surveyed(Karanth *et al.* 2008, 2011). Each type of sign detected was assigned either 1 for detection or 0 for non-detection to generate histories required for occupancy analyses which were then further combined at one km length to form spatial replicates (MacKenzie *et al.* 2002; Hines *et al.* 2010).

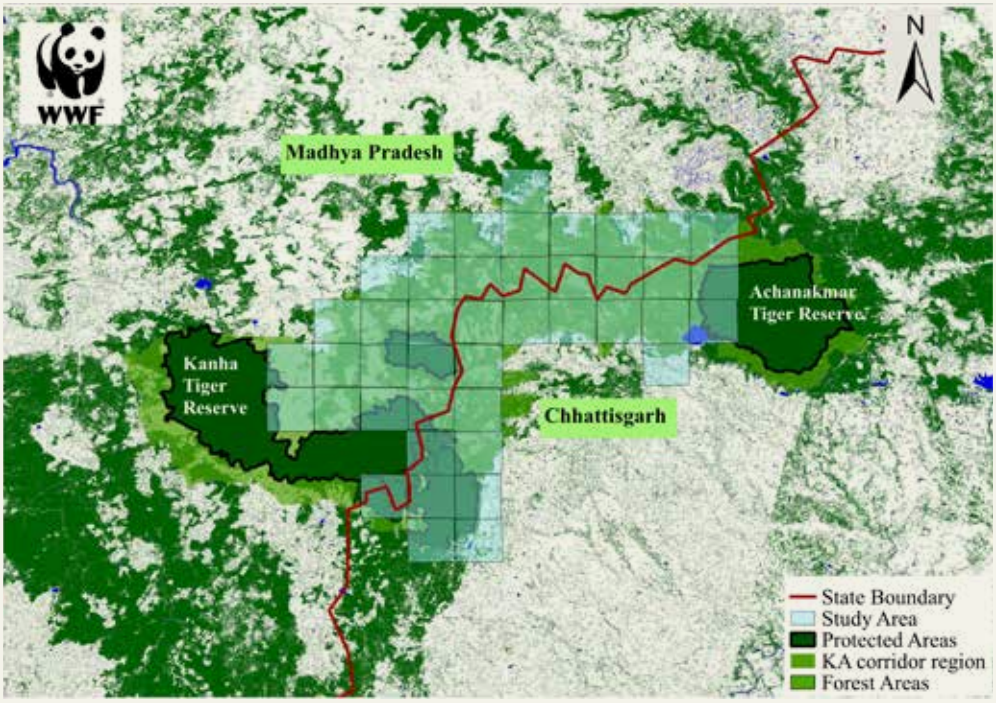

Figure 3. Map showing grids in blue color were surveyed for this study

ANALYTICAL DETAILS

OCCUPANCY

For occupancy analysis, program PRESENCE version 9.3 (Hines 2010) was used. Prey and human presence and use were used as covariates in occupancy models to assess their influence on detecting tiger signs. MacKenzie *et al.* (2002) models and Hines *et al.* (2010) models were initially compared without any covariates to decide the appropriate model type for further analyses (Karanth *et al.* 2011). The model comparisons were based on Akaike Information Criterion (AIC) values (Burnham & Anderson 2002).

ENCOUNTER RATE

The encounter rate (number of signs obtained per km) was used to determine the extent of carnivores, ungulates and human presence and use in the corridor. Encounter rate was calculated for each 10x10 km grid based on number of signs encountered in each beat falling under a particular grid.

RESULTS & DISCUSSIONS

TIGER OCCUPANCY AND DISTRIBUTION OF OTHER CARNIVORE SPECIES

A total of 1233.76 km within 199 different beats was surveyed for carnivore signs. Tiger signs in the form of pugmarks and scats were detected from 37 beats (Fig 4). The overall encounter rate of tiger signs was 0.048 signs/km. The standard model (MacKenzie *et al.* 2002) was used for occupancy analysis which performed better (AIC = 408.71) in comparison with the Hines *et al.*'s (2010)model (AIC = 412.60). It was estimated that of the 4300 km^{2}potential tiger habitat available in KAC, the proportion of area occupied by tigers was 39 %, or an area of around 1677 km^2. The final parameter estimates for tiger habitat occupancy and sign detection probabilities were:

Ψ(SE Ψ)= the fraction of area occupied by tigers in KAC = 0.39 (0.09).

p(SE p)= the probability of detecting a tiger sign, given the presence of tigers on the replicate= 0.11 (0.03)

It was noted that the main factor influencing the detection of tiger signs in the area was prey presence (Table 1). It was also observed that no covariate was influencing tiger presence directly, which could be due to scarcity of the tiger signs from the area. Model which was second to best showed that human presence in the tiger habitat area to some extent was influencing tiger occupancy. Other

studies have shown that both prey presence and absence of human use significantly contributed to the variation in sign detection probability (Karanth *et al.* 2011; Yumnam *et al.* 2014, Borah *et al.* 2015).

Model	AIC	deltaAIC	AIC wgt	Model Likelihood	no. Par.	2*LogLike
psi(.),p(preypres)	397.55	0	0.3597	1	3	391.55
psi(humdist),p(preypres)	398.61	1.06	0.2117	0.5886	4	390.61
psi(.),p(humdist+preypres)	398.69	1.14	0.2034	0.5655	4	390.69
psi(preypres),p(preypres)	399.49	1.94	0.1363	0.3791	4	391.49
psi(humdist+preypres),p(preypres)	400.5	2.95	0.0823	0.2288	5	390.5
psi(.),p(humdist)	406.07	8.52	0.0051	0.0141	3	400.07
psi(.),p(.)	408.71	11.16	0.0014	0.0038	2	404.71

Table 1: Model selection results based on covariates for probability of tiger occupancy using the standard model

It is noteworthy that besides tigers, other sympatric carnivores such as leopards and sloth bears were also recorded from the study area (Fig 5 & 6). Leopard signs were found in 135 beats with the overall encounter rate being 0.281 signs/km. Sloth Bear signs were found in 135 beats with overall encounter rate being 0.336 signs/km.

The high level of leopard presence compared to tigers could be attributed to the fact that leopard's ability to adapt to its environment to hunt and feed (Bertram 1999) which is not the case with tigers. Studies have shown that leopard detection and space use is hardly significantly affected by human presence (Carter *et al.* 2015). They are known to live in human-dominated landscapes (Athreya *et al.* 2004). Tigers, on the other hand, are found to avoid people or any human settlement and avoid moving in landscapes that are extremely modified by human activity (Barber-Meyer *et al.* 2012; Harihar & Pandav 2012; Sunarto *et al.* 2012).

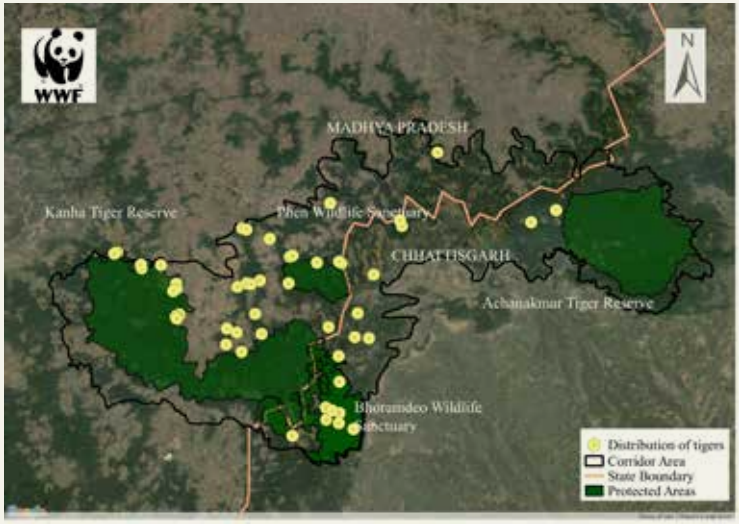

Figure 4. Distribution of tiger signs along the study area

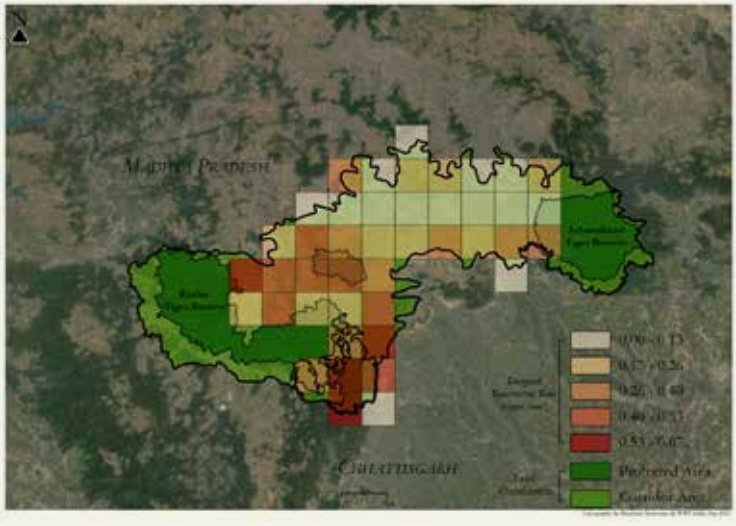

Figure 5.Encounter rate of leopards sign along the study area with different grids showing different rates

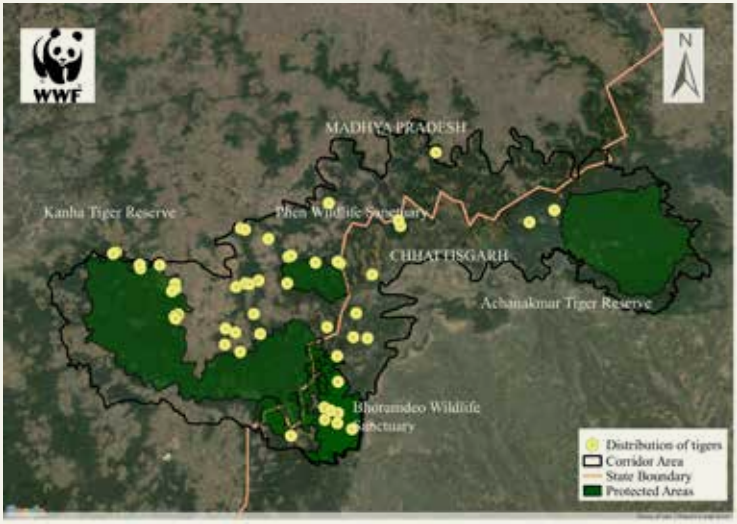

Figure 6. Encounter rate of sloth bears sign along the study area with different grids showing different rates

HUMAN PRESENCE

Presence of human and their use within the study area was assessed using different parameters like signs of wood cutting and lopping, number of people and livestock encountered in different beats. Livestock was seen in 148 beats while people were encountered in 108 beats. There are several permanent (revenue as well as forest villages) human settlements all along the corridor. Around 280 villages in the forest corridors in between Kanha and Achanakmar were encountered, and the population is ever increasing in these settlements. Human dependency on forests (signs of wood cut, lopping and NTFP collection) was found to be high all along the surveyed area and forest resource use was seen in almost all the beats (Fig. 7).

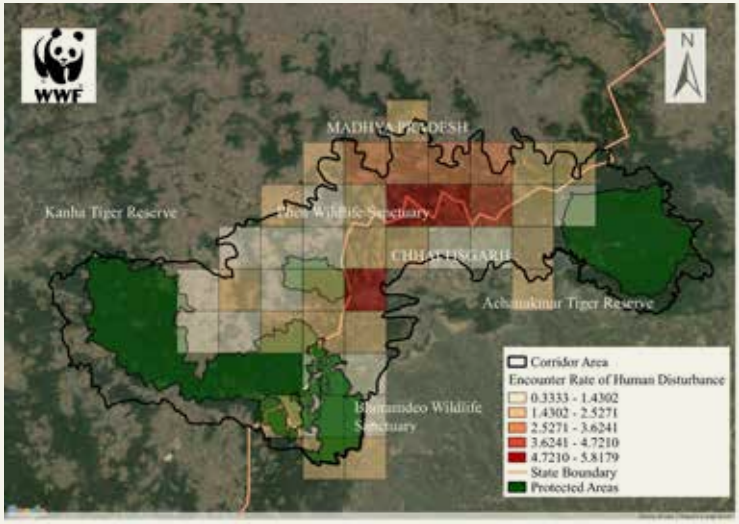

Figure 7. Human presence and use rate in the corridor area

EVIDENCE OF PREY

The present study could not reliably estimate the density of prey species due to a low detection of prey thus leading to very small sample size which was not conducive for determining prey estimates. However, indirect evidence in the form of pellets and dung revealed several prey species having patchy distribution (Fig 8). Signs of prey in terms of pellet or footmarks were found in 148 beats. The wild prey species recorded during the sampling period included chital, sambar, nilgai, barking Deer and wild Pig.

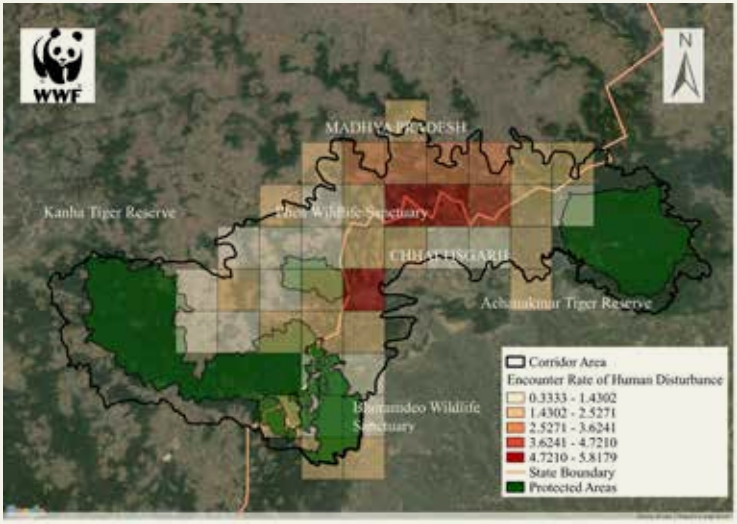

Figure 8. Encounter rate of signs of prey species along the study area with different grids showing different rates

The study highlights the importance of Kanha–Achanakmar corridor as an important dispersal ground for tigers between two important tiger bearing areas in central India. Maintaining functional connectivity between these sites is crucial to the long term presence of tigers in the region. It calls for a common understanding and shared vision among all stakeholders toward protecting the corridor.

CRITICAL LINKAGES

The forests along the KAC have different degrees of protection given their legal status (reserved forest and protected forest). To manage, maintain or even restore the connectivity, it is therefore essential to identify different blocks in the corridor which would require different strategies and management interventions.

From the present study, we identified the critical linkages (Fig 9) between the two tiger reserves based on tiger presence, prey base, human pressure, degree of fragmentation, and threats. The objective was to highlight the areas so that immediate action can be taken to secure dispersal of tigers and other wildlife between larger habitat blocks. The linkages that are crucial for maintaining connectivity in the KAC and which need immediate attention have been discussed below. The blocks have been designated as vulnerable and threatened. The vulnerable blocks are the linkages which show potential for wildlife movement with relatively better forest habitats and minimum fragmentation, and which are still considered functionally connected. The threatened blocks are the linkages which have the potential to be converted from their current condition to a situation which will not be conducive to wildlife movement, and thus require immediate attention and prioritization for providing enhanced protection regime.

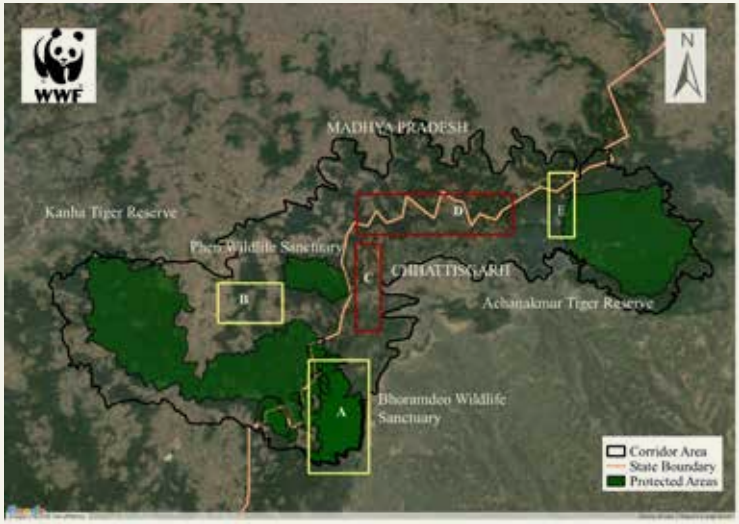

Figure 9. Critical linkages along the KA corridor. Block A, B and E depict area which are vulnerable for sustaining wildlife while blocks C and D shows threatened linkage in the corridor.

Block A: A major part of this block is covered under the Chilpi and Bhoramdeo Ranges of Kawardha Forest Division and is very crucial in terms of presence of carnivore species and prey base. Almost all beats surveyed under this area had good source of water too, which helps in sustaining good presence of wildlife. This part has relatively less human presence with around 8583 people (Census 2014). Some of the beats that had good presence of both carnivore and ungulate species with fewer use by humans were Bhawartola, Dhandabra, Prabhujhola and Rochen. National Highway 12 (NH 12) connecting Jabalpur to Raipur cuts through some very important portions of Block A.

Block B: The block occupying Mawai, Sijhora, Garhi, Motinala ranges falling under divisions of Kanha Buffer, Phen wildlife sanctuary and parts of East Mandla is another critical block in the corridor area. Some significant beats viz. Majhgaon, Hatta, Motinala and Bamhnimatta showed high presence of large carnivores (in terms of signs obtained) with low human pressure in those areas.

National Highway 12 (NH 12) again passes through some very important areas of Block B.

Block C: The block falling under Taregaon range of Kawardha Forest Division had very high human settlement, but it also showed presence of ungulate prey species. Fresh scat of tigers and leopards were recorded in Dholbajja, Sambhupipar and Bokkarkhar areas. Forest of Block C also face serious threat from mining operations. In order to maintain connectivity from Bhoramdeo Sanctuary towards Achanakmar, it is very crucial to restore and secure this patch of forest.

Block D: The block falls under South Samnapur, Bajag and Karanjiya (East and West) range of Dindori Forest Division in Madhya Pradesh and under Pandariya (west and east) range of Chhattisgarh. This block facilitates movement of species along the corridor and maintains connectivity in the corridor. At the same time, it is also the most fragmented part of the corridor with huge pressure from human settlements, livestock grazing and NTFP collection.Moreover, State Highway (SH) 9 cuts through some of the important areas of Block D.

Block E: This block which falls under Maniyari range of Achanakmar Tiger Reserve and Karanjiya (East and West) range of Dindori Forest Division is another crucial block of this corridor because of the presence of wildlife. Important beats over this block that showed potential in maintaining wildlife population are Patparha and Boiraha.

THREATS

The entire corridor is managed as different administrative status such as territorial forest division, sanctuary, national park and buffer of tiger reserves, and therefore experiences varying degrees of protection. Human settlements were observed all along the corridor

during the survey period. The major threats within this area are the increasing human population, their dependency on forest resources (fuel wood collection, NTFP collection and grazing of cattle) and developmental pressure-linear infrastructure and mining (Fig 10). The threats are further discussed briefly as follows.

Roads

One of the major issues threatening the connectivity in the area is linear infrastructure-roads. Two major roads built under the Pradhan Mantri Gram Sarak Yojna (PMGSY), pose the greatest threat to the corridor.

1. The national highway (NH-12): This highway connecting Jabalpur and Raipur goes through Chilpi Range within KA corridor (Fig 10) and cuts through a very important section of corridor covering ranges of Garhi, Motinala, Chilpi and Bhoramdeo in East Mandla and Kawardha Forest division, respectively. The importance of this part of corridor which is being intersected by the road can be gauged by the evidence that encounter rate of tiger was found to be 0.06 signs/km, while leopard's was 0.37signs/km, sloth bear's was 0.35signs/km and that of prey was 1.17signs/km in the area. The criticality of this part can be further inferred from the fact that it's not only close to the Kanha Tiger Reserve but also provides an important connectivity between this tiger reserve and Phen Wildlife Sanctuary. There is a crossing point right on this road in Motinala range through which tigers, tigress with cubs and leopards crossing the road have been recorded (Source: Forest Department).

Figure 10. The main threats within the corridor area

2. The state highway (SH-9): This state highway passes through Kawardha in Chhattisgarh to Sahdol in Madhya Pradesh via Pandaria. While conducting the survey, few road-kills involving wild animal were also recorded on these roads which intersect the corridor at several points.

Another road which passes through the corridor considered important for wildlife movement is Chilpi - Salhewara road. This road passing right through the middle of Bhoramdeo Wildlife Sanctuary has been turned to a tarred road and will severely impact the movement of wildlife species once commercial vehicles start using it. Since this road crosses one of the strong linkages of corridor (Block A in figure 9), it is important that any future construction or modifications should involve proper mitigation measures.

Although the present study did not come across any tangible evidences that these roads are impenetrable, they all still hinder wildlife movement to varying degrees. It was observed that speeds

on this road are somewhat kept in check by the nature of the road, which perhaps could be a factor that contributes to the ability of mammals to successfully cross.

Dams

Two dams have been proposed in the area (Fig 10). Even though one of them, proposed on the Narmada River, does not directly intersect the corridor, but being located in the Dindori Forest Division at almost 25km away from the corridor (Fig 10), it will definitely impact the flora and fauna of the location.

The second dam that has been proposed to be built on Halon River is situated right on NH12A. It is also worrying that the project site is just about six km from Sijhora range which is part of the core area of Kanha Tiger Reserve. This will not only hamper the connectivity of corridor due to submergence but will also impact the composition of flora and fauna of the area. In due course of time, it could create huge environmental setbacks such as degraded water quality through increased salinity and decomposition of organic matter. The effect of dam is likely to be further compounded due to its location right on NH12 further hampering movement of species.

Mining

The mining at Daldali which falls under Taregaon range of Kawardha Forest Division is another serious developmental threat for the corridor area (Fig 10). The Bauxite mine owned by the Bharat Aluminium Company Limited (BALCO) is a conventional semi-mechanised open cast mine with a lease area of 626.117 hectares. BALCO is a public sector enterprise in the country and Government of India still holds 49% of its share. The mining activities have resulted in emergence of roads which has led to increased road traffic. It was observed that around 150 trucks pass through this corridor from evening (5:00pm) till early morning which could greatly disturb the movement of wildlife species.

Resource Dependence of Local Communities

The forests of this corridor have numerous human settlements in the form of small and large villages (Fig 11), whose livelihoods are largely dependent on agriculture and forest resource collection. Most of these local communities depend on the forest for their daily needs like fuel wood, timber, minor forest products and also for grazing their cattle. While surveying these areas, several local people were found cutting trees or collecting non-timber forest products. Collection of *Madhuca indica* (Mahua) was found to be high in these areas during the study period itself. There is also high grazing pressure on the forest from the livestock being reared by the locals which leads to overgrazing in several areas hampering forest regeneration and degrading the existing forest. Several cattle camps were sighted in few areas under Prabhujhola (South & North) beat in Bhoramdeo and Pandrapani beat in Pandaria West range.

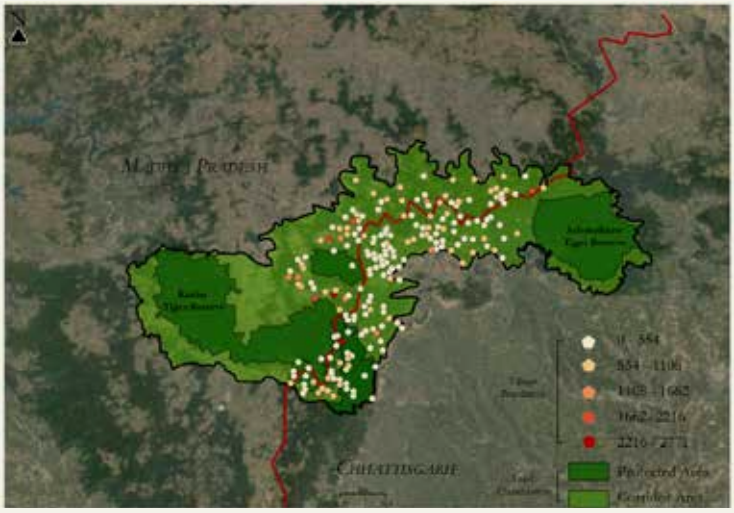

Figure 11. Location and population of different villages along the corridor

CONCLUSION

The present study is focused on identifying the potential of the Kanha-Achanakmar corridor in providing dispersal opportunities to wildlife species, particularly tigers. The study helped in identifying areas which need immediate action for not only maintaining but also restoring the connectivity of corridor. The results of this study may serve as an important baseline for the future monitoring of the corridor and are also important for preparing a long term corridor conservation plan.

The results from the survey suggest that the Kanha-Achanakmar corridor area still allows for movement of mammal species. In areas near Kanha Tiger Reserve, Bhoramdeo Wildlife Sanctuary and buffer areas of Achanakmar Tiger Reserve due to the good forest cover, the low-to medium-density developments, and the current permeability of roads, to animals trying to get from one side to the other, seem to be working together to support the tigers and its prey animals. The main message here is to maintain the conditions that currently exist, and guarding against future changes that would prevent animals from moving and fulfilling their basic needs. It would be imperative to increase permeability of the roads by maintaining or enhancing the areas where wildlife are able to cross, and considering ways to create continuous natural cover paths between the two forest habitats.

Additional work could be planned along with other stakeholders such as district administrations, state planning agencies and local communities to promote the importance of the identified corridor and impact on wildlife due to development and linear infrastructure projects. The results of this study do not dispute ceasing development, or for making dramatic changes to road

infrastructure. It rather suggests taking into account the wildlife movement (Fig 12) while making decisions on development and roads. Based on the data and information collected over the survey period, the following recommendations are being presented.

1. Tigers continue to persist near the PAs, particularly near the source population of Kanha. Fewer yet encouraging signs of tiger were recorded in the intervening matrix between Kanha and Achanakmar. Extensive signs of leopards and sloth bears in the intervening matrix between the PAs also indicate functionality of the corridor for large carnivores. It becomes important that activities such as commercial forestry, do not disrupt the functionality of the corridor, and efforts should be taken to regulate such activities in the corridor area.

2. The crucial strong linkages in the corridor include the Chilpi and Bhoramdeo Range of Kawardha Forest Division, and Maniyari range of Achanakmar Tiger Reserve, parts of Mawai range and Phen wildlife sanctuary. Besides these, Dholbajja, Sambhupipar and Bokkarkhar of Taregaon range; Patparha and Boiraha of Maniyari range; Amaniya and Bhelki of Pandaria West range areas showed relatively better prey presence along with lesser disturbance, and therefore protection and management of these areas should be prioritized to maintain the connectivity.

3. Several cattle camps were sighted in areas under Prabhujhola (South & North) beat in Bhoramdeo, Pandrapani beat in Pandaria West range and Pandripani in Karanjiya West range. Livestock presence was found uniformly distributed across the area. Efforts should be undertaken to regulate and control the grazing pressures in and around the PAs in particular and in select sites to prevent degradation of the habitats. This can be achieved by trying out developing pasture lands for the livestock, outside protected areas and corridor forests in consultation with the local stakeholders and communities. It would also be necessary to win the support of local community

to manage grazing through rotational grazing. Improved livestock keeping practices too are likely to result in reduced pressure on forests due to grazing.

4. Immediate attention is required in areas considered as critical linkages to maintain the connectivity in corridors. Tantar in Bajag range, Pandripani in Karanjiya west range and Kandwani in South Samnapur range of Dindori Forest Division, Anjwainwah of Pandariya east range and Bhelki of Pandariya west range of Kawardha Forest division are places that has to be restored and regenerated in order to support the movement of wildlife through the corridor.

5. Restorative ecology and eco-development inputs through local communities' participation should be undertaken immediately to alleviate the threats due to biotic pressures from forest dwelling communities in the corridor area. This can play a major role in conservation of tigers and other species in KA corridor. Engaging with local communities, introducing mechanism of regenerating or replanting the fragmented patch, and continuous monitoring of the tiger population annually in this corridor are some of the major activities, which would ensure that the functionality of the corridor is better understood and maintained.

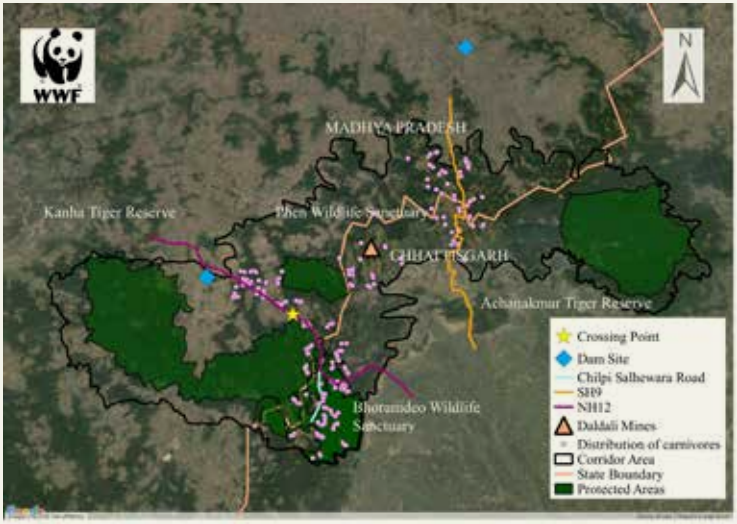

Figure 12. Distribution of carnivore species along different roads and mining area in the corridor

Any expansion of roads or railways should be carefully planned to avoid further fragmentation of the corridors. National highway (NH-12) connecting Jabalpur and Raipur, and state highway (SH-9) passing through Kawardha in Chhattisgarh to Shahdol in MP via Pandariya should atleast remain in their present form and should not be expanded further, as these pass through two critical linkages of the corridor. At crucial crossing points, measures like speed limit and barriers should be maintained. It is recommended that any major developmental activities planned along the stretch of this highway should take into account appropriate 'green and smart infrastructure' mitigation measures. Other roads like Chilpi-Salhewara need to be constructed along with the required mitigation measures.Improvements along this and even other roads should weigh the impact on wildlife and whether they continue to maintain the overall permeability of the road. It is necessary that actions that help maintain or increase wildlife passage along these roads be planned and implemented.

6. Mining at Daldali in Taregaon range of Kawardha forest division, is major threat to wildlife. Mining activities have resulted in emergence of roads and massive traffic that passes through this corridor area. The huge traffic flow of trucks since evening to early morning poses a huge threat to movement of wildlife species. Any further expansion or conversion of lands for mining purposes should be strictly regulated and such areas need to be declared as off- limits for mining. Even the present mining activities should use green and eco-friendly mechanisms for reducing its environmental impact.

7. The KA corridor area is being used by different carnivore species to move from one place to animal. In order to maintain their movements and permeability across the landscape, any linear infrastructure growth needs to consider measures in crossing points regularly used by wildlife species. The construction of any other infrastructure like dams should be planned in order to reduce their impact on viability of wildlife species and prevent biodiversity, in consultation with experts.

The study highlights the importance and urgency of managing and restoring the Kanha-Achanakmar corridor for it to be considered as an important dispersal and breeding ground for tigers between two source populations. Earlier studies have shown dispersal ability of tigers through sub-optimal habitat patches (Smith 1993, Carter *et al.* 2012) and if these corridors are maintained and conserved properly, they may be able to persist themselves. Therefore, to ensure long term survival of tigers in this landscape, the current connectivity must be strengthened along with re-establishing the fragmented part and ensuring protection for the future.

The pressures threatening long term persistence of tiger population and wildlife movement are increasing human settlements, linear infrastructure development, agriculture expansion, mining and other extractive industries. To safeguard these corridors for long term survival of wildlife population, restorative inputs and

retrofitting of infrastructural development within these corridors are necessary. Infrastructure in the form of roads and railway lines need to have alternative structures such as over and under -passes in the corridor habitat so as not to form linear barriers. There should be an eco-friendly approach in every land use plan occurring in the corridor areas. These spaces need to be monitored, managed with appropriate green infrastructure and if possible given a legal status (Quintero *et al.* 2010) to continue gene exchange between the population reserves. This would require a careful planning and management in the landscape involving all the major stakeholders. However, working with partners and communities should not focus so exclusively on wildlife movement that it ignores the many other benefits that are generated from living within and helping to maintain a connected, natural, landscape.

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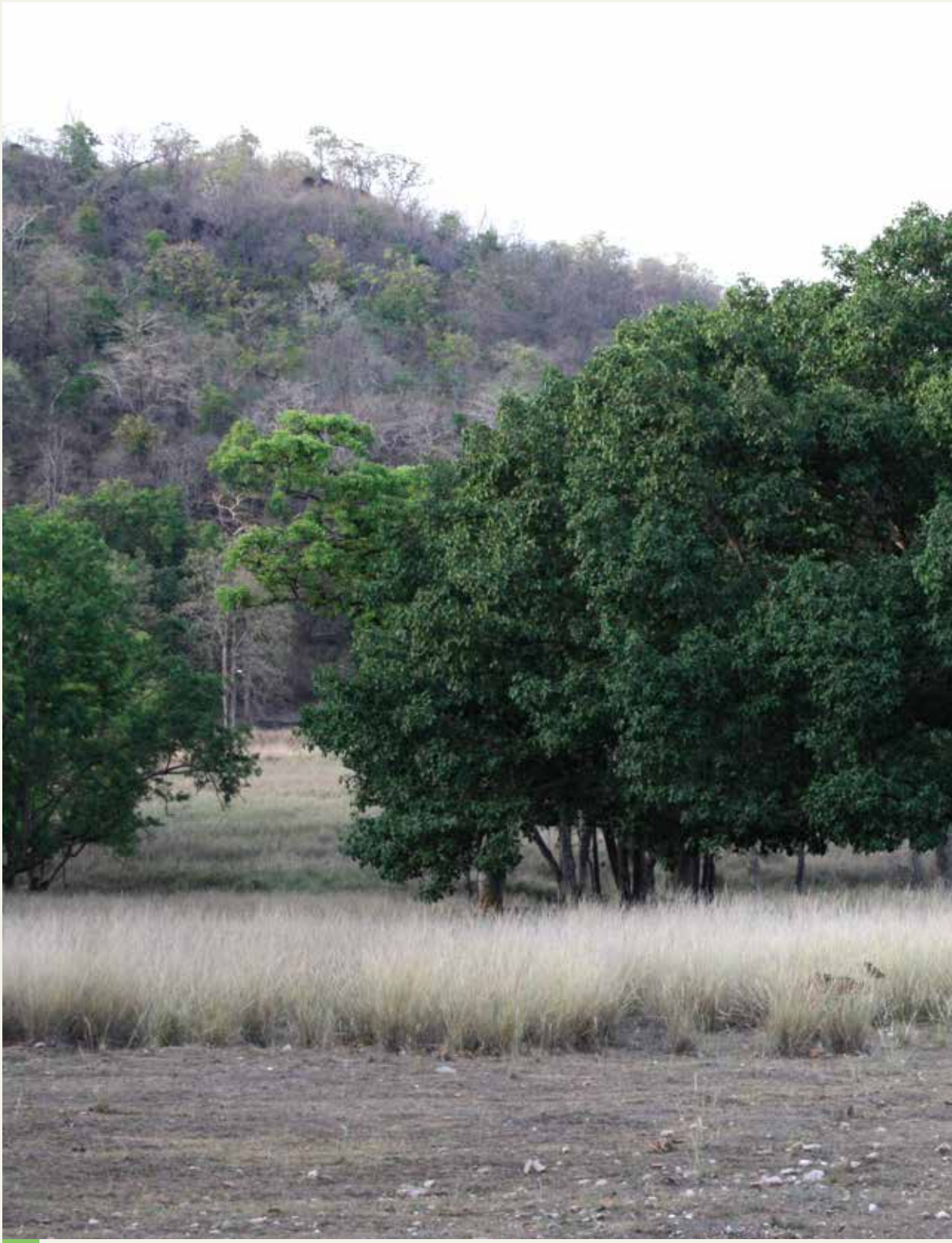

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