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Beyond the realms of Ranthambhore

The Last Abode for Arid Zone Tigers

Status report on tiger and its prey in the Western India Tiger Landscape

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Beyond the realms of Ranthambhore

The Last Abode for Arid Zone Tigers

Status report on tiger and its prey in the Western India Tiger Landscape

Foreword

VASUNDHARA RAJE

CHIEF MINISTER RAJASTHAN

FOREWORD

The charm of vibrant Rajasthan, its timeless and unmatched heritage, colorful culture, mysterious sand-dunes, and Aravalli Mountain Ranges with varied wildlife makes it a unique land of diversities. The varied ecosystems of its desert, hills, forests, and wetlands have supported life for eons, and in return, the native people have also contributed for conserving biodiversity in Rajasthan. Some of the important fauna in the region includes the rare Great Indian Bustard, the charismatic Tiger, the elusive Leopard, the mysterious Caracal and the wandering Wolf. However, the ecosystem diversity of the desert and Aravalli in Rajasthan, southern moist deciduous forests, and Indo-Gangetic Plains is under stress from human population growth, development activities and other anthropogenic pressures.

Tigers and other wildlife outside the protected areas of Ranthambhore and Sariska are facing increasing degrees of disturbance in the form of habitat degradation and fragmentation due to ever growing needs of human population. The maintenance and even creation of wildlife corridors thus assumes increasing importance in sustainable conservation and in the long run, an important step in maintaining viable populations of wild tigers.

This report by World Wide Fund for Nature – India brings insight into the different corridors and habitat blocks that connect Ranthambhore to different sites across the Western India Tiger Landscape – the last home of arid zone tigers. This report offers information set to the forest department and others to maintain functionality of the corridors. For a knowledge-based department such as a forest department, it is vital that modern scientific, analytical and statistical tools are regularly used in planning and operations. It would be unfortunate if this volume is relegated to the library and not used as a management document.

I extend my appreciation to the officers and staff of the concerned forest divisions who partnered with WWF – India to come up with this important document. As has been pointed out, community stewardship shall be an important component in any successful conservation strategy. In all likelihood, the competing demands on land shall continue to rise and thus it is important that the Government devises strategies that allow a balance between conservation and development. For this, wide – spread awareness building and creating adequate capacities in the human resources are mandatory steps.

I congratulate both the forest department and WWF-India for working together to compile this valuable information on the tiger, its habitat and prey status in Rajasthan. I urge all stakeholders to work with the Government and knowledge institutions to ensure the long-term survival of the Tiger and other wild animals in Rajasthan, without which the state and indeed the country would be much poorer.

Vasundhara Raje

(Vasundhara Raje)

Preface

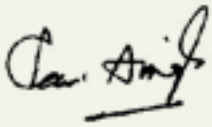
WWF-India initiated in 2012 a landscape level conservation programme in the area of the Ranthambhore Tiger Reserve, termed in the larger form as the Western India Tiger Landscape. We have been working with the state forest department and other local stakeholders on monitoring the populations of tigers, co-predators and prey, protecting them and their habitats and securing functional corridors in the landscape.

In order to understand tiger dispersal patterns in the Western India Tiger Landscape, we have been monitoring tiger movements through extensive field surveys including camera trapping since 2013. Past records have indicated that tigers were once present in the forests across this landscape, both within Rajasthan and across the Chambal river in Madhya Pradesh. Today, due to several factors, mainly loss of habitat and its fragmentation, developmental pressures and poaching threats, tiger distribution is restricted in the Ranthambhore Tiger Reserve.

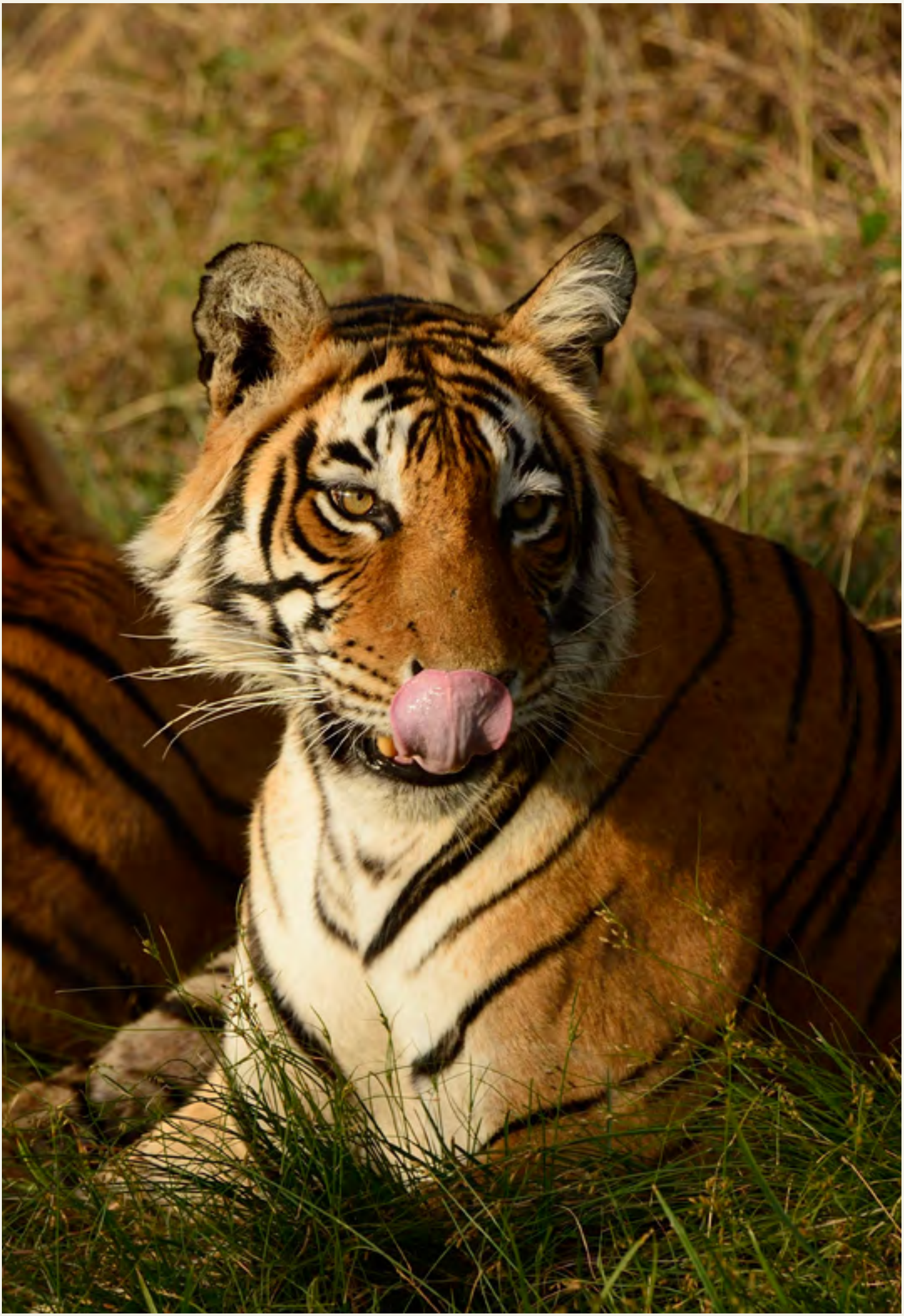
One of the critical requirements to maintain a genetically diverse population of tigers in this landscape is to allow for their safe dispersal by ensuring well protected corridors for undisturbed movement. Field studies have now broadened our understanding of the prevalent routes preferred by the tigers dispersing from Ranthambhore, as well as some potential routes which could be used if protection is strengthened and have further helped us envision several precautions that can be put in place to ensure safe passage of tigers.

In this report, WWF-India identifies a few such habitat blocks that need effective and urgent protection for the future populations of the tiger and other wildlife. Based on our studies, we have suggested some initial conservation measures to ensure corridor connectivity in this landscape.

We sincerely thank the government of Rajasthan and Madhya Pradesh, and the Forest Department, local stakeholders and individuals who supported us in this endeavour to understand tiger occupancy in the Western India Tiger Landscape. We hope these outcomes will serve as a useful resource for framing future conservation strategies in this landscape.



Ravi Singh
Secretary General & CEO, WWF-India



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Forest Department, Mukundra Hills Tiger Reserve (Rajasthan)

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University of Kota (Department of Wildlife Science)

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We also commend Prerna Sharma, Santosh Bhattarai, Hemant Bajpai and Chetan Misher in collection of data from the Indragarh range, Ranthambhore-Kailadevi-Kuno Corridor.

Well Wishers

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WWF-India (WITL)

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Executive Summary

This report presents information on the status of tigers and wild ungulates in the Rajasthan part of the Western India Tiger Landscape (WITL). The study, conducted in association with the Rajasthan Forest Department, was focused on understanding the connectivity of different sites for dispersing population of tigers from the Ranthambhore National Park (RNP).These surveys for tigers and other wildlife were the most intensive and rigorous of their kind to date from the area, and the findings of two years of field-sampling have been analyzed and presented in this report. With the greater purpose of generating reliable information on the occurrence of tigers and their prey outside Ranthambhore, in order to inform conservation planning and wildlife management, at both the local and landscape scales, this study addressed several major objectives.

The potential corridors from Ranthambhore have been identified and surveyed. The Protected Areas (PAs) and habitat blocks which were assessed during the course of the study includes: Kailadevi Wildlife Sanctuary (KWLS), Ramgarh Vishdhari Wildlife Sanctuary (RVWLS), Mukundra Hills Tiger Reserve (MHTR), Banas River habitat block (connecting RNP–KWLS), Sewti Chambal habitat block (connecting RNP-Sheopur-Kuno-Palpur in Madhya Pradesh), and Indragarh-Talwas-Lakheri Habitat blocks (connecting RNP-RVWLS-MHTR).There is a notably large difference in tiger distribution and prey densities amidst the mentioned sites. Tiger occupancy for areas outside Protected Areas varied from 0.21 (SE ± 0.09) at Banas-Chambal Habitat Block to 0.44 (SE ± 0.80) at Kailadevi WLS, indicating there are locations outside RNP, which have potential to harbor tigers as well as provide space for dispersal and movement of prey. The combined wild ungulate density varied from 3.58 (SE±0.88) at Banas-Chambal habitat block to 25.13 (SE±3.18) at MHTR.

Observed patterns of tiger distribution and prey densities are likely to be on account of anthropogenic pressures on wildlife and their habitats in the form of poaching, excessive livestock grazing and the entry of large numbers of people collecting wood and grass from deep inside wildlife habitats. Another significant threat to the survival of tigers and other mammals arises from the proposed development of new roads and broadening of existing roads that would severely fragment the region's fragile corridors.

Largely the connectivity between Ranthambhore National Park and Kailadevi WLS (part of Ranthambhore TR) and further to Kuno-Palpur WLS and Madhav NP in Madhya Pradeshis a form of "stepping stone" connectivity. Towards the south west, a linear corridor connects Ranthambhore to Ramgarh Visdhari WLS in Bundi district further connecting it to Mukundra Hills TR in Kota district of Rajasthan. Tigers from Ranthambore have been reported to disperse along the ridge top forest connectivity in the district of Kota and Bundi. Along with forested area tiger dispersal is also supported by the riverine habitats along the rivers such as Chambal, Kalisindh, Mez,

Parbati, Kuno, Seep and Machali. The ravines also act as corridors for the dispersing animals.

This report also identifies threats, and recommends actions for specific sites that can be adopted by the forest department, and other relevant stakeholder's towards conservation of tigers including policy inputs, suggestions for community involvement in conservation, and also for identifying important areas for future research and monitoring.

1. Introduction

1.1 THE HISTORY OF TIGER DISTRIBUTION AND CONSERVATION IN RAJASTHAN

The tiger holds a special status in India since time immemorial because of its ferocity, power, speed and charismatic beauty. It is also considered as a symbol of strength and royal power. Overpowering or killing this animal was considered a sign of bravery which is why most paintings and portraits of the nineteenth and early twentieth centuries preserved in the castles and forts of erstwhile kings, depict the winner (the *shikari*) posing triumphantly along with the loser (the tiger) (Bhardwaj and Sharma 2013). Early literature on tigers is full of stories of hunting of tigers narrated by *shikaris*, kings, British army officers, civil servants, princes and landlords which also gives an account of the number of tigers they had bagged. For example, the Maharaja of Udaipur shot at least 1,000 tigers during his lifetime (Singh 1959), while there is archival footage from the 1960s of tigers being hunted from the area of Kota, quite close to Ranthambhore (Thapar 2006). In colonial times, all the forests in eastern Rajasthan acted as gathering place for dignitaries. There are records of tiger hunting in the register of *Shikargarh* by King George of Greece to Lord Mountbatten, and from Duke and Duchess of Gloucester to Queen Elizabeth II. A total of 1,074 tigers were shot on license in the forests of present day Rajasthan between 1929 and 1939 (Prater 1940).

By 1947, tigers were locally extinct in most of the forests within Rajasthan. The Rajasthan Forest Act was enacted in 1953, giving the forests more legal protection, and by 1955, many of them were declared Protected Areas. At this time, the practice of sale of forest produce through royalty permits came to an end and this was when the forests received their first “real” protection (Bhardwaj and Sharma 2013). Subsequently in 1970, tiger shooting was banned and the Government of India enacted the Wildlife (Protection) Act in 1972. In 1973, Project Tiger was launched, with the declaration of nine protected areas as tiger reserves, out of which Ranthambhore and Sariska, represented the state of Rajasthan.

Today, the distribution of tigers in the state of Rajasthan is limited to the eastern corner of the state where the high hills of Aravallis and Vindhyas support dry deciduous and thorn scrub forests in the landscape. It constitutes the driest habitat for tigers in the country, and probably in the world. Records from the past indicate that tigers once moved freely across the landscape from Madhya Pradesh in the east towards Rajasthan in the west. Today, however, only two forests accommodate tigers in Rajasthan: Sariska in the district of Alwar and Ranthambhore in the district of Sawai Madhopur.

In the past, the *Shikarkhana* department of the princely states of Jaipur and Karauli managed the forests of Ranthambhore (Bhardwaj and Sharma 2013). Some portions of this area were notified as the Sawai Madhopur Game Sanctuary in 1955, which was later declared as a Tiger Reserve in 1973 when Project Tiger was launched. Ranthambhore National Park was subsequently established in 1980, with the establishment of Kailadevi Wildlife Sanctuary and Sawai Mansingh Wildlife Sanctuary following in 1983 and 1984 respectively.

1.2 THE LANDSCAPE CONCEPT

Increasing human populations and developments associated with the increasing populations together with an even greater rise in demand for resources have led to an increase in fragmentation of wildlife habitats and forests threatening the survival of wildlife and biological diversity. Such habitat fragmentation often leads to the isolation of small populations that are more susceptible to local extinction because of demographic as well as stochastic events (Gilpin and Soule 1986). The natural habitats transforms into smaller, isolated patches due to fragmentation, which are surrounded by a more or less hostile matrix, reducing the continuity or connectivity of the landscape (Ferreras 2001). The connectivity between the fragmented patches facilitates the gene flow between subpopulations and is vital for population survival (Crooks 2002). Meta-populations are sets of local populations connected by corridors and dispersal is a key process in determining the survival of these populations (Davis and Howe 1992; Fahrig and Merriam 1994).

In the field of landscape ecology, the term corridor has been structurally defined as a linear habitat, embedded in a dissimilar matrix that connects two or more larger blocks of habitats, which is proposed for conservation on the grounds that it will enhance or maintain the viability of specific wildlife populations in the habitat blocks(Beier and Noss 1998).Corridors enhance connectivity for wildlife by providing safe passage between fragmented habitats and it is rightly said that corridors are bandages for wounded landscapes. Furthermore, landscape connectivity enhances population viability for several species (Beier and Noss 1998). Corridors are vital conservation tools for connecting isolated patches to protect biological diversity (Rosenberg et al.1997). Protection of naturally existing forest corridors will therefore promote ecological processes and may benefit local and regional biological diversity. The 30,000 km^2 of Western India Tiger Landscape (WITL) houses several such areas within the states of Rajasthan and Madhya Pradesh.

Large mammalian carnivores are particularly vulnerable to local extinction in fragmented landscapes because of their low numbers, large home ranges, dependence on large ungulate prey and to negative changes in habitat conditions (Noss et al. 1996; Crooks 2002). Tigers thus form an excellent focal species to evaluate the importance and degree of functional landscape level connectivity, as they require corridors for movement between forests.

1.3 THE WESTERN INDIA TIGER LANDSCAPE

The State of Rajasthan has a forest cover of 16,086 km² comprising 4.70 % of the geographical area of the state (FSI, 2013). Of this, 26.7% of the State's forest cover is restricted to the districts of Sawai Madhopur and Alwar, which also host the two well-known Tiger Reserves in the country, Ranthambhore and Sariska. They form the only arid zone meta-population of tigers and it thus becomes vital to conserve the tigers and habitat of this region. For the long term stability of a tiger population, it is necessary to develop landscape scale conservation initiatives that support large area of tiger habitat under one conservation unit (Wickramanayake et al. 1998; Sanderson 2006). With this vision, WWF-India formed the Western India Tiger Landscape (WITL) for conserving the western most arid zone of tigers. WITL straddles across two states namely, Rajasthan and Madhya Pradesh. This landscape consists of numerous Protected Areas (Figure 1) and primarily comprises of Ranthambhore National Park (RNP), Kailadevi Wildlife Sanctuary (KWLS), Sawai Mansingh Wildlife Sanctuary (SMWLS) and Qualji Closed Area, Ramgarh-Vishdhari Wildlife Sanctuary (RVWLS), Mukundra Hills Tiger Reserve (MHTR), Kuno-Palpur Wildlife Sanctuary (KPWLS), Sheopur Territorial Forests, and Madhav National Park (MNP) in Madhya Pradesh. Historically, tigers were reported in all around these forests. However, due to subsequent habitat loss, poaching, and fragmentation over the years, their distribution has now been largely restricted to RNP.

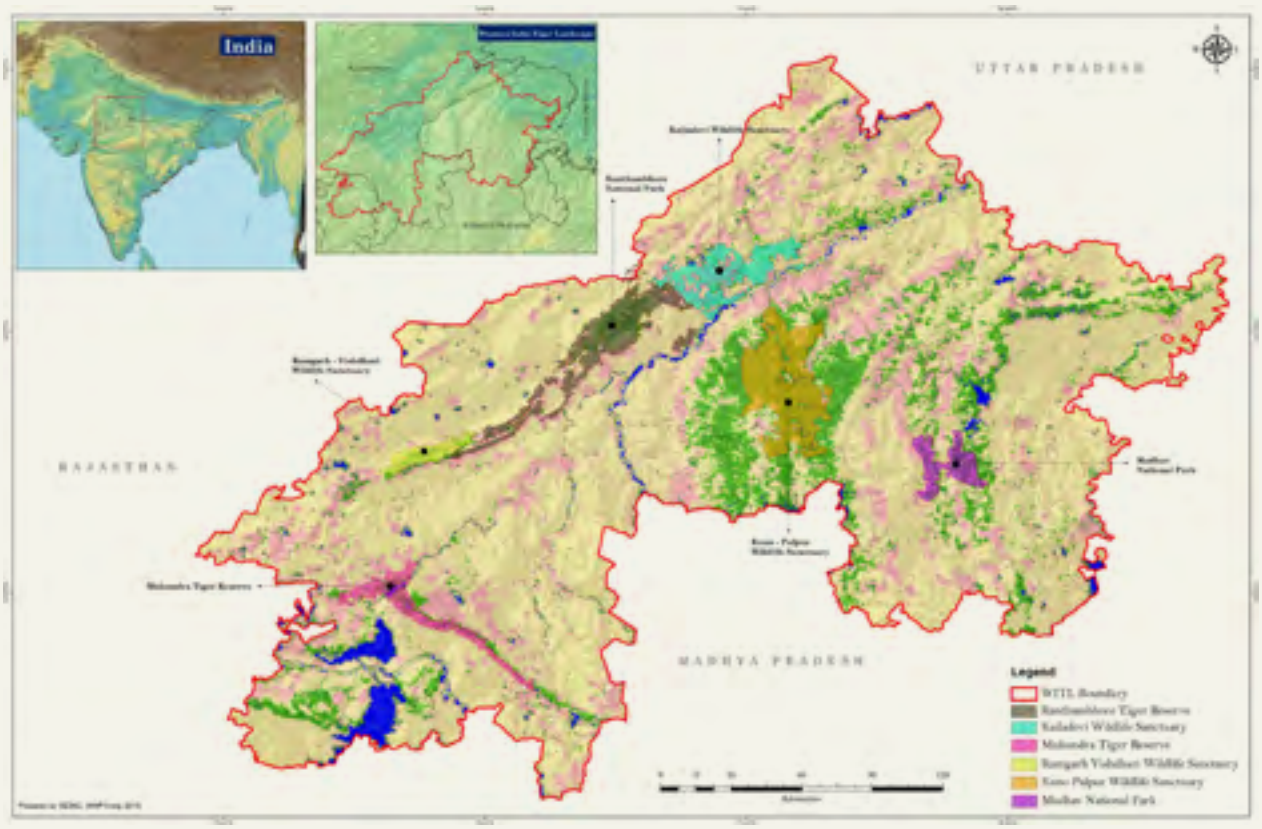


Figure 1: Network of Protected Areas in Western India Tiger Landscape, India

The Ranthambhore Tiger Reserve (RTR) is spread over an area of approximately 1334.64 km2 and has RNP as its core zone, while KWLS in the district of Karauli, SMWLS, and Qualji closed area in the district of Sawai Madhopur and parts in Indragarh, Bundi form the buffer. The Banas River separates the two parts of RTR with the Kailadevi Wildlife Sanctuary in the north and the RNP in the south before joining with the Chambal River. Some parts of the Banas River act as permanent water sources for wild animals of the reserve, especially during the dry hot summer. RTR and its adjoining Protected Areas form the western-most geographical limit of the distribution of the Bengal tiger and support a significant tiger population.

The Kailadevi Wildlife Sanctuary (Figure 2) is contiguous with the RNP separated by River Banas and several villages in the zone. Villages on the periphery of the forest, the network of roads connecting different cities, and sand mining in the Banas River are constant threats to the only existing corridor between Kailadevi and RNP. Quarrying of sandstones among others is another important threat to both RTR and KWLS. The presence of religious sites within the National Park and close to Qualji Closed Area also attracts large number of pilgrims. Revival of KWLS would have an added advantage of providing connectivity between Kuno-Sheopur, which together with RTR could be managed as a meta-population to ensure long-term survival of tigers in this semi-arid ecosystem.

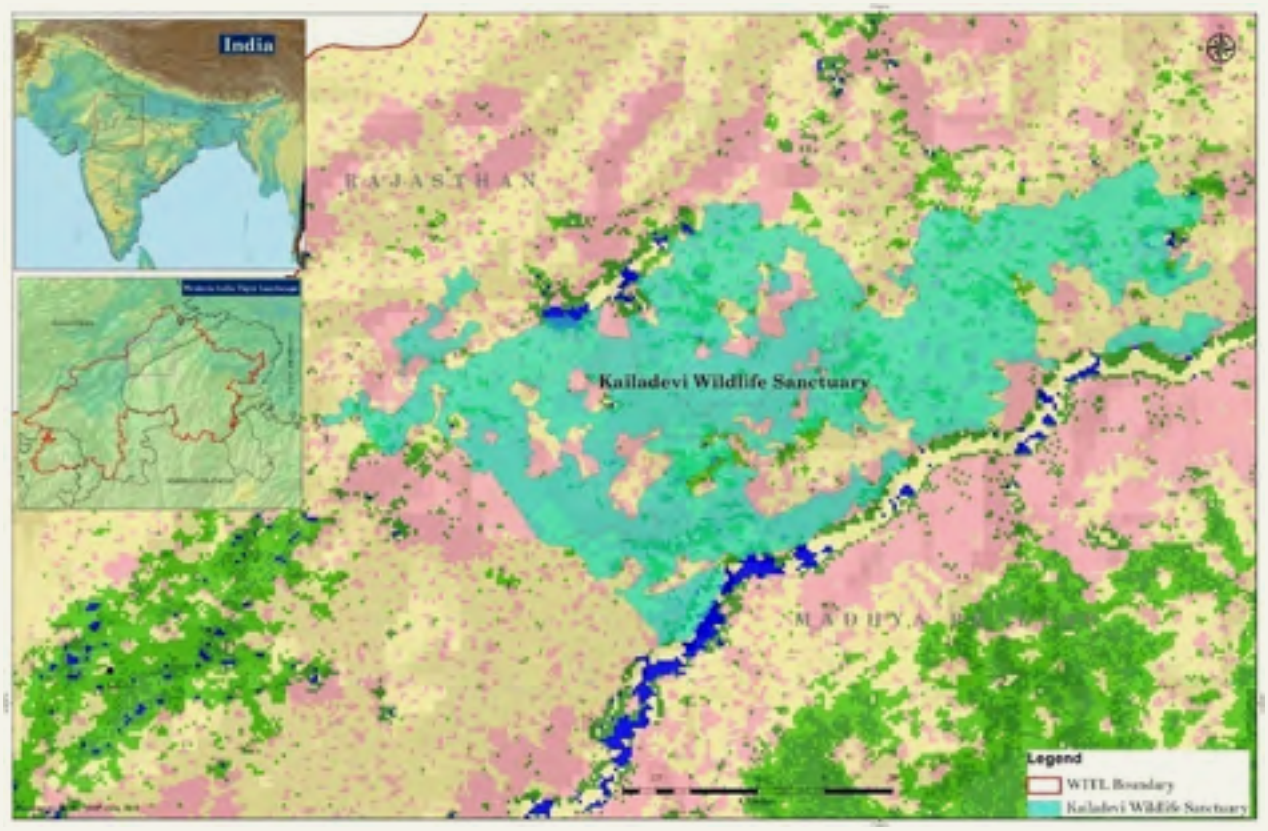


Figure 2: Kailadevi Wildlife Sanctuary in Western India Tiger Landscape, India

The newly created Tiger Reserve in Mukundra (Figure 3) comprising of Darra hill Ranges in Kota district and the adjoining forests of Jawahar Sagar Wildlife Sanctuary in Bundi district, which lies along the banks of River Chambal is also connected to RTR. Mukundra Hills Tiger Reserve has the potential to support a small population of tiger with restorative management and enhancement of prey base (Jhala et al. 2011). However, due to its small size, linear shape and being surrounded by dense human population, a sizable tiger population here is likely to cause severe human-tiger conflict in the region. This aspect needs to be kept in mind before promoting tiger occupancy in this tiger reserve (Jhala et al. 2011).

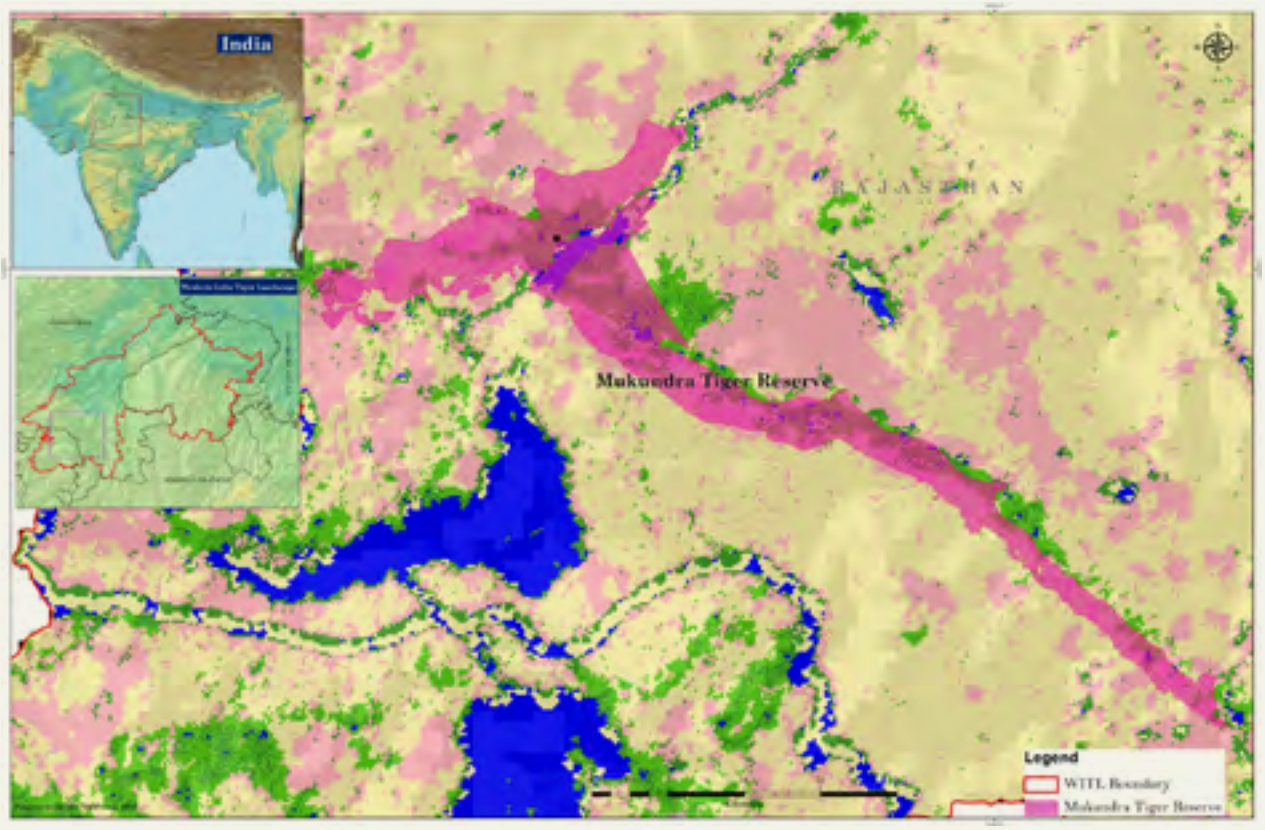


Figure 3: Mukundra Hills Tiger Reserve in Western India Tiger Landscape, India

In 2010, the recorded tiger abundance in an area of 613 km² of RTR was found to be 30 to 32 tigers while in 257 km² of Kuno-Sheopur-Madhav area, 3 tigers were reported (Jhala et al. 2011). However, the source population of tigers in this landscape is limited to Ranthambhore National Park in a range of 30 to 32 (Jhala et al.2011).RNP with 392.5 km² is ecologically a small area to accommodate large numbers of tigers in the park and hence it is desirable to extend the connectivity beyond the national park to manage genetically viable meta-population of tigers in the landscape.

1.4 LOCATION, GEOGRAPHY AND VEGETATION:

The administrative boundary of WITL in Rajasthan runs through the districts of Sawai Madhopur, Kota, Bundi, Karauli and Tonk. WITL is geographically connected to the ranges of Aravallis and Vindhyas. It is interspersed with valleys, flat hills, steep hills, hill-tops and ravines which are formed by rivers including the Chambal, Banas, Mez, Kalisindh, Parban, Machali and Parbati. Ravines starting from Kota district run till the Karauli district.

1.4.1 Ranthambhore Tiger Reserve

The Ranthambhore Tiger Reserve (Figure 4) is named after the grandiose 'Ranthambhore' fort, which is situated inside the national park on top of a hill. It lies between latitudes 25°41› N to 26°22› N and longitudes 76°16› E to 77°14› E. On eastern part of the reserve is the river Chambal which flows from south to north. The Banas River divides the reserve into two management divisions i.e. Ranthambhore and Karauli. The Great Boundary Fault signifies the point where the Aravallis meet the Vindhyas and has a unique geomorphology. The topography is highly undulating with altitude ranging from 300m above MSL to 500m above MSL.

Figure 4: Location map of Ranthambhore Tiger Reserve in Rajasthan, India

As per the biogeography classification (Rodgers & Panwar, 1988) it falls in 4 B (semi-arid zone and Gujarat-Rajwara biotic province). The area forms transition zone between the true desert and seasonally wet peninsular India. The forests are mainly of edaphic climax and belong to the sub group 5B- Northern Tropical Dry Deciduous forests and subgroup 6B -DS1-Zizyphus scrub. The degradation stages found here are DS1-Dry deciduous scrub and SS4 -Dry Grass lands (Champion &Seth, 1968). The area largely represents dry deciduous *Anogeissus pendula* forests sub type in association with *Boswellia serrata*, *Acacia catechu Capparis decidua, Zizyphus mauritiana* and *Prosopis juliflora*. KWLS of RTR represents large patches of scrub forests dominated by *Zizyphus-*, *Acacia- Anogeissus* woodland.

1.4.2 Mukundra Hills Tiger Reserve

The Mukundra Hills Tiger Reserve (Figure 5) includes the areas of Darrah, Jawahar Sagar and part of National Gharial Sanctuary in the districts of Kota, Jhalawar, Bundi and Chittorgarh. It lies between 24° 37' to 25° 7' N Latitude and 75°26' to 76° 12' E Longitude. Geologically, the area of the reserve is occupied by the Vindhyan Supergroup, one of the thickest sedimentary successions in the world, which forms the part of Great Vindhyan Basin. The area is rich in sandstone, shale and limestone.

Figure 5: Mukundra Hills Tiger Reserve in Western India Tiger Landscape, India

The climate of the area is tropical and the mean annual temperature is 25°C with an average rainfall of 800 mm. The tree cover includes dry deciduous forest, dry deciduous mixed forest, *Anogeissus pendula* forest, *Anogeissus pendula* scrub forest, *Boswellia serrata* forest, dry tropical riverine forest and dry grassland (Champion and Seth, 1968)).

1.4.3 Ramgarh-Vishdhari Wildlife Sanctuary

Ramgarh-Vishdhari Wildlife Sanctuary (Figure 6) is a single, compact ecosystem in Hadoti region. The total area of the sanctuary is 307 km^2. It lies in the south-eastern part of Rajasthan between 24°59' to25°53' North latitude and 75°19' to 76°49' East longitude. The sanctuary was formed by the Aravallis and Vindhyan system of rocks hence climate, vegetation type and geomorphology are similar to Ranthambhore and Mukundra.

Figure 6: Ramgarh-Vishdhari WLS in Western India Tiger Landscape, India

1.4.4 Ranthambhore-Kailadevi-Kuno Corridor

a) **Banas River Habitat Block:** This habitat block of around 30 km^2 connects the RNP with the KWLS (Figure 7).This block has witnessed more than six tiger migrations towards Kailadevi and further in almost 10 years. The ravines formed by

Banas River gives a natural passage to wildlife for them to move across RNP. The vegetation consists largely of *Prosopis juliflora*, *Acacia* spp. and *Anogeissus* spp., with several types of weeds and grasses interspersed between them. Ravines are the largest geographical phenomena in this habitat that is sprawled all across this block. This geographical feature gives the best shelter to tigers and other wildlife moving towards the north of KWLS, which is part of the critical tiger habitat of RTR. The prey species that have been recorded are nilgai *Boselaphus tragocamelus*, chinkara *Gazella bennettii*, Indian hare *Lepus nigricollis*, wild pig *Sus scrofa*, Indian peafowl, *Pavo cristatus* and large number of domestic livestock. Major co-predators that were recorded are leopards *Panthera pardus*, sloth bear *Melursus ursinus*, Jackal *Canis aureus*, Wolf *Canis lupus* and Indian fox *Vulpes bengalensis*, with occasional records of tigers in the area. It is a key corridor to maintain the tiger movement between RNP and KWLS. The status of land in this habitat is mostly revenue lands, which jeopardizes the protection of this habitat block.

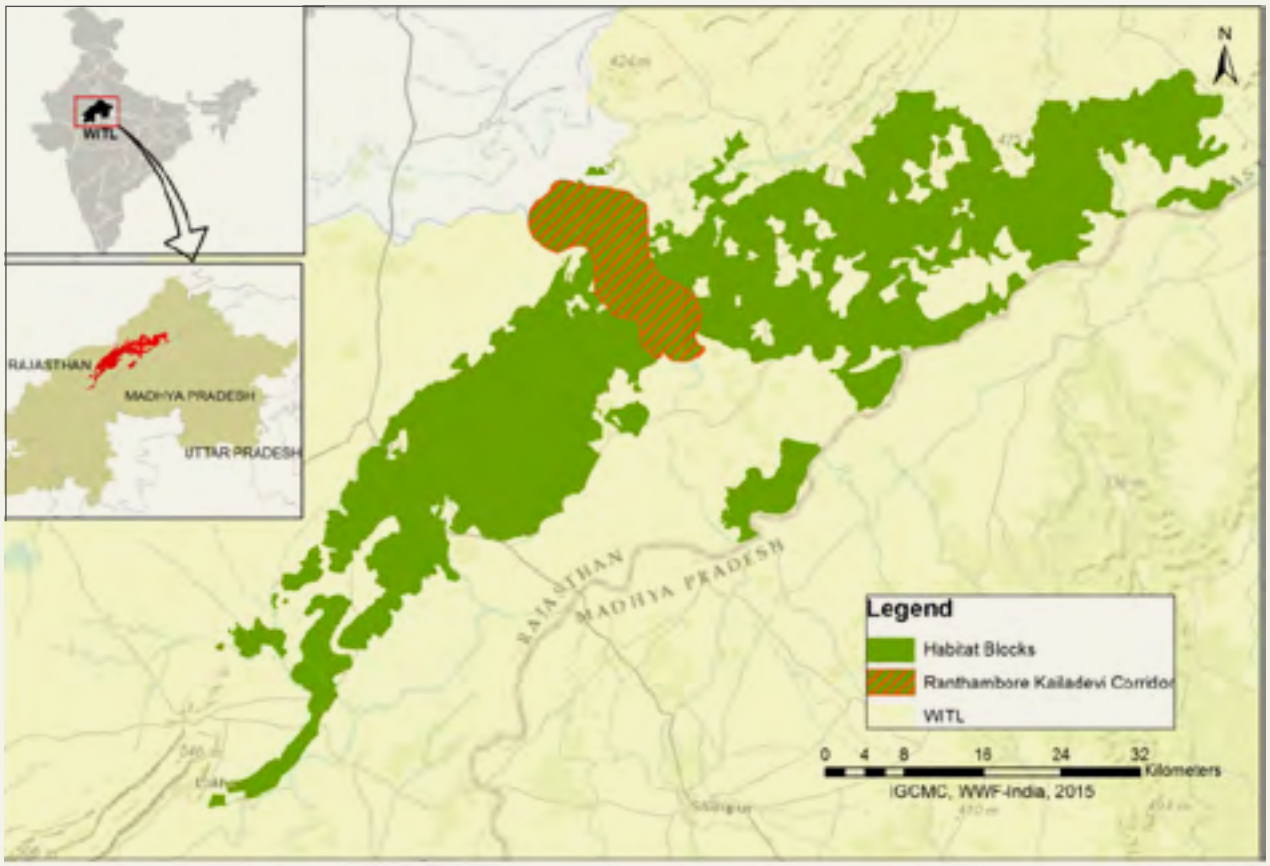


Figure 7: Banas River habitat block connecting Ranthambhore and Kailadevi

b) Sewti-Chambal Habitat Block: This habitat block is situated in the confluence of the Chambal River and the Banas River. The ravines created by these rivers along with river seep forms a tri-junction near Sewti-Chambal that provides a passage for wild animals to move across. This habitat block is part of the RTR buffer area. It connects the Khandar range of RNP (Figure 8) with the forest of Sheopur through

National Chambal Sanctuary (NCS). It is further connected to KWLS by the Baler and Chambal ravines. The dominant vegetation of the Sewti-Chambal Habitat Block is *Prosopis juliflora*. The major prey and carnivore species found are similar to those found in the Banas river habitat block.

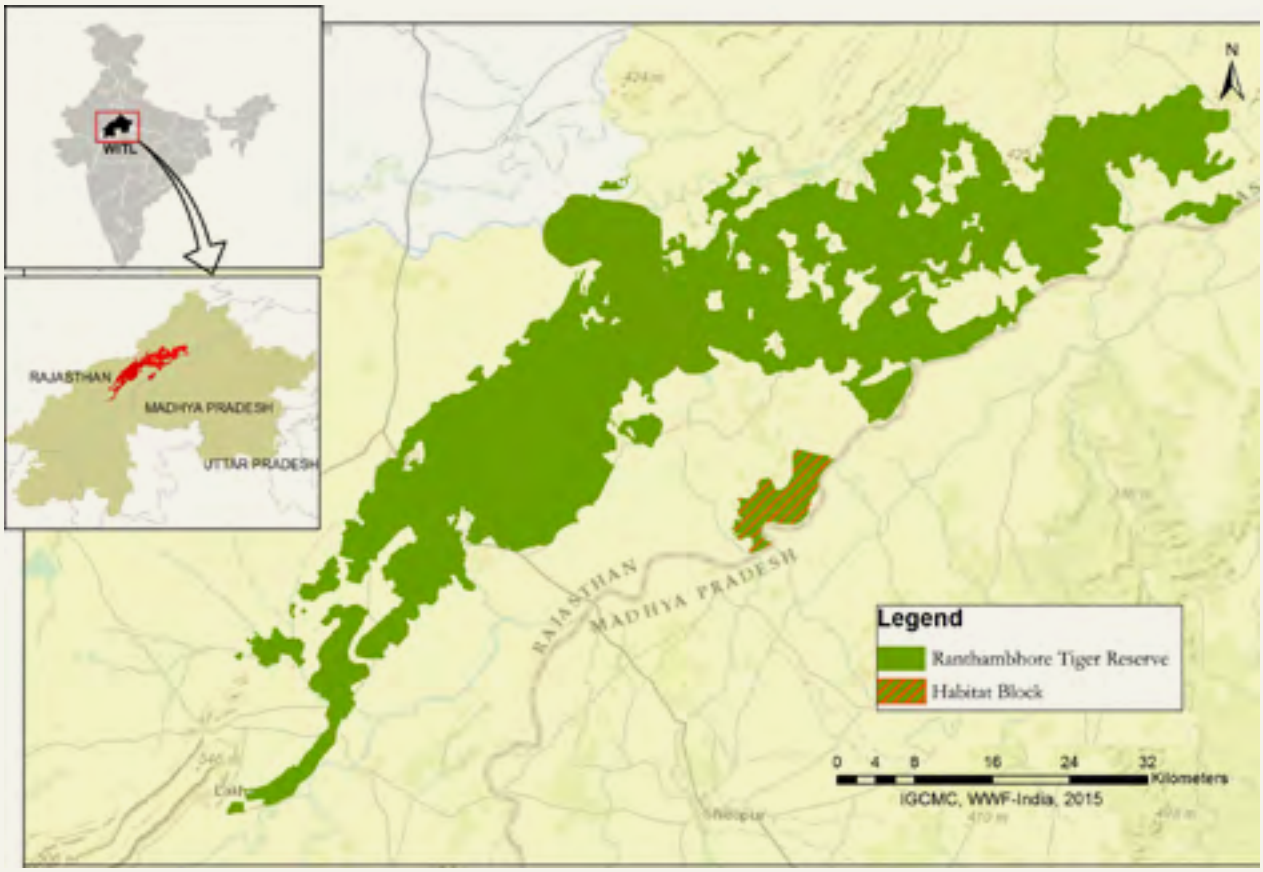


Figure 8: Sewti-Chambal habitat block connecting Ranthambhore and Sheopurforests

1.4.5 Ranthambhore-Ramgarh-Mukundra Hills TR Corridor

c) Indragarh-Talwas Block:This block is situated towards the south-west of RNP. It is a linear patch of forest that connects RNP and Ramgarh Vishdhari WLS (Figure 9). Geographical features such as hills, table tops and valleys together form this habitat block that gives an ideal passage for wildlife. The vegetation here is dominated by *Anogeissus pendula*. Earlier, the forests of this block were a part of the Bundi territorial division but they are now managed as a part of the buffer of RTR.

d) Bundi Forest Block: Part of the Vindhyan system, the Bundi forest block is a significant part of the corridor between MHTR and Ramgarh (Figure 9).The Bundi Forest Block connects MHTR with the southern forest of RVWLS. The two major species of vegetation include is *Anogeissus pendula* and *Boswellia serrata*. There are several blocks which have a high density of *Prosopis juliflora* and *Acacia* species forest. The southern side of Ramgarh WLS connects to the dhonk forest of the Bundi

territorial division, which is the most crucial part of the corridor from Ramgarh to MHTR.

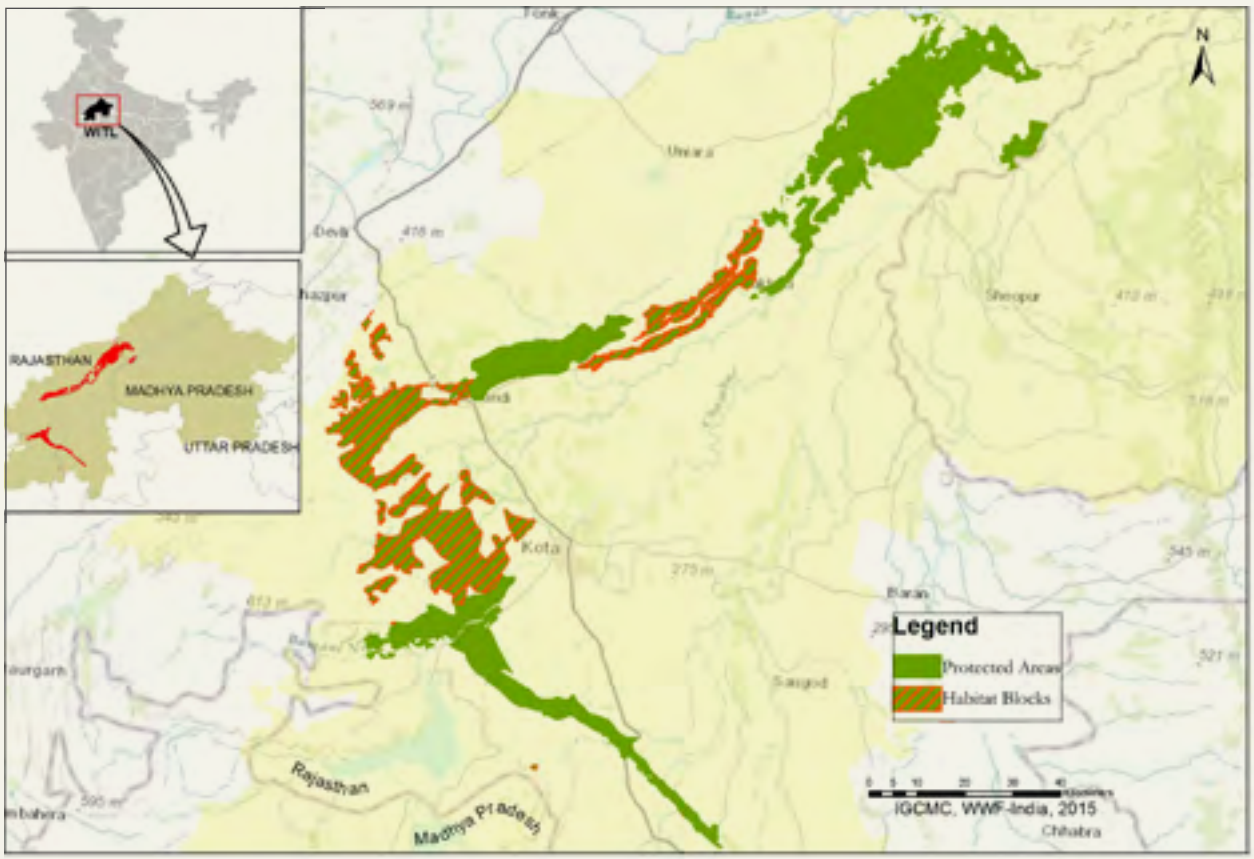


Figure 9: Indragarh-Talwas and Bundi habitat blocks connecting Ranthambhore with Mukanadra Hills

1.5 CONSERVATION THREATS IN THE LANDSCAPE

Although RNP itself is relatively free of threats especially in the core area, the same does not hold true for the rest of the landscape where there are considerable threats and pressures both in the PAs and corridor areas. To ensure the conservation effectiveness within Protected Areas as well as in the corridors and potential habitats in WITL, it is important to understand the major threats (Figure 10) and prioritize which need to be addressed for effective interventions.

1.5.1 Increasing human population and expansion of agriculture fields

Rajasthan has a total human population of 68,621,012 and is the eighth most populated state in India. Human population density in Rajasthan has now increased to 201 persons per km^2, when compared to the year 2001 when it was 165 people per km^2 (Census of India 2011). This increasing population has severely compromised

the condition of tiger habitats. Given that most of the sites have lesser protection regimes, such disturbances have a greater impact on wildlife as compared to forests with a protected 'core'. Although, RNP is relatively free from human imprint in the core areas, there is a considerable level of disturbance level in its buffer areas, more towards the north-west portion leading to Kailadevi WLS. There are numerous settlements in and around KWLS exerting pressure on the forests and subsequent competition for resources between the village livestock and the wildlife inhabiting the region. These settlements have poor road connectivity and most inhabitants regularly traverse through KWLS. The growth of these settlements is worrying as KWLS is fragmented and surrounded by human settlements in most directions. Similarly, there is a continuous movement of herders within Ramgarh, where they travel from the western parts of Rajasthan with their livestock. Expanding agricultural fields in the periphery and in some cases even within the Protected Areas is a matter of concern.

1.5.2 Grazing pressure

The grasslands are degraded and overgrazed in most parts of the landscape. Livestock signs were common in most of the areas sampled in the landscape. Though nearly every village has some common grazing land, these are mostly poorly managed as well as inadequate and livestock are usually led in to the adjacent forests. Large livestock populations of both settled and nomadic villagers graze within and in the periphery of the PAs particularly KWLS, RVWLS and MHTR. There is a continuous movement of herders within RVWLS where they travel from the western parts of Rajasthan with their livestock.

It is likely that the livestock in these areas are creating high grazing pressure. In several overgrazed sites, forest under-story has been degraded, resulting in loss of ground cover and suppressed regeneration. Intense grazing pressures are also associated with rampant proliferation of invasive species.

1.5.3 Weed abundance

The quality of habitat is adversely affected by the spread of invasive weed species. Proliferation of *Prosopis juliflora (*mesquite) in and around RTR, KWLS and RVWLS as well as *Lantana camara (wild sage)* in MHTR is a major issue in the landscape. *Lantana camara* which grows in thick tangles often out-grows native flora with better forage value for wild ungulates. Another dominant weed in this landscape is the strong aromatic American mint *Hyptis suaveolens*. Invasive weeds can therefore lower the habitat's carrying capacity for wild prey and subsequently for top predators like tigers. The gradual rise of degraded forests and spread of weeds in the Banas River habitat block, Indragarh-Talwas (RTR), and Bundi Forest block has affected the wildlife population dramatically.

1.5.4 Mining

There is unregulated mining of limestone, boulders, and sand in several specific corridor blocks i.e. the Banas River habitat block and Indragarh-Talwas habitat block. Although mining is not an issue in Protected Areas, an increase in mining activities all

around might lead to further degradation and fragmentation of these habitat blocks. There are several abandoned mines which are not being restored and would require assisted restoration to make the sites conducive for wildlife use.

1.5.5 Linear infrastructure

Tiger conservation in the WITL will only be successful in the long run if connectivity is maintained between different patches of habitat. Currently, most linear developments in terms of roads and railways threaten wildlife movements in corridor areas. There is overwhelming evidence in literature of the adverse impacts of roads on large mammals in general, and specifically on tiger survival. Some of the existing roads act as barriers for animal movements while some of these are responsible for affecting their population through road-kills. Such roads include:

1. One national highway (NH-12) and two state highways (SH-33 & 9A) connecting different major and minor cities of Rajasthan and Madhya Pradesh cutting across MHTR,;
2. State highway (SH-30) running between RNP and Sawai Mansingh WLS connecting Sawai Madhopur in Rajasthan to Sheopur in Madhya Pradesh;
3. State highway (SH-29) cutting Indragarh habitat block of RTR connecting Kota and Lalsot in Rajasthan.

Furthermore, the railway lines running through MHTR connecting Delhi and Mumbai experience a significant amount of traffic. Several major and minor trains run through this patch thus hampering wildlife movement. In 2003-04, a sub-adult tiger called 'broken tail' which had dispersed from Ranthambhore was reportedly killed along this railway line.

1.5.6 Flattening of ravines

The ravines of the Chambal, Banas, Mez and Kali Sindh are unique geographical features in this landscape. These ravines act as a refuge and corridors for various animals including tigers. Tigers use these ravines to move between RNP to Kuno-Palpur, and RNP to RVWLS. While several farmers have on their own initiative sought to reclaim small portions of the ravine area and use these for agriculture, earlier this year the state government of Madhya Pradesh unveiled an ambitious plan to convert an area of approximately 700 km^2 (180 $km^2$of which is to be leveled) spread across the three districts of Morena, Sheopur and Bhind in to agricultural land. The development could potentially disrupt the ecological balance of the area as also cut off access for tigers moving from RNP and KWLS to Kuno Palpur.

1.5.7 Poaching and protection

Habitat connectivity plays an important role in maintaining wildlife populations. However, there are several other factors that affect population size and species recovery, and poaching is prominent among these. Poaching could be of subsistence and/or trade and commonly occur in corridors and in Protected Areas where

patrolling is minimal. Observations from field visits revealed that lack of manpower and ineffective protection in corridor areas has likely led to decimation of wildlife population in corridor areas. Although all these sampled sites form part of a larger landscape, they do not appear to sustain viable tiger populations at present, except in Ranthambhore National Park. Evidence of poaching was found on more than one occasion, when survey teams encountered armed poachers in certain sites. Empty cartridge shells were also encountered during the sampling period indicating active poaching of wild animals.

1.5.8 Heavy footfall in PAs for religious and cultural purposes

There is heavy footfall in KWLS during the winter season and close to 200,000 visitors travel to the Kailadevi temple for the annual fair. Similarly in RVWLS and MHTR, forests are being highly pressurized due to constant incursions by people. Thousands of people visit places like the Ramgarh Mahal for religious purposes.

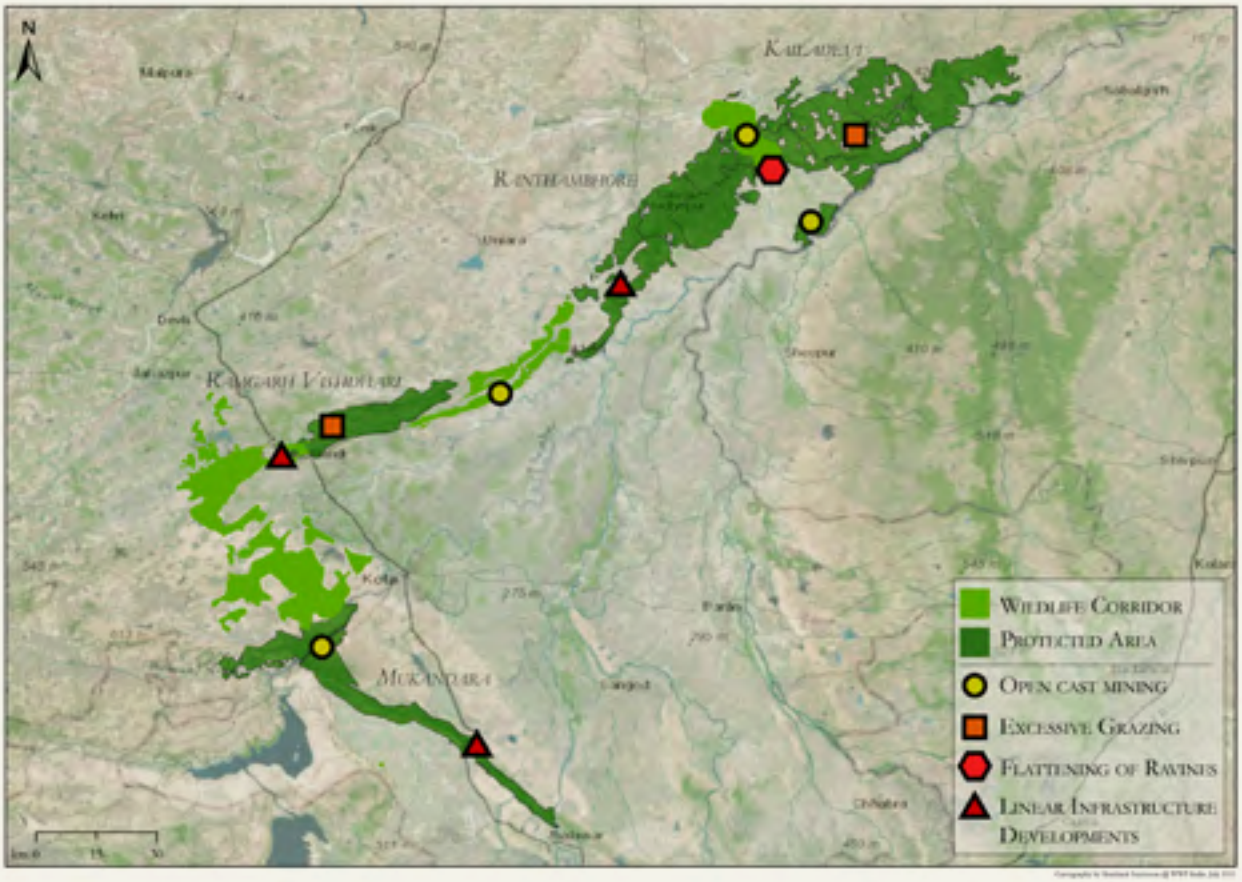


Figure 10: Sites showing major conservation threats in WITL

2. Tiger Dispersal from Ranthambhore National Park

Tigers dispersing out of Ranthambhore NP into adjoining Protected Areas have to travel through heavily populated and highly fragmented wildlife corridors. This dispersal thus comes with a specific set of risks such as conflict with humans and poaching. To mitigate these risks, WWF-India and the State Forest Department monitor the movement of these dispersing tigers to ensure that necessary protection measures are implemented along the dispersal route. In 2014, four tigers safely moved out from Ranthambhore NP into Kuno-Palpur WLS, Ramgarh-Vishdhari WLS and Kailadevi WLS, facilitating the distribution of the species across a wider habitat.

The dispersal of tigers in general is necessary to avoid conflict in the source habitat (e.g. Ranthambhore), to maintain genetic diversity among the species and to avoid inbreeding depression. Increasing tiger numbers in source sites often leads to a concurrent increase in human-wildlife conflict cases and natural dispersal provides an opportunity for tigers to populate new areas beyond source population sites, thus reducing pressure and consequently the potential for conflict in these sites. The monitoring of dispersing tigers from Ranthambhore NP is an essential step towards ensuring successful repopulation of neighboring PAs from where tigers have disappeared years ago. The Western India Tiger Landscape has the potential to support a population of around 100 tigers.

Brief notes on the tigers that had dispersed from Ranthambhore are as follows:

The first proper record of a tiger to move out of Ranthambhore was that of a female in 1998-1999. The tigress settled in Bharatpur and is believed to have lived in Keoladeo Ghana WLS for approximately six years before dying of natural causes.

The second was a sub-adult that dispersed in 2003-04. This tiger was well known as 'Broken Tail'. It moved towards the south of RNP and travelled a distance of approximately 100 to 150 km. It was possibly killed by the Rajdhani Express on the railway track passing through MHTR.

Until 2006, there were tigers in Ramgarh WLS of Bundi District, Rajasthan. This was because of dispersal from Ranthambhore to Ramgarh through southwest corridors from RNP. Prior to the last dispersal in 2013, an incident was observed by an ex-forest officer from Ramgarh WLS, in which a tiger reached as far as Indragarh forest (at present, the buffer zone of RTR), via ravines of the river Mez. This was the third dispersal of a tiger from RNP to neighbouring forests.

In 2009, the fourth tiger dispersed from RNP to Kailadevi WLS and reached the Morena forest area of Madhya Pradesh MP via Dhoulpur District in Rajasthan. It subsequently moved back to Kailadevi WLS and has been living there over the last four years. The Forest Department has camera-trapped this tiger in Kailadevi WLS. This tiger is locally known as 'T-47'.

The fifth tiger, known as 'T-7' dispersed in August 2010 towards the north of RNP via Bhuripahadi village and the Banas River. After a case of livestock depredation in the village, the Forest Department attempted to tranquilize the tiger. Unfortunately in the process, the RTR Assistant Conservator of Forests, Mr. Daulat Singh Shaktawat, was badly injured. The tiger crossed Kailadevi WLS, Dholpur forests and Bandh Baretha forests, and further travelled to Mathura District in Uttar Pradesh. The tiger later walked back to Bharatpur and spent a few months in Keoladeo Ghana WLS. It was later reintroduced into Sariska Tiger Reserve in February 2011 where it was renamed 'ST-6'.

The sixth individual, a tigress known as 'T-35' in Ranthambhore, dispersed to the Sultanpur area of Kota District as well as to Baran District of Rajasthan. It settled in the ravines near the Chambal River. This tiger covered more than 100 km during its ranging period.

The seventh tiger from Ranthambhore, identified as 'T-38', dispersed in 2010 via the Banas River, the Karanpur Range of Kailadevi WLS and the tributaries of the river Chambal and Kuno. This tiger reached Kuno-Palpur WLS and has been surviving in the area where there are currently no other large cats.

The eighth tiger, a sub-adult male tiger from Ranthambhore, dispersed at the end of January 2013. The tiger crossed the Chambal River through the Nain-ya-ki range of

RTR. It then crossed the territorial forests of the Sheopur District of MP. The tiger was believed to have spent 30 to 35 days in Sheopur and Kuno WLS. In mid-March 2013, the tiger was found in the Seonda range of Datia MP. Camera-trap images of the tiger in Datia and a previous picture from Ranthambhore were compared to confirm that it was the same individual from Ranthambhore.

The ninth tiger, a sub-adult female, was photographed in an opportunistic camera-trapping exercise carried out by the WWF-India field team working in Khandar Range at the periphery area of RNP, which is actually a block of forest in the corridor connecting Kailadevi WLS. Khandar is a multi-use landscape.

The tenth tiger, a sub-adult from RTR, identified as the offspring of female 'T-8', was camera-trapped in the Talwas/Nainwa range of the Bundi territorial forest. It had dispersed from Ranthambhore in August 2013.

The eleventh tiger, a sub adult from RTR and offspring of T-30 was camera trapped by WWF- India team in Kuno-Palpur WLS. It had used the same route as some others, via Kailadevi WLS and river Chambal to reach Kuno WLS. It was first camera trapped in Kailadevi WLS in the end of 2014 and after span of four months, again in 2015, at Kuno WLS.

The twelfth dispersal was by one sub adult male tiger, an offspring of T-13 and it was camera trapped in the month of April –May 2015 on a livestock kill in Kailadevi WLS.

The most recent recordings were those of two more individuals 'T-76' and 'T-72' from Kailadevi WLS. Both the individuals had dispersed from RNP.

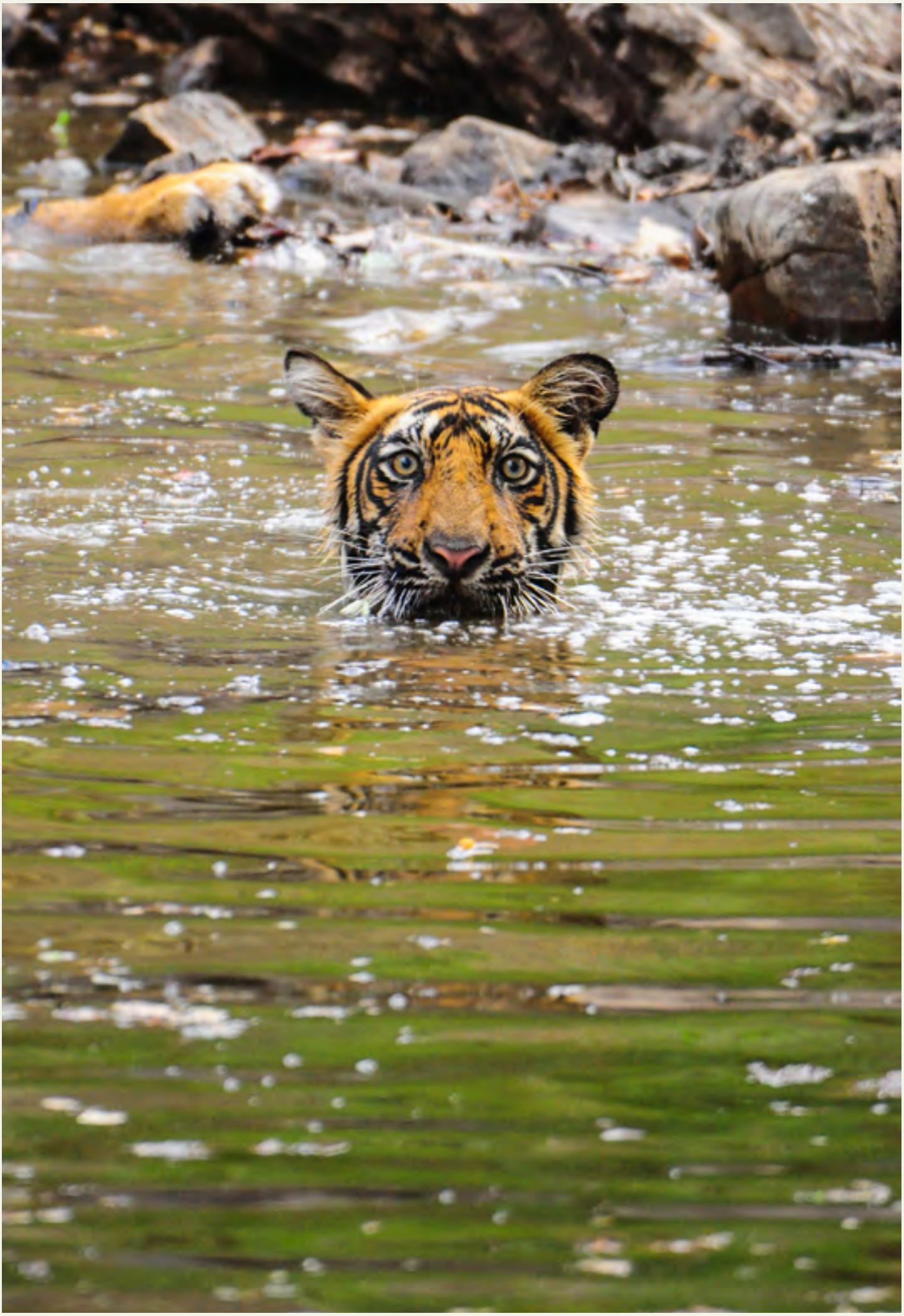
Dispersal routes: Based on our observation, we divided the potential dispersal routes of tigers as follows:

Primary dispersal routes:

- Phalodi-Qualji-Papda-Indragarh (Lakheri)-Ravines of River Kalisindh-Sultanpur ravines-Mukundra Hills Tiger Reserve
- Phalodi–Qualji–Papda-Indragarh (Lakheri)-Ramgarh WLS -Bundi Forests-Darra WLS
- Killa Khandar-Banas-Baler-Karanpur–Chambal-Nadi gaon-Virpur range of Sheopur Territorial-Kuno-Palpur WLS
- Talra-Buripahari-Banas river habitat block-Hadoti-Kailadevi-Van vihar (Dholpur)-Bayanka Reserve forest and Bundh baretha WLS-Keoladeo Ghana NP

Secondary dispersal routes:

- Killa Khandar-ravines of river Banas-Sewti-Chambal-Khadi and Budhera range of Sheopur Territorial-Sironi Range of Kuno buffer-Kuno Palpur WLS
- Karanpur-Mandrayel-Ravines of River Chambal-Dholpur-Murena Forest Division



3. Tiger occupancy and prey status

3.1 AIMS AND OBJECTIVES

The study in the Western India Tiger Landscape focused on the potential of corridors to support migrating tigers within the landscape. This study determines the area being used by tigers in specific sites and further recommends strategies to manage the areas that need immediate attention. The study hopes to help form a long-term conservation plan, and serve as a baseline for research and monitoring in the WITL.

The aim of this survey was to determine the tiger occupancy to better our understanding of the tiger's dispersal pattern in the WITL. Ranthambhore National Park acts as a source for tigers, some of which disperse or emigrate to other neighbouring forested areas such as Kuno-Palpur Wildlife Sanctuary to the east and to the forests of Kota and Bundi districts to the south (Jhala et al. 2011). There have been occasional reports of tiger sighting in the areas between Ranthambhore and Kuno-Sheopur forests, across the Chambal, and near the confluence of the Chambal and Kuno River. Though the corridor is scattered with agriculture and other human settlements, it has forested patches and a fissured rugged terrain, which is conducive to movement of carnivores under the cover of darkness. The tiger population outside Ranthambhore was accessed and documented, after acquiring the facts and secondary information generated from various sources. Another objective was to reliably estimate the prey status in areas surrounding RNP.

3.2 TIGER OCCUPANCY SURVEY

In order to assess the occupancy of tigers in the landscape, the study area was gridded into grid sizes of 100 km^2. Following this, trails (roads, river beds, existing trails and ridge tops) were chosen for sign surveys in each grid to maximize probability of encountering said signs. The surveyed distance walked within each grid varied from 5 to 40 km depending upon the available tiger habitat (based on land-cover features). Indirect evidences in the form of pugmark, scats and scrapes were recorded to assess occupancy rates of tigers. The exercise was carried out with a team of 2-5 people and at an average speed of 1.25-1.5 km/hr of walking. Data was collected at 1 km segments. In addition to the frequency of occurrence of tigers, the occurrence of leopards, principal prey species, as well as livestock and human activity was also estimated as a percentage representing the number of 1 km segments with signs by the total number of segments surveyed per trail. The key objective was to map tiger distribution so as to identify the use of the corridor by tigers and associated animal species. Grids with

<10% tiger habitat and forest fragments of <10 km² were excluded from the survey, because tigers were unlikely to occupy these areas (Karanth et al. 2011).

Occupancy surveys for animal signs involved 1213kilometers of foot surveys in MHTR, KWLS, RVWLS, Banas-Chambal and Indragarh Talwas block. Overall, this sampling exercise was the largest survey effort of its kind in the region till date, and involved a partnership between forest department, state government agencies, research institutions, non-governmental organizations, and members of local communities who also participated in the research.

3.2.1 Field protocol

The survey was conducted in the dry season to minimize variations in animal detection probabilities due to rainfall. Typically, tigers move along forest trails to hunt or to locate, avoid or deter con-specifics (Schaller 1967; Karanth and Sunquist 2000). Their passage is marked by tracks and occasional scat deposits (Smith et al. 1987). Fresh signs of tigers, leopards, and major ungulate prey species were identified, photographed, and recorded by trained observers. Only unambiguously identified signs were recorded. Each type of sign detection was assigned only once to each trail segment, thus yielding the standard '1' (detection) or '0' (non-detection) histories required for occupancy analyses. These sign detection data were aggregated at 1 km length to form 'spatial replicates' (MacKenzie et al. 2006; Hines et al. 2010).

The survey was conducted from September 2013 to March 2015and had an effort of 962 man-days. Analyses were performed using program PRESENCE (Hines 2006).

3.2.3 Model structure and spatial dependency

Occupancy models of MacKenzie et al. (2002) and Hines et al. (2010) without additional covariates were compared first to choose the appropriate model type for conducting further analyses (Karanth et al. 2011). All model comparisons were based on Akaike Information Criterion (AIC) values (Burnham and Anderson 2002). We estimated the overall occupancy rate, ψ (SE), with the result pertaining to the different areas enclosed by the surveyed grids. To assess factors influencing tiger presence, the proportion of replicates with different habitat types, terrain type and human/livestock signs were used as additional covariates in our models. The exercise to assess the status of other carnivores, prey and their habitat in the region were carried out in a systematic framework as suggested by Jhala et al. (2008).

3.3 PREY ESTIMATION

Information on the status of ungulate prey is needed to better understand their influence on the distribution and dynamics of tiger populations. Availability of prey is thought to be the most important factor determining carnivore's spatial distribution across habitat types and their overall abundance (Carbone and Gittleman 2002).The density and distribution patterns of large predators, like tigers, are primarily governed by the availability of ungulate prey (Karanth and Nichols, 1998; Karanth and Nichols 2002;

Harihar and Pandav 2012).The importance of abundant prey populations in sustaining viable tiger populations is well known. As a result, securing and managing high density ungulate prey population is an important measure to promote tiger population at key tiger conservation areas (Sanderson et al. 2006; Chapron et al. 2008; Walston et al. 2010).

Distance sampling using transect lines is the most commonly employed method to estimate the densities of wildlife populations, particularly the prey population. The technique involves generating data on perpendicular sighting distances by walking in multiple transect lines, and recording the distance from the observer on the transect line to the animals detected (Buckland et al. 2005). Observers recorded the sighting distance to the animal and also the angle of detection using a range finder and a compass, respectively, when animals were detected while walking in a line transect. Densities were estimated using computer program Distance 6.0 (Thomaset al. 2010).

3.3.1 Field protocol

Grid sizes of roughly 2 x 2 km were drawn out on a map of the study area and were quantified to select sampling area. Subsequently, grids for sampling were systematically selected, while ensuring that a sufficient number of grids were picked to spatially cover the sampling area. Random starting points were picked for transects within each of the selected grids, which had been randomly sampled between October 2013 to March 2015. In total, approximately 143 transects were walked, each of which were 2 km long, except in a few cases where difficult terrain and dense vegetation obstructed the walk. Each transect line was sampled 1-4 times by 2-3 observers on foot. Transect lines were sampled in the morning and evening hours, and records were made of animal attributes (sex, group size), with respect to distances and angles from the observer's location on transect to the animals. The total sampling effort was around 879.2 km.

3.3.2 Prey density estimation

Line transect data was analyzed using the program DISTANCE version 6 (Thomas et al. 2010). This yielded estimates of the density of principal prey species for each study site. Two approaches were used for analyzing the data:

1. Pooling data for all or major prey species for fitting global detection function curve; and
2. Fitting detection function at species level when there were sufficient detections. The goodness of fit (GoF-P) test was used to judge the fit of the model, and the 'best' model from the subset of models was selected using AIC value (Burnham and Anderson 2004).

The current study provides systematic baseline estimates for ungulate prey densities based on robust sampling techniques (Karanth and Nichols, 2002). Densities of major prey species have been estimated for Kailadevi WLS, Ramgarh Visdhari WLS, Banas-Chambal, Talwas and Mukundra TR using data from variable distance transect sampling conducted over a period of one year.

We also calculated group encounter rates for each species, i.e. the total number of groups of each species detected per unit transect effort per site. These estimates can be interpreted relative probabilities of encountering any species during transect sampling at a site. Encounter rates are simple indices of relative abundance of a species and do not account for detection probabilities. These indices provide estimates of population trend only if the assumption that the proportion of animals detected is constant across time and species holds true. Since this assumption is seldom met, encounter rate indices are not reliable estimates of species abundance and they are of limited utility in monitoring population trends.

3.4 OPPORTUNISTIC CAMERA TRAPPING

For obtaining information on tiger movement and dispersal, opportunistic camera trapping was conducted in specific sites. The trapping locations were selected based on the sign survey data and secondary information collected from various sources. However, camera trapping in RVWLS was systematically carried under National Tiger Conservation Authority (NTCA) guidelines (Qureshi et al. 2014).

4. Results and discussions

4.1 TIGER OCCUPANCY

Sign surveys, such as the current surveys in the landscape, are useful means of monitoring the occurrence of species such as tigers and their prey over large spatial areas and over time (Karanth et al. 2011). Moreover, data collected using a site-occupancy design can allow the monitoring of population trends and changes in species-occurrence using contemporary occupancy modeling approaches (Noon et al., 2012). Such occupancy surveys should be carried out in subsequent years to understand the population of endangered species like tigers. During the sampling period, no resident tiger may have been present in the sites that were sampled. This however does not rule out the possibility of the occurrence of one or more tigers in areas outside Ranthambhore. Site-wise occupancy of tigers and other carnivores have been presented below:

4.1.1 Kailadevi Wildlife Sanctuary

A total of 301 km was walked during the occupancy survey in KWLS. Signs of tigers were found during the sampling period between October and November, 2014. Along with tiger signs, other large carnivore signs encountered were of leopard, wolf, hyena and sloth bear. The habitat occupancy, Ψ(SE), for tigers (Figure 11) was estimated to be 0.44 (0.8). Habitat occupancy for other large carnivores was estimated to be 0.44 (0.09) for leopard, 0.13 (0.09) for wolf, 0.92 (0.04) for hyena and 0.59 (0.01) for sloth bear. The detection probability value varied from 0.13 to 0.62 in the area.

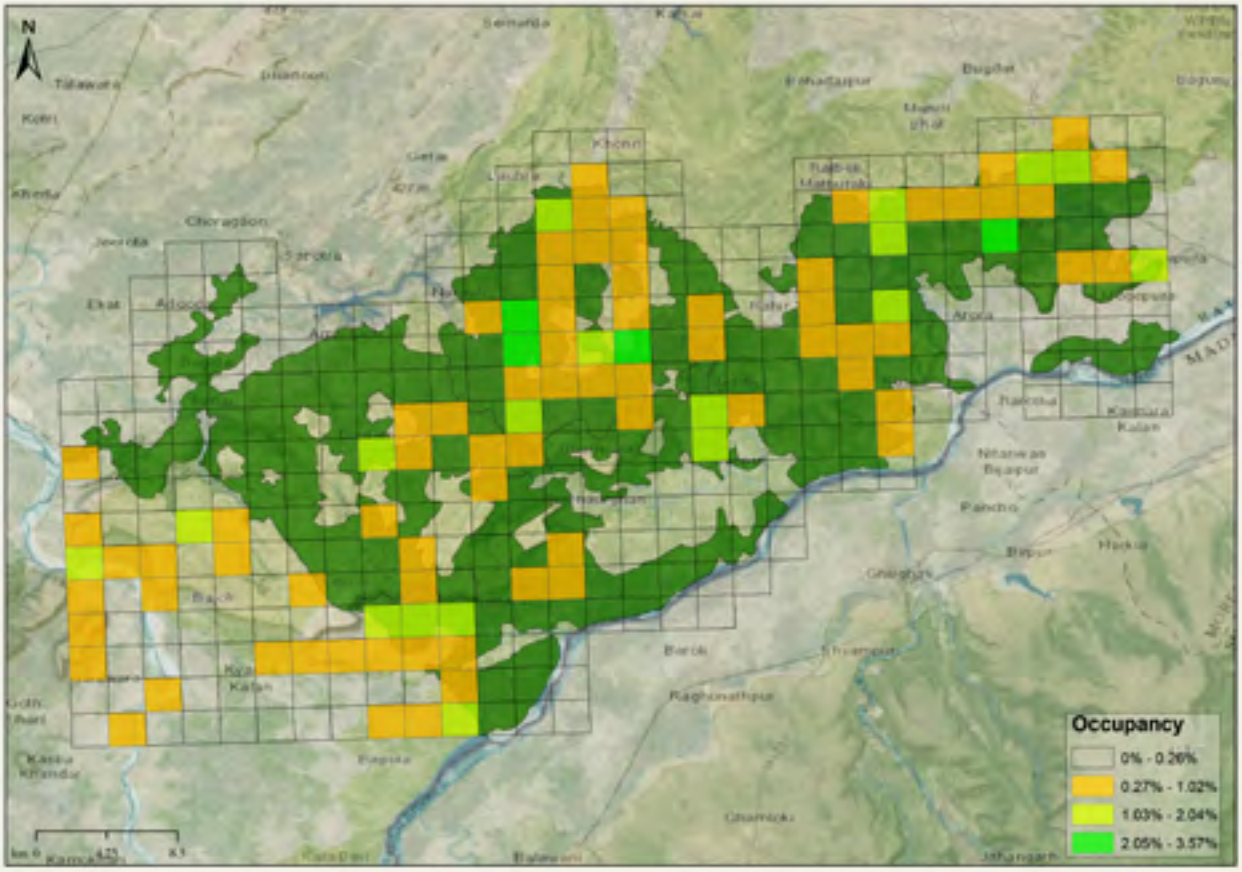


Figure 11: Tiger occupancy in Kailadevi WildlifeSanctuary

4.1.2 Ramgarh-Vishdhari Wildlife Sanctuary

A total of 243 km was walked for occupancy survey in RVWLS. Signs of tigers were found during the sampling period between March and May, 2014. Along with that of tigers, other large carnivore signs encountered were those of leopard, hyena and sloth bear. The habitat occupancy, Ψ(SE), for tigers (Figure 12) was estimated to be 0.29 (0.09). Habitat occupancy for other large carnivores was estimated to be 0.67 (0.1) for leopard, 0.81 (0.1) for hyena, and 0.29 (0.14) for sloth bear. The detection probability value varied from 0.12 to 0.27 in the area.

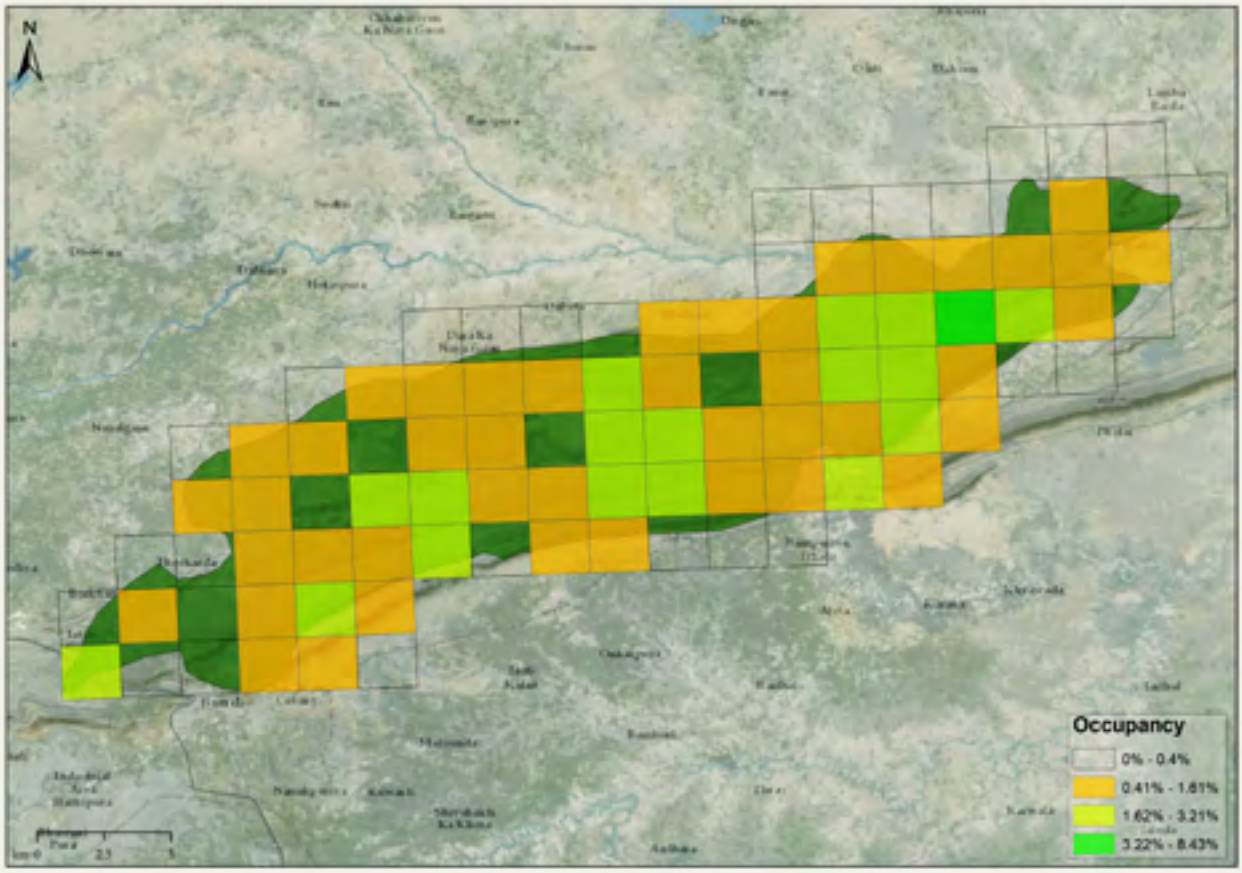


Figure 12: Tiger occupancy inRamgarh-Vishdhari Wildlife Sanctuary

4.1.3 Mukundra Hills Tiger Reserve

A total of 362 km was walked for occupancy survey in MHTR (Figure 13). No signs of tigers were found during the sampling period between February and March 2015. However, signs of large carnivores including that of leopard, wolf, hyena and sloth bear were encountered. The habitat occupancy, Ψ(SE), was estimated to be 0.33 (0.08) for leopard, 0.24 (0.01) for wolf, 0.9 (0.04) for hyena and 0.65 (0.07) for sloth bear. The detection probability value varied from 0.2 to 0.53 in the area.

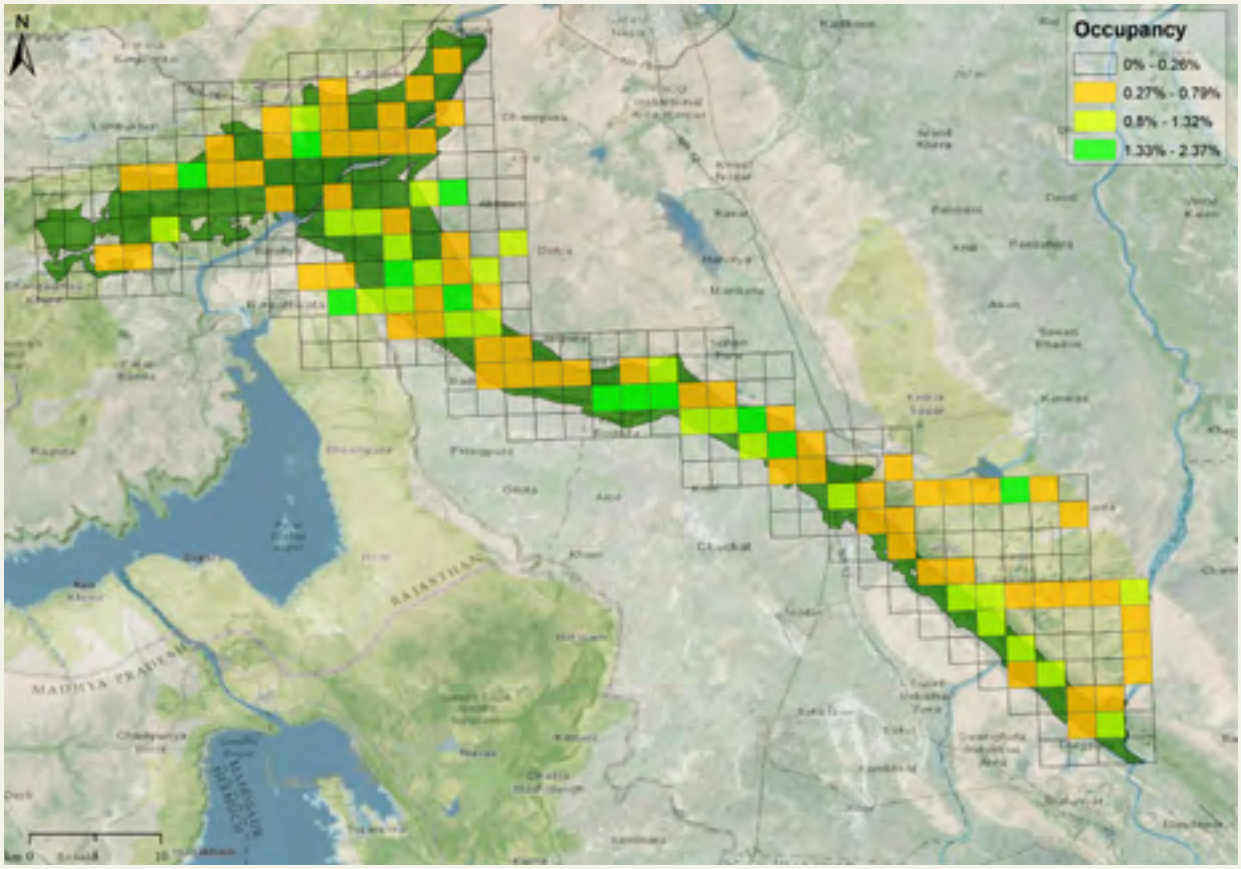


Figure 13: Tiger occupancy in Mukundra Hills Tiger Reserve

4.1.4 Indragarh-Talwas Habitat Block

A total of 144 km was walked for occupancy survey in this habitat block. No signs of tiger were found during the sampling period between September and November, 2013. Other carnivore signs encountered in the area included leopard and hyena, and habitat occupancy was estimated to be 0.6 (0.12), and 0.76 (0.09),respectively. The detection probability value varied from 0.35 to 0.37 in the area.

4.1.5 Banas-Chambal Habitat Block

A total of 164 km was walked for occupancy survey in the habitat block. Signs of tigers were found during the sampling period between November and December 2013. Along with tigers, other large carnivore signs encountered as well were that of leopard, wolf, hyena and sloth bear. The habitat occupancy, Ψ(SE), for tigers (Figure 14) was estimated to be 0.21 (0.09). Habitat occupancy for other large carnivores were estimated to be 0.1 (0.07) for leopard, 0.25 (0.17) for wolf,0.8 (0.8) for hyena, and 0.1 (0.07) for sloth bear. The detection probability value varied from 0.04 to 0.29 in the area.

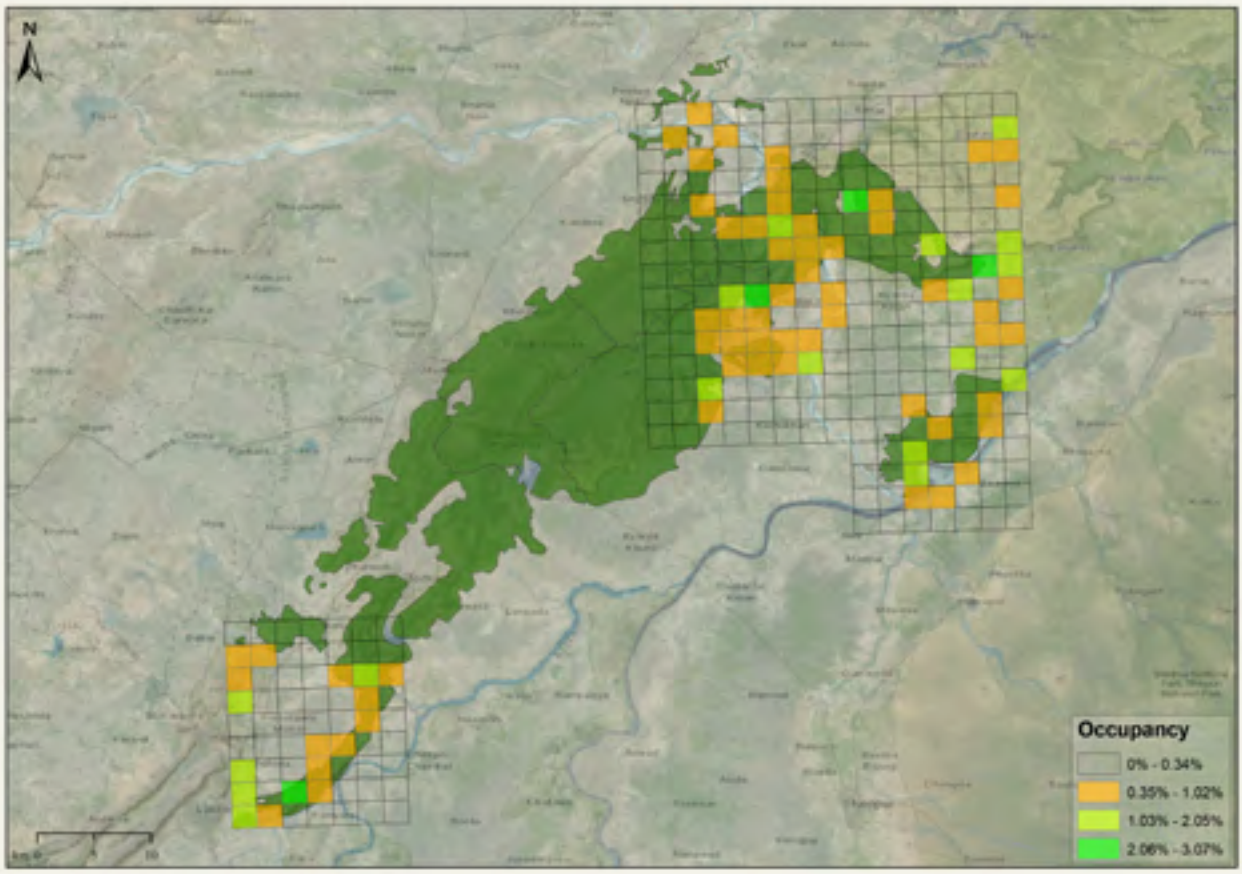


Figure 14: Tiger occupancy in Banas Chambal habitat blocks

4.2 COMPARISON OF TIGER OCCUPANCY

The study reveals that there is considerable spatial heterogeneity in the distribution and occupancy of tigers across the landscape. Tigers in Rajasthan are mostly confined in Protected Areas such as Ranthambhore and Sariska (Jhala et al. 2011). Tiger occupancy for areas outside PAs varied from 0.21 (SE ± 0.09) to 0.44 (SE ± 0.80). This indicates that tigers are using these areas for movement. There were also several locations where no tiger sign was detected, which, however, had the potential to harbor tigers due to prey presence as was observed during the sampling period.

Local tiger presence outside PAs is strongly governed by prey density, level of human disturbance and protection effectiveness in respective sites. Site occupancy estimates permit rapid field assessment of tiger population status across large landscapes (Karanth et al. 2011) and therefore should be used to monitor tiger distribution and occupied area in different sites.

Habitat blocks such as Indragarh-Talwas and Banas-Chambal need to be provided with adequate protection to help tigers and other wildlife in the area. Connectivity towards Mukundra and Kailadevi needs to be secured so that the tigers from Ranthambhore have space to sustain themselves in meta-population framework. MHTR in Kota district, together with the adjoining forests of Jawahar Sagar Wildlife Sanctuary in Bundi district should be given more attention by strengthening the existing corridors. MHTR has the potential to sustain tiger populations with restorative management and enhancement of prey base (Jhala et al. 2011; Nayak et al. 2015). Correspondingly, efforts should be made to revive Kailadevi as a good tiger habitat, which would have the added advantage of providing connectivity to the landscape of Kuno-Sheopur, and together with RNP could be managed as a meta-population to ensure long-term survival of tigers in WITL.

The conservation of tigers is highly dependent on the appropriate management of large areas of landscape (Wikramanayake et al. 2004). Huge areas of tiger habitat are rapidly vanishing (Dinerstein et al. 2007) and major investment would be required to monitor, manage and safeguard these habitats to ensure their long-term survival. Determining tiger occupancy in the landscape level is therefore crucial for conservation investment, habitat management, planning development projects, formulation of policy and for law enforcement.

4.3 PREY DENSITY ESTIMATION

Estimated densities for major ungulate prey were pooled across species for specific sites sampled. The major prey species found were sambar, nilgai, wild boar, and chinkara. Besides these wild preys, most of sampled sites had ample livestock. These livestock in most cases ‘act’ as prey for the dispersing tigers.

The density and diversity of prey species available at a site determines the distribution of predators such as tigers, leopards and wild dogs (Karanth and Sunquist 1995; Andheria et al. 2007; Odden et al. 2010). Previous studies suggested that areas with high densities of large and medium sized prey could support sympatric populations of tigers and leopards (Karanth and Sunquist, 1995). As primary consumers, ungulates significantly affect plant community composition and contribute to nutrient cycling, thus affecting ecosystem functioning, in addition to their direct role in structuring carnivore communities(Hobbs 1996; Sankaran et al. 2013; Moe and Wegge 2008). Prey estimates are provided site-wise below.

4.3.1 Mukundra Hills Tiger Reserve

A total of 39 transect lines were walked (Figure 15) and each transect was sampled four times. Sampling involved walking a total distance of 307 km, resulting in detections of a total of 2431 clusters of prey species, including the livestock. The estimated average probabilities for visual detection of prey in the sampled area varied greatly among species, ranging between 0.2 and 0.8. Models of detectability based on the half-normal key function with one or no adjustment terms adequately fitted data, with the hazard rate or uniform cosine key function fitting data adequately in the remaining cases.

Prey diversity was found unevenly distributed among all ranges, with the highest in Raontha, Jawahar Sagar and Borawas ranges (Appendix 1, Table 1). From the entire

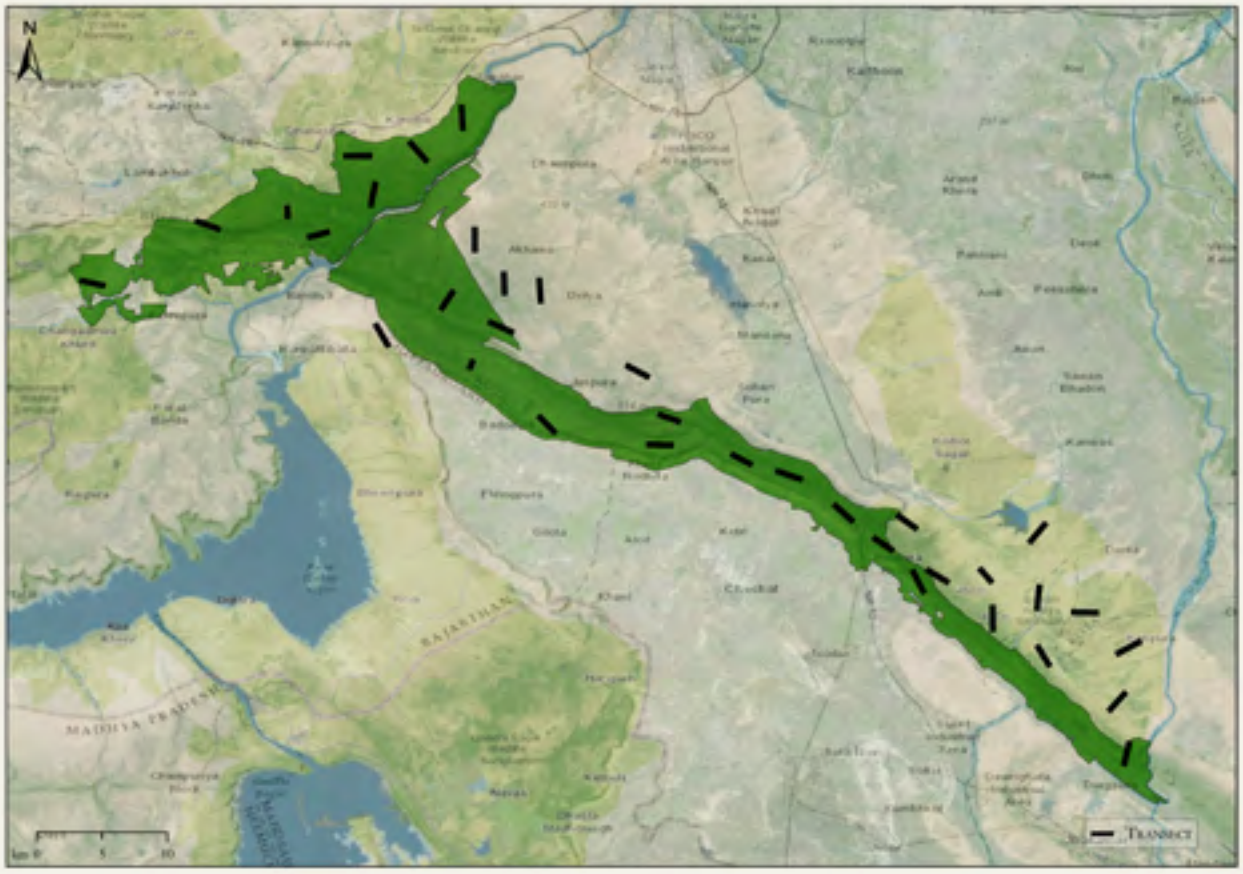


Figure 15: Distribution of transect lines in Mukundra Hills Tiger Reserve, Rajasthan

transect walk exercise in MHTR the major herbivore species encountered were nilgai, chinkara, chital, wild pig, sambar, and livestock. Apart from this, blackbuck, langur, macaque, hare, and peafowls were encountered. The range wise encounter rates (ER) (no./km) for ungulate species and livestock are given in Appendix 1, Table 2.

The overall density for the principal ungulates species was found to be low. Moreover, presence of humans in day-time for resource extraction, traffic on both primary and secondary roads, and livestock herders for grazing of animals possibly had an effect on the prey distribution.

Table 1: Density estimates for prey species in MHTR

Species	Selected model	ESW ± CV		Density ± SE		Group Density		Group Density ± SE	
Wild ungulates	Half-normal/ Cosine	54.68	7.42	25.13	3.18	8.30		8.30	0.87
						6.75	10.21		
Livestock	Half-normal/ Cosine	69.91	13.47	105.92	24.19	6.22		6.22	0.94
						8.37	114		

Measurement Units:
Density: Numbers/Square kilometers, ESW: meters
ESW= Effective Strip Width (ESW), SE= Standard Error, AIC= Akaike Information Criterion

Species specific density estimation of the animals was not done given the overall low wild prey densities and as they did not meet the required number of detection sufficient enough for conventional distance analysis (Anderson et al. 1979; Buckland et al. 1993).

4.3.2 Kailadevi Wildlife Sanctuary

A total of 46 transect lines were walked (Figure 16) and each transect was sampled only once. Sampling involved walking a total distance of 120.6 km, which resulted in detection of a total of 1307 clusters of prey species, including the livestock. The estimated average probabilities for visual detection of prey in the sampled area varied greatly among species. Models of detectability based on the half-normal key function with cosine adequately fitted data, with the half normal hermite key function fitting data adequately in the remaining cases.

Ungulate diversity was found distributed among all ranges, with the highest in Nain-ya-ki, followed by Mandrayal, Karanpur and Kailadevi ranges (Appendix 1, Table 3). From the entire transect walk exercise in KWLS, the major herbivore species encountered were nilgai, chinkara, chital, wild pig, sambar, and livestock. Apart from this, langur, macaque, hare and peafowl were also encountered. The range wise encounter rates (ER) (no./km) for major ungulate species (chinkara and nilgai) are given in Appendix 1,Table 4 .

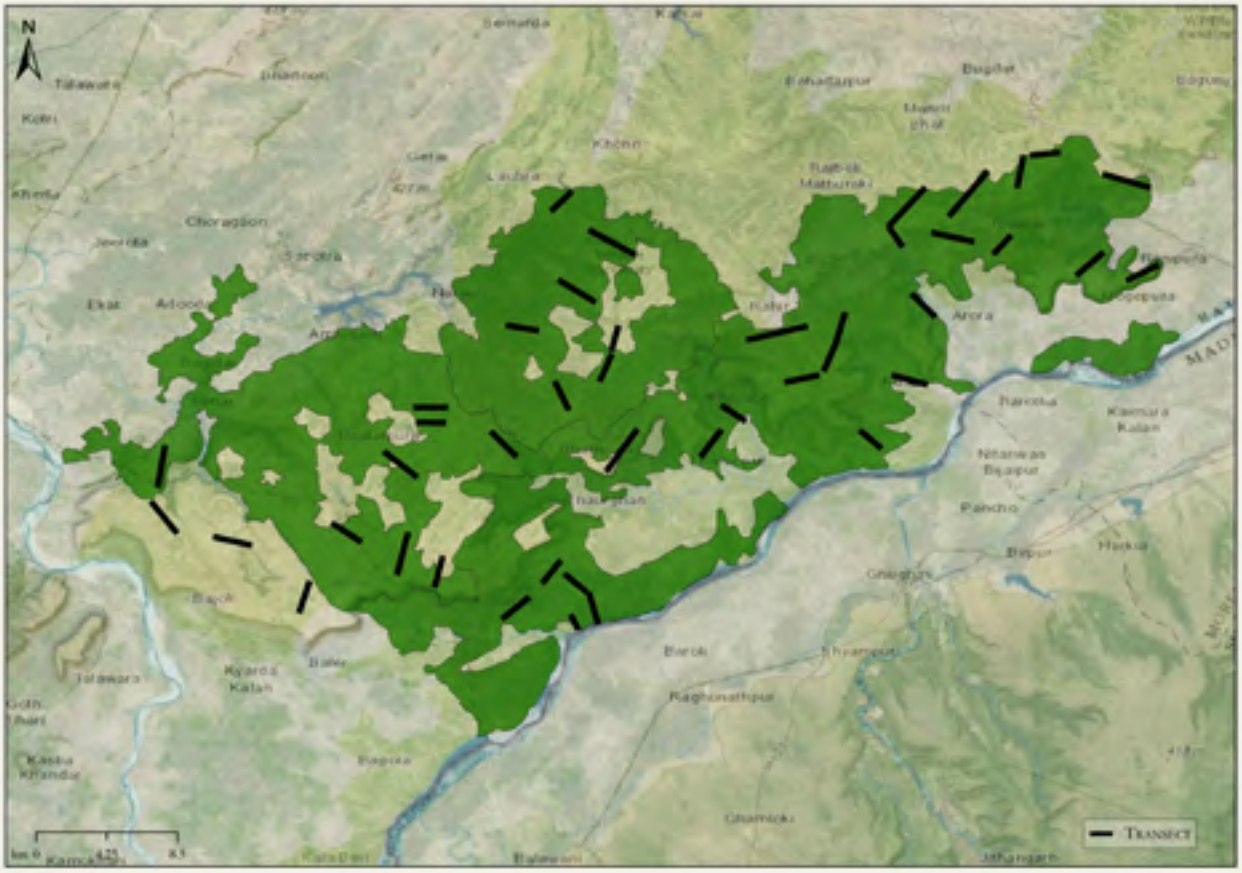


Figure 16: Distribution of transect lines in Kailadevi Wildlife Sanctuary, Rajasthan

Species specific density estimation of the animals was not done given the overall low wild prey densities and they did not meet the required number of detection sufficient enough for conventional distance analysis (Burnham et al. 1993). Principle wild ungulate species comprising of chinkara and nilgai were added and their group density was estimated separately to be 4.77 (±2.38). This was followed by a pooled analysis of all livestock species group, comprising of cattle, buffaloes, goat, sheep and camels and was estimated to be 182.69 (±40.67).

Table 2: Density estimates for prey species in KWLS

Species	Selected model	ESW ± CV		Density ± SE		Group Density		Group Density ± SE	
Wild Ungulate (Nilgai & Chinkara)	Half-normal/ Cosine	32.72	21.07	4.77	2.38	1.90		1.90	0.76
						0.88	4.12		
Livestock	Half-normal/ Hermite	28.24	9.06	182.69	40.67	11.71		11.71	1.73
						8.75	15.67		

Measurement Units:
Density: Numbers/Square kilometers, ESW: meters
ESW= Effective Strip Width (ESW), SE= Standard Error, AIC= Akaike Information Criterion

4.3.3 Ramgarh Visdhari Wildlife Sanctuary

A total of 22 transect lines were walked(Figure 17) and each transect was sampled 4 times. Sampling involved walking a total distance of 176 km, resulting in detections of a total of 764 clusters of prey species, including the livestock. Models of detectability based on the hazard cosine key function adequately fitted data, with the half-normal hermite key function fitting data adequately in the remaining cases.

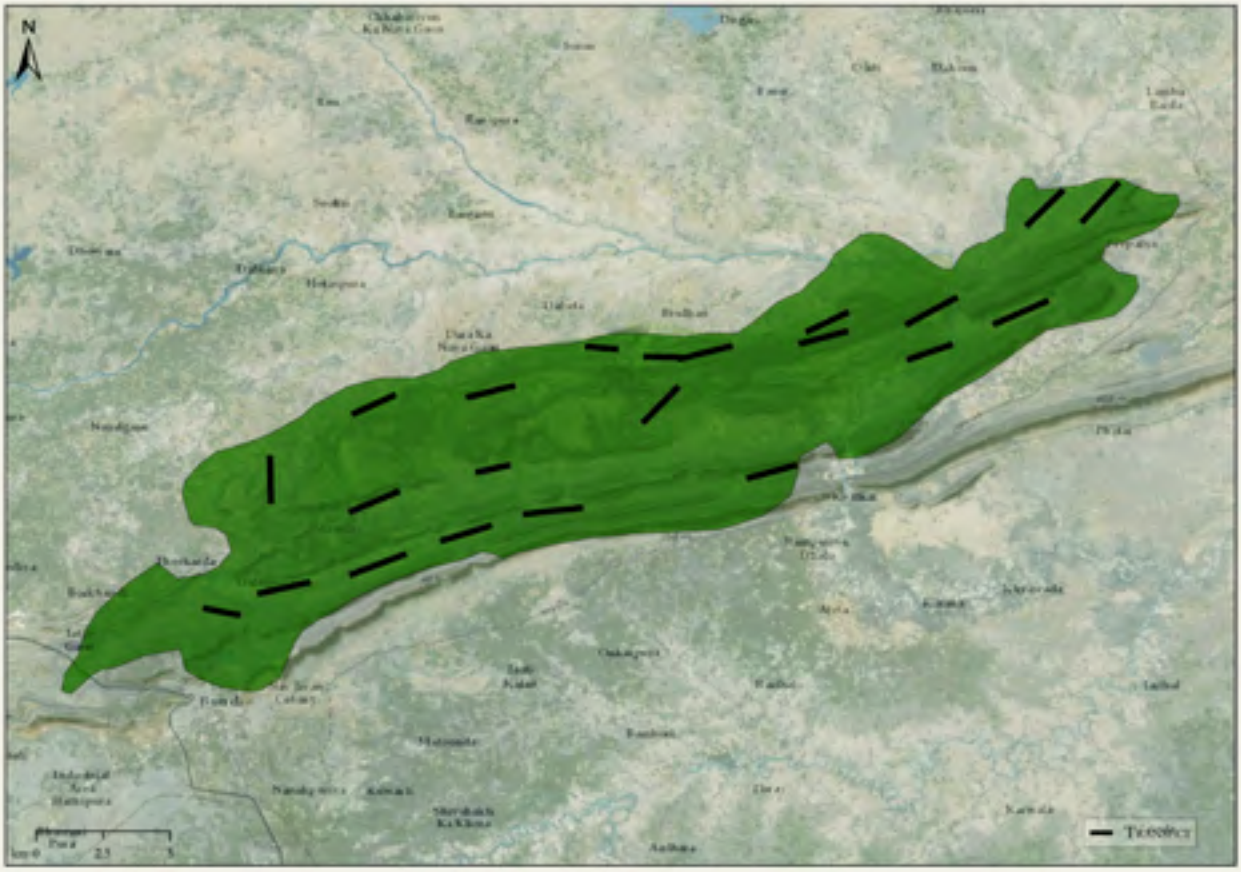


Figure 17: Distribution of transect lines in Ramgarh-Visdhari Wildlife Sanctuary, Rajasthan

Prey diversity was found equally distributed among two ranges, Jetpur and Bundi (Appendix 1, Table 5).For the entire transect walk exercise in RVWLS, the major herbivore species encountered were nilgai, sambar, wild pig, and livestock. Apart from this, langur, macaque, hare and peafowl were encountered. The range wise encounter rates (ER) (no./km) for major ungulate species (nilgai and sambar) are given in Appendix 1, Table 6.

Since species specific density estimation of the animals was not done given the overall low wild prey densities and detection as in KWLS, principle wild ungulate species comprising of nilgai and sambar were added and their group density was estimated separately to be 13.9 (±5.75). This was followed by a pooled analysis of all livestock species group, comprising of cattle, buffaloes, goats, sheep and camels were estimated to be 33.09 (±11.61).

Table 3: Density estimates for prey species in RVWLS

Species	Selected model	ESW ± CV		Density ± SE		Group Density		Group Density ± SE	
Wild Prey (Nilgai & Sambar)	Hazard/ Cosine	18.76	35.61	13.92	5.75	5.98		5.98	2.40
						2.40	40.13		
Live Stock	Half-normal/Hermite	27.56	13.59	33.09	11.61	3.45		3.45	0.88
						0.88	25.62		

Measurement Units:
Density: Numbers/Square kilometers, ESW: meters
ESW= Effective Strip Width (ESW), SE= Standard Error, AIC= Akaike Information Criterion

4.3.4 Banas-Chambal Habitat Block

A total of 22 transect lines in Banas-Chambalwere walked respectively (Figure 18) and each transect was sampled 4 times. Sampling involved walking a total distance of 172.2 km, resulting in detections of a total of 2964 clusters of prey species, including the livestock. Models of detectability based on the half-normal cosine key function with one or no adjustment terms adequately fitted data.

Prey diversity was found distributed among all ranges, with the highest in Khandar, followed by Nain-ya-ki, Talra and Baler ranges (Appendix 1, Table 7). For the entire transect walk exercise in Banas-Chambal habitat block, the major herbivore species encountered were nilgai, sambar, wild pig, chinkara,and livestock. Apart from this langur, hare, and peafowl were also encountered. The range wise encounter rates (ER) (no./km) for major ungulate species(nilgai, wild pig and sambar) are provided in Appendix 1, Table 8.

Since species specific density estimation of the animals was not done given the overall low wild prey detection, principle wild ungulate species comprising of chinkara, nilgai, wild pigand sambar were added and their group density was estimated separately as wild ungulates, and was estimated to be 3.58 (±0.88). This was followed by a pooled analysis of all livestock species group, comprising of cattle, buffaloes, goats, sheep, and which was estimated to be 98.15 (±20.00).

Table 4: Density estimates for prey species in Banas-Chambal

Species	Selected model	ESW ± CV		Density ± SE		Group Density		Group Density ± SE	
Wild Prey (Chinkara, Nilgai, Sambar & Wild pig)	Half-normal/ Cosine	94.11	11.00	3.58	0.88	1.40		1.40	0.29
						0.94	2.09		
Live Stock	Half-normal/ Cosine	68.21	9.11	98.15	20.00	6.60		6.60	1.11
						4.74	9.18		

Measurement Units:
Density: Numbers/Square kilometers, ESW: meters
ESW= Effective Strip Width (ESW), SE= Standard Error, AIC= Akaike Information Criterion

4.3.5 Talwas Habitat Blocks

A total of 14 transect lines in Talwas habitat blocks were walked (Figure 18) and each transect was sampled 4 times. The sampling effort involved walking a total distance of 110.4 km, and resulted in detections of a total of 1841 clusters of prey species, including livestock. Models of detectability based on the half-normal cosine key function adequately fitted data, with uniform–cosine key function fitting data adequately in the remaining cases.

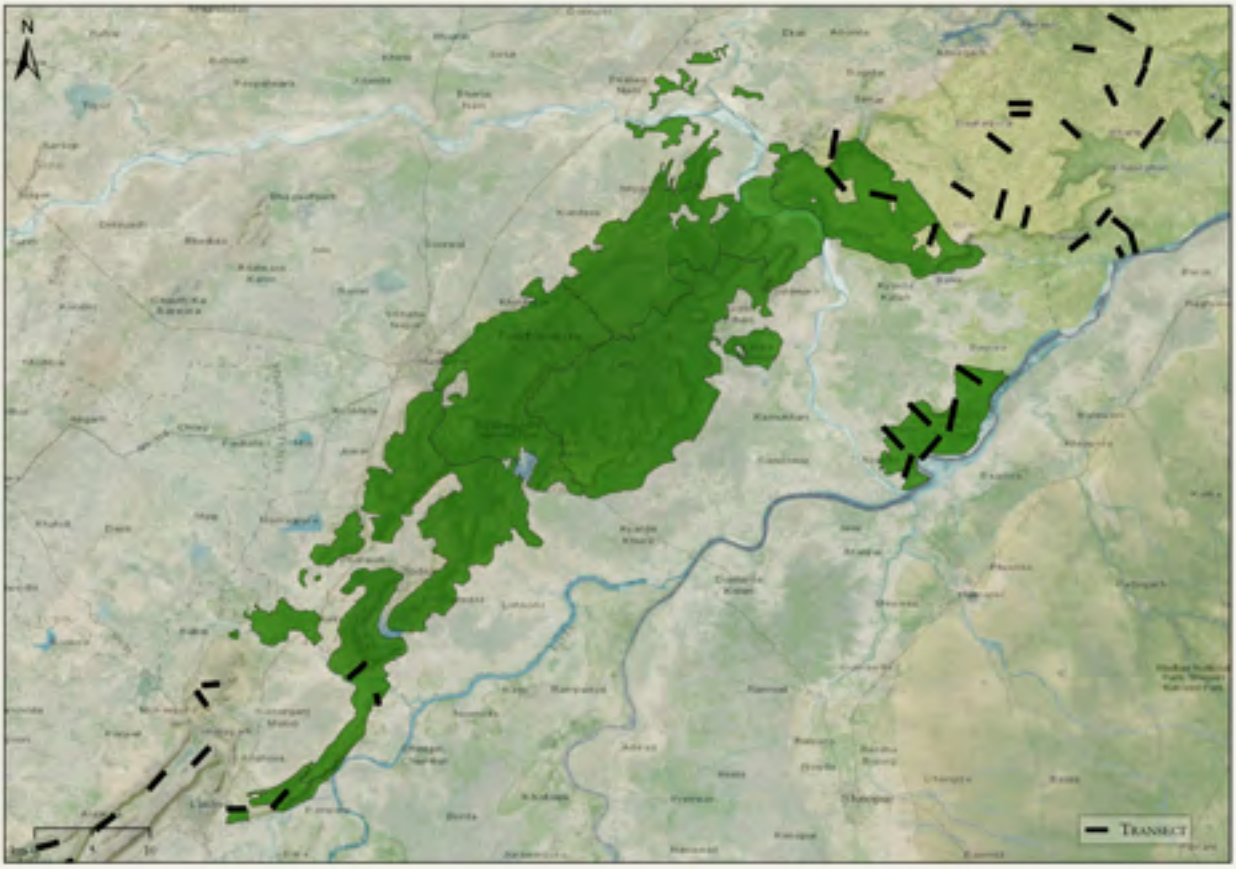


Figure 18: Distribution of transect lines in Banas-Chambal & Talwas habitat blocks, Rajasthan

Ungulate diversity was found distributed among all ranges, with the highest in Nainwa, followed by Falaudi and Indragarh ranges (Appendix 1, Table 9). For the entire transect walk exercise in Talwas habitat block, the major herbivore species encountered were nilgai, chital, sambar, wild pig, and livestock. Apart from this langur, hare and peafowl were also encountered. The range wise encounter rates (ER) (no./km) for major ungulate species(nilgai, wild pig and sambar) are given in Appendix 1, Table 10.

Since species specific density estimation of the animals was not done given the overall low wild prey detection, principle wild ungulate species comprising of chital, nilgai, wild pig and sambar were added and their group density was estimated separately to be 18.23 (±4.33). This was followed by a pooled analysis of all livestock species group,

comprising of cattle, buffaloes, goats, sheep and camels, which was estimated to be 136.04 (±34.4).

Table 5: Density estimates for prey species in Talwas

Species	Selected model	ESW ± CV		Density ± SE		Group Density		Group Density ± SE	
Wild Prey (Chital, Nilgai, Sambar & Wild pig)	Half-normal/ Cosine	43.91	12.55	18.23	4.33	6.23		6.23	1.28
						4.16	9.34		
Live Stock	Uniform/ Cosine	57.54	9.33	136.04	34.40	9.12		9.12	1.87
						6.09	13.65		

Measurement Units:
Density: Numbers/Square kilometers, ESW: meters
ESW= Effective Strip Width (ESW), SE= Standard Error, AIC= Akaike Information Criterion

Prey densities in WITL

It was observed that there was wide variation in prey density across the landscape. Prey densities were notably high in the well-established PAs of Rajasthan, for e.g. in Ranthambhore and were exceedingly low in the areas beyond Ranthambhore. Despite a good overall effort, density estimates were quite different for the sites sampled. However, these estimates represent combined ungulate density estimates(comprising of detection of at least 1-4 ungulate species) and there is considerable uncertainty associated with them. This is largely a result of sparse-data, and of some limitations in sampling efforts across the landscape. The uncertainty in estimates is largely due to variability in encounter rates and unexplained variation in detection probabilities as a consequence of pooling data across species (Chanchani et al. 2014). Because of varying habitats, there is considerable variation in encounter and detection rates across species. Given the overall low prey densities, there were not sufficient detections to estimate species specific densities by conventional distance analysis. Pooling detections across species to estimate a detection probability assumes homogeneity in detection probabilities, an assumption likely to be false (Buckland et al. 2001). In order to estimate species-specific densities transect effort will have to be significantly increased in future studies to generate accurate detections for most of the species.

5. Conclusions

The survey of tigers and prey in the Western India Tiger Landscape (WITL) was carried out for generating baseline information on the occurrence and abundance of these species. Based on the data and information collected, the following actions are proposed to augment tiger and prey populations and their habitat quality in the landscape and across corridors. We also present site specific key threats, and provide recommendations and interventions through community engagement, policy and advocacy, and research and monitoring. These actions might be necessary to be strategized and properly addressed through consultations among various stakeholders.

1. Breeding populations of tigers continue to persist in the larger habitat patches of the Ranthambhore Tiger Reserve. Ranthambhore is the source for the entire landscape and tigers have now been recorded dispersing from Ranthambhore to forests of Kota and Bundi to the south and forests of Kuno-Sheopur across the Chambal River in the east.
2. Important Protected Areas and habitat blocks supporting the dispersing tigers and other wildlife include Kailadevi WLS, Banas-Chambal-Sewti Chambal habitat blocks, Kuno-Palpur WLS and Madhav NP in east; and Indragarh-Talwas habitat blocks, Ramgarh Vishdhari WLS and Mukundra Hills TR in the south.
3. Tiger movements were documented between habitat areas towards the south and east of RTR, and only from sites that are well connected by forested corridors e.g. Banas and Indragarh. This reiterates the importance of maintaining and restoring corridors between the source sites.
4. Radio-collaring studies of sub-adult dispersing tigers in KWLS, MHTR, RVWLS and in the corridors need to be undertaken to better ascertain their movement patterns, threats faced and to improve the management of the corridor, from a tiger dispersal perspective.
5. There are differences in the densities of ungulate prey species between the sites. The densities of prey species in other sites are not as high as in RNP, and have the potential to increase. Strict protection regime as well as proper management interventions such as intensive law enforcement, increasing patrolling efforts, strong intelligence networking along with strengthening staff capacity, would aid in augmenting the prey population in MHTR and KWLS. Introducing prey species from other source sites for e.g. Ranthambhore or Kuno Palpur can be explored for this purpose.
6. Managing habitat by controlling livestock grazing and spread of weeds and invasive species, and developing perennial grasslands will help in augmentation of prey in the long run. The key to the recovery of tiger populations in WITL will be the recovery of prey populations in the sites surveyed.
    i. Controlling grazing pressures: It would be beneficial to develop pasture lands for the livestock outside Protected Areas and corridor forests in discussion with the local stakeholders and communities. Rotational grazing in such areas may also be practiced to maximize the use of the same. Efforts should

be made to promote stall feeding of livestock and by replacing unproductive local livestock with high yielding breeds.

ii. Controlling weeds: Different kinds of weeds and invasive species such as *Prosopis* spp., and *Lantana camara* should be removed periodically to help development of grasslands. These can be done manually or if required by using best possible mechanical process. The uprooting of weeds that can be used as fuel woods maybe tried out by involving the local communities. It would be suggestive of managing such areas as potential habitat and the process should be made a part of management plans of particular site.

iii. Developing grasslands: Existing grasslands need to be managed effectively by rotational cutting and burning in the winter months. Grasslands have to be actively managed to prevent encroachment of woody vegetation. In some areas, developing perennial palatable grass species like *Dichanthium annulatum, D. caricosum, D. tuberosum, Cynodon dactylon, C. Barberi, Chloris virgata, Heteropogon contortus, Cenchrus ciliaris, Urochloa mutica,* and *Themeda triandra* by active management practice should be adopted.

7. Protection and management of habitat blocks needs to be prioritized, particularly for areas connecting different sites, e.g. Banas-Chambal and Indragarh-Talwas. The occupancy survey helped reveal that the areas were being utilized by various animals including large carnivores and herbivores.

8. Community participation in the restoration and protection of habitats and wildlife can play a major role in the conservation of tigers and other species in WITL. The areas where local communities can contribute include Kailadevi, Banas-Chambal, Mukundra and Indragarh. Strategic restoration and protection of habitats through community participation to maintain and restore habitat connectivity, and regular monitoring of the intervention sites should be explored and executed. They can be engaged in restoring the natural habitats by replacing invasive species with local and perennial species of grasses. They can also contribute by getting themselves involved in protection of wildlife and its habitat by forming strategic networks and thus avoid any untoward incidences in form of retaliatory killing of tigers and poaching.

9. While habitat factors limit prey populations, ungulate densities are also low in several areas in the landscape, including at Mukundra and Ramgarh. To prevent further losses of prey densities due to unwanted incidences, there is an urgent need to systematically and regularly patrol on foot the areas in the forest interior, away from roads and trails. The manpower deficit in the forest department, frontline staffs in particular, has resulted in a situation where several sites are under patrolled or inadequately managed. It would be ideally be fruitful to engage people from the residing local communities and employ them temporarily for patrolling. The team could act as 'strike force' or 'tiger force' and can be trained in wildlife monitoring as well as in basic law enforcement mechanisms. The 'force' can thus supplement the efforts of existing frontline staffs in key sites.

10. Upcoming developmental activities such as railways and roads should be designed in a way so that fragmentation of the corridors can be avoided. The Delhi-Mumbai railway line, Sawai Madhopur-Sheopur highway and roads passing through MHTR and Kota should remain in their present form and should not be broadened without appropriate mitigation measures, as this will act as a barrier for animal movement as it passes through critical linkages of the corridor. Any

further plan of expansion should be discussed among the concerned authorities, particularly between forest department, National Highway, Railways, NTCA and civil society. Studies should be undertaken to record and document wildlife-vehicular collisions cases in these areas to understand how traffic can influence animal population.

11. Large scale mining of sand and stone should be banned in and around the RTR, RVWLS and corridor areas that connects these protected areas, for e.g. Lakheri cement works in Indragarh habitat block.

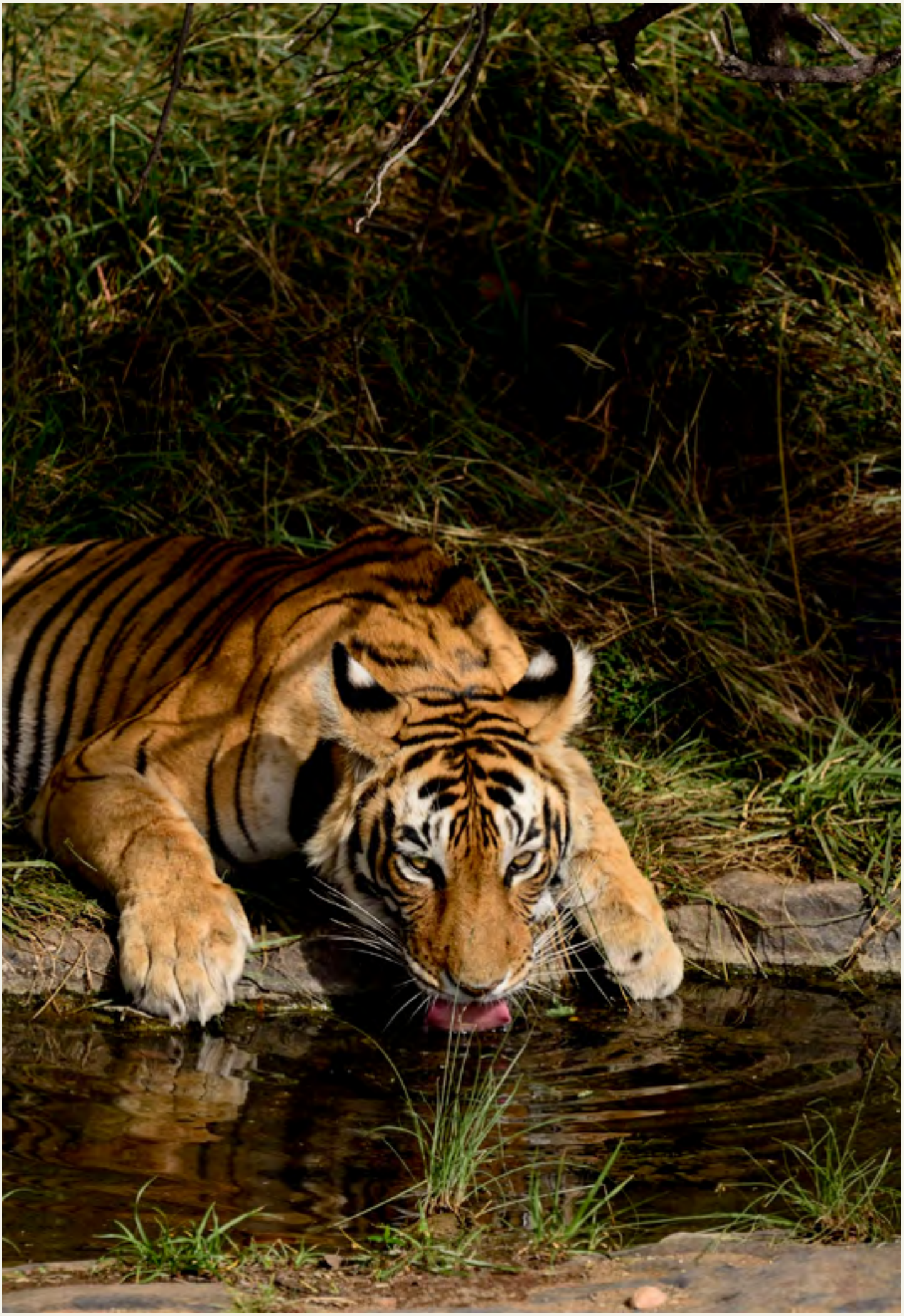
12. Pressure from excessive lopping and grazing is present throughout the landscape including both within PAs and corridors. During the surveys it was observed that the south-west corridors from RNP i.e. Indragarh-Talwas blocks, Ramgarh WLS and Kailadevi WLS are suffering tremendous pressure due to grazing and tree cutting. Seasonal grazers and herders (Bawariyas) from other states also pose a serious threat to the habitat and corridors. Effective action as described in Point 8 above is key if the habitat and corridors are to be restored and maintained.

13. Flattening of ravines, in the Banas habitat block and along the course of the Chambal river and its tributaries, for expanding agriculture fields is causing fragmentation of the corridors. The proposed large scale conversion of ravine lands as envisioned by the state governments of Madhya Pradesh and Rajasthan in Banas-Chambal, Sewti-Chambal, Baler, Chambal and Indragarh could pose a threat to the corridors and hinder tiger movement if it is not planned and implemented keeping in mind the necessity of preserving the wildlife corridors.

14. Alternative and sustainable livelihood options need to be provided to local stakeholders in the corridor to reduce fuel wood dependency for both self consumption and sale. There could be a coordinated strategy planned with Panchayati Raj and rural development committees to promote alternative energy efficient models. For villagers dependent on natural resources, it is suggestive to promote adoption of energy efficient alternatives like LPG, solar stoves and biogas. There needs to be intensive awareness campaigns and education on such adoption of alternative energy sources. Additionally, better cattle grazing practices should be encouraged to prevent conflicts. These practices include developing grass lands over waste land areas, promote stall feeding and setting models on green fodder plots. Incentives should be provided to villages that facilitate tiger dispersal, for the cost of living in tiger conflict landscapes. Local stakeholders must be actively involved to reduce biotic pressure with additional benefits for successful conservation in the corridor.

15. The Banas Chambal Habitat block should be included as a buffer of the Ranthambhore TR without any further delay. This block has recorded frequent tiger movement during the last few years. Similarly, Kailadevi WLS provides excellent habitat for tigers, leopards, hyenas and wolves, and is an important habitat link in terms of connectivity between Ranthambhore and Kuno.

16. Economic valuation, particularly of the corridor areas, should be carried out to determine the ecological and biological values. The forests of corridors are important for the ecosystem services they provide to humans and wildlife. Such information would be helpful in making decisions at the highest administrative level.



SITE SPECIFIC THREATS AND WAY FORWARD FOR THE TIGER CONSERVATION IN WESTERN INDIA TIGER LANDSCAPE

Sites	Key Threats/ Issues	Recommended actions	Community engagement	Policy and advocacy	Research and Monitoring
Kailadevi	Grazing pressure	• Development of pasture lands outside protected areas and corridor forests. • Rotational grazing practice.	• Promote stall feeding • Promote high quality breed to reduce unproductive livestock pressure • Set at least one model on green fodder	• Mandatory vaccination of livestock around protected areas. • Policy to curb illegal conversion of grazing lands. • Policy to develop grass lands over waste lands.	• Development of grass land on waste land. • Study on availability and production of green fodder throughout year.
	Illicit cutting and lopping of trees for fuel wood and subsistence use.	• LPG connections to community living in and around park and strict implementation. • Setting up LPG distribution centre by district administration. • Promote alternative energy models. • Promotion of biomass briquette, biogas and energy efficient stoves. • Develop plots and plantation of tress for fuel wood.	• Adoption of alternative energy models. • Mobilisation for continuous use of LPG. • Education and awareness for adoption of energy efficient models.	• Coordinated strategy with Panchayti Raj and rural development for promotion of energy efficient models. • SOP for district administration for disbursement of LPG connections	• Identify alternative fuel wood options and setting up at least one model for energy efficient stoves
	Spread of invasive species e.g. *Prosopis*spp.	Remove unwanted vegetation and invasive species periodically and promote grass lands	Community based uprooting for weeds that might be used as fuel wood.	Managing degraded lands and converting as potential habitat should be part of TCP/ Management plans.	Mapping and continuous ground truthing of areas prone to weed spread
	Road kills	• Identification of bottle necks • Signage's for slow driving • Construction of speed breakers at frequent points	Local residents to identify wildlife crossing points in forest roads	Policy document on a "green way "	Study extent of road kills and develop plan for green infrastructure
	Monitoring of dispersing tiger population from RNP	Separate monitoring wing to monitor dispersing tigers.	Community involvement to avoid unwanted incident for e.g. poisoning, conflict	Coordination between forest divisions and district level SOP	• Radio collaring sub adults on periphery of RNP. • Rigorous monitoring of tigers, leopards, wolves and their kills

Sites	Key Threats/ Issues	Recommended actions	Community engagement	Policy and advocacy	Research and Monitoring
Ramgarh	Grazing pressure	• Development of pasture lands outside protected areas and corridor forests. • Rotational grazing practice. • Develop plots and plantation of tress for fuel wood.	• Promote stall feeding • Promote high quality breed to reduce unproductive livestock pressure • Set at least one model on green fodder	• Mandatory vaccination of livestock around protected areas. • Policy to curb illegal conversion of grazing lands. • Policy to develop grass lands over waster lands	• Development of grass land on waste land. • Study on availability and production of fodder throughout year.
	Illegal tree lopping and cutting for fuel wood purpose	• LPG connections to community living in and around Park and strict implementation. • Setting up LPG distribution centre by district administration. • Promote alternative energy models. • Promotion of biomass briquette, biogas and energy efficient stoves.	• Adoption of alternative energy models. • Mobilisation for continuous use of LPG. • Education and awareness for adoption of energy efficient models.	• Coordinated strategy with Panchayti Raj and rural development for promotion of energy efficient models. • SOP for district administration for disbursement of LPG connections	• Identify alternative fuel wood options and setting up at least one model for energy efficient stoves
	Poaching	• Intensive law enforcement • Increase patrolling efforts. • Strong intelligence network • Strengthen staff capacity	• Education and awareness • Alternative livelihood options to communities involved in poaching.	• Increase Anti-poaching camps and team with monetary support. • Policy to involve police at all level of investigation and support.	• Mapping of zone of influences and hotspots • Implementation of LEM tools for e.g. SMART, M-Stripes
Banas-Chambal	Flattening of Ravines	• Bring ravines in corridor areas under aegis of Forest Department • Enforcement of laws for conservation of ravines	• Community awareness programs to stop flattening for agriculture	• Policy for managing wastelands and ravines falling in forest and corridor areas by State forest department.	• Mapping of ravines at micro scale that falls in corridor areas • Study use of Ravines by Wildlife.
	Sand and stone Mining	• Regulate mining outside forest areas. • Divert mining lease away from corridors • Restoration activity by lease companies.	• Share of community over natural resources harvested by private companies	• Policy that support lease of mining sites in corridors and around PAs can be applied by NGOs where same royalty paid by lease organisation under conservation concession scheme.	• Mapping of extent of mining in and around corridor areas and identification of tools to restore open caste mines in corridors.
	Spread of invasive species like *Prosopis* spp.	Remove unwanted vegetation and invasive species periodically and promote grass lands	Community based uprooting of weeds that are in use as fuel wood.	Managing degraded lands and converting them into potential habitat.	Continuous ground truthing of areas prone to weed spread and mapping

Sites	Key Threats/ Issues	Recommended actions	Community engagement	Policy and advocacy	Research and Monitoring
Mukundra	Stone mining	• Regulate mining outside forest areas. • Divert mining lease away from corridors • Restoration activity by lease companies.	Share of community over natural resources harvested by private companies	Policy that support lease of mining sites in and around PAs can be applied by NGOs where same royalty is paid by lease organisation under conservation concession scheme.	Mapping of extent of mining in and around corridor areas and identification of tools to restore open caste mines in corridors.
	Road kills	• Identification of bottle necks • Signage for slow driving • Construction of speed breakers at various points	• Local residents to identify wildlife crossing points in forest roads. • Report road kills by vehicles	• Policy document on a "green way"	• Study extent of road kills and develop plan for green infrastructure
	Spread of invasive species like *Prosopis* and *Lantana camara*	• Remove unwanted vegetation and invasive species periodically and promote grass lands	• Community based uprooting of weeds that are in use as fuel wood. • Promotion of *Lantana* furniture made by community.	• Managing degraded lands and converting as potential habitat.	• Mapping and ground truthing of areas prone to weed spread.
	Poaching	• Intensive law enforcement • Increase patrolling efforts • Strong intelligence network • Strengthen frontline staff capacity	• Education and awareness. • Alternative livelihood to poaching communities.	• Increase anti-poaching camps and team with better financial support. • Policy to involve police and civil administration at all level of investigation and support.	• Mapping of zone of influences and hotspots • Implementation of LEM tools e.g. SMART, M-Stripes

Sites	Key Threats/ Issues	Recommended actions	Community engagement	Policy and advocacy	Research and Monitoring
Indragarh	Limestone Mining	• Regulate mining outside forest areas. • Divert mining lease away from corridors • Restoration activity by lease companies.	• Communities share over natural resources harvested by private companies	• Policy that support lease of mining sites in corridors and around PAs can be applied by NGOs where same royalty paid by lease organisation under conservation concession scheme.	• Mapping of extent of mining in and around corridor areas and identification of tools to restore open cast mines in corridors.
	Spread of invasive species e.g. *Prosopis* spp	Remove unwanted vegetation and invasive species periodically and promote grass lands	Community based uprooting of weeds that are in use as fuel wood.	Managing degraded lands and converting them as potential habitat should be part of TCP/ Management plans.	Continuous ground truthing of areas prone to weed spread and mapping
	Eutrophicaiton in Wetlands. e.g. Algal bloom	• Adoption of best wetland management practice. • Creation of drainage and linking of wetlands with streams and rivers	Education and awareness on water stewardship	Managing wetlands and preventing further degradation should be part of TCP/Management plans.	• Regular monitoring of water quality • Monitoring of visitor birds
	Poaching	• Intensive Law enforcement • Increase patrolling efforts. • Strong intelligence network • Strengthen staff capacity	• Education and awareness • Alternative livelihood to poaching communities.	• Increase anti-poaching camps and team with better financial support. • Policy to involve police and civil administration at all level of investigation and support.	• Mapping of zone of influences and hotspots • Implementation of LEM tools e.g. SMART, M-Stripes

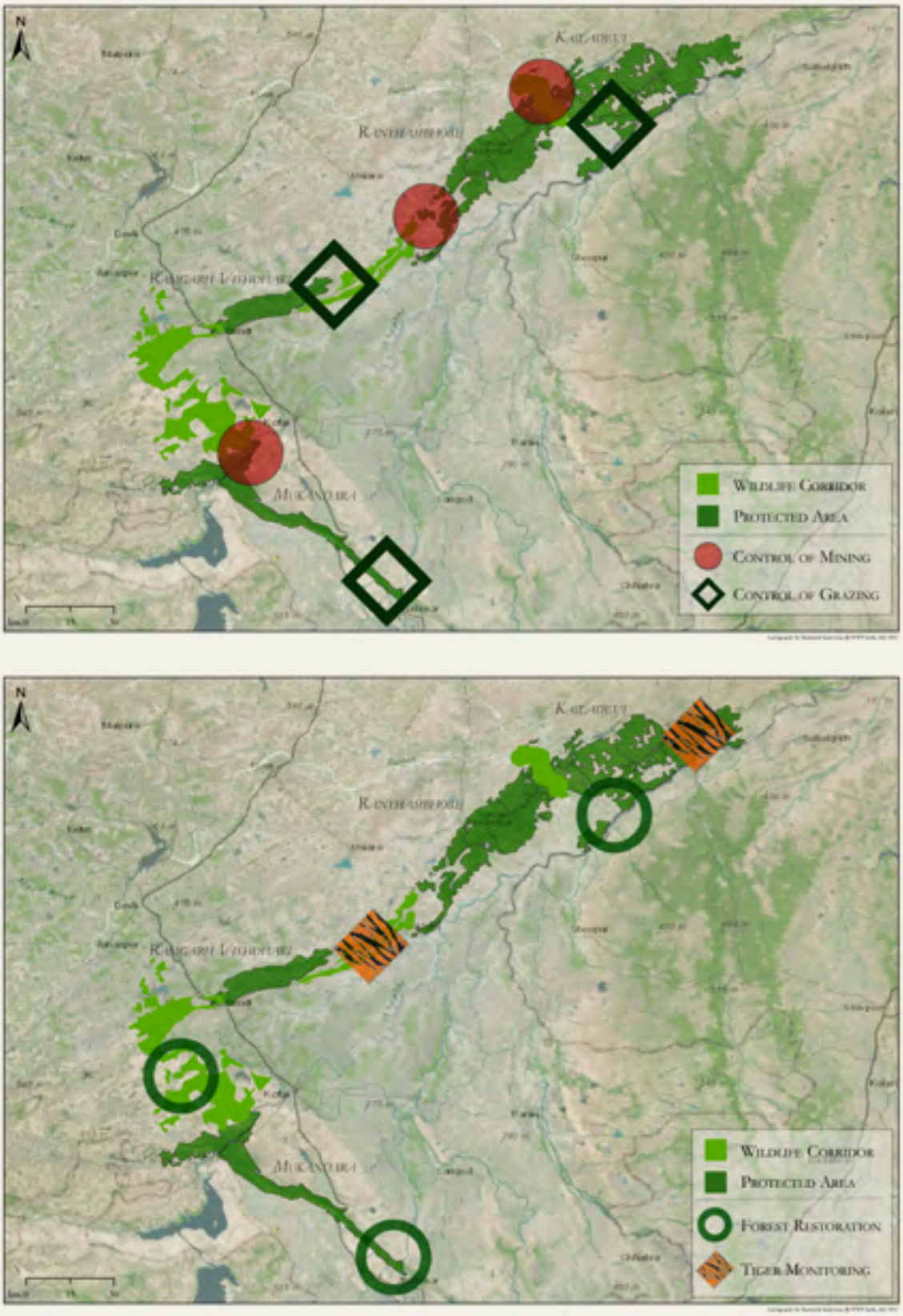


Figure 19: Site specific threats in WITL

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Annex 1

PICTURES OF TIGERS DISPERSED FROM RANTHAMBHORE






Annex 2

PHOTOGRAPHS OF FAUNA FROM WITL

Leopard

Tiger

Hyena

Jackal

Wolves

Caracal

Jungle cat

Desert cat

Sloth bear

Honey badger

Small Indian civet

Common palm civet

Indian crested porcupine

Ruddy mongoose

Hare

Chital

Sambar (M)

Sambar (F)

Blue bull (M)

Blue bull (F)

Indian wild pig

Indian peafowl

Annex 3

RANGE WISE TRANSECT DETAILS AND ENCOUNTER RATES OF UNGULATE SPECIES

A. Mukundra Hills Tiger Reserve

Table 1: Range-wise transect details in MHTR

Range	No. of transects	Total walks	Mean transect length (km)	Minimum length (km)	Maximum length (km)	Total (km)
Borawas	7	28	1.9	1.8	2	55.2
Jawahar Sagar	9	36	1.8	1.6	2	69.6
Kolipura	4	16	1.92	1.85	2	31.4
Raontha	5	20	1.95	1.9	2	39.6
Darra	7	28	2	2	2	56
Gagron	7	28	2	2	2	56

Table 2: Range-wise encounter rates of ungulate species in MHTR

Range	Total transect length (km)	Species	Total animal sighted	Encounter rate (no./km)
Raontha	39.6	Chital	37	0.9343
		Sambar	1	0.0253
		Nilgai	8	0.2020
		Wild pig	6	0.1515
		Chinkara	8	0.2020
		Livestock	115	2.9040
		Over All		**4.4192**
Darra	56	Sambar	21	0.3750
		Chital	5	0.0893
		Nilgai	29	0.5179
		Wild pig	0	0.0000
		Chinkara	16	0.2857
		Livestock	173	3.0893
		Over All		**4.3571**

Range	Total transect length (km)	Species	Total animal sighted	Encounter rate (no./km)
Borawas	55.2	Nilgai	49	0.8877
		Sambar	0	0.0000
		Chital	11	0.1993
		Wild pig	7	0.1268
		Chinkara	35	0.6341
		Livestock	586	10.6159
		Over All		**12.4638**
Gagron	56	Wild pig	12	0.2143
		Sambar	0	0.0000
		Nilgai	36	0.6429
		Chital	0	0.0000
		Chinkara	14	0.2500
		Livestock	399	7.1250
		Over All		8.2321
Jawahar Sagar	69.6	Chinkara	16	0.2299
		Sambar	0	0.0000
		Nilgai	40	0.5747
		Wild pig	2	0.0287
		Chital	0	0.0000
		Livestock	309	4.4397
		Over All		**5.2730**
Kolipura	31.4	Sambar	0	0.0000
		Chital	0	0.0000
		Nilgai	11	0.3503
		Wild pig	0	0.0000
		Chinkara	3	0.0955
		Livestock	7	0.2229
		Over All		**0.6688**

B. Kailadevi Wildlife Sanctuary

Table 3: Range-wise transect details in KWLS

Range	No. of transects	Total walks	Mean transect length (km)	Minimum length (km)	Maximum length (km)	Total (km)
Keladevi	10	10	2.75	2	3.5	27.5
Karanpur	10	10	2.75	2	3.5	27.5
Mandrayal	16	16	2.6	2	3.2	41.6
Nain ya ki	10	10	2.4	2	2.8	24

Table 4: Range-wise encounter rates of ungulate species in KWLS

Range	Total transect length (km)	Species	Total animal sighted	Encounter rate (no./km)
Kailadevi	24	Chinkara	2	0.08
		Nilgai	3	0.13
		Overall		0.21
Karanpur	22.9	Chinkara	4	0.17
		Nilgai	1	0.04
		Overall		0.21
Mandrayal	37.8	Nilgai	9	0.24
		Overall		0.24
Nain ya ki	22.4	Nilgai	12	0.54
		Overall		**0.54**

C. Ramgarh Vishdhari Wildlife Sanctuary

Table 5: Range-wise transect details in RVWLS

Range	No. of transects	Total walks	Mean transect length (km)	Minimum length (km)	Maximum length (km)	Total (km)
Jetpur	8	32	2	2	2	64
Bundi	14	56	2	2	2	112

Table 6: Range-wise encounter rates of ungulate species in RVWLS

Range	Total transect length (km)	Species	Total animal sighted	Encounter rate (no./km)
Jetpur	64	Nilgai	32	0.5
		Overall	**32**	**0.5**
Bundi	112	Nilgai	54	0.48
		Sambhar	1	0.01
		Overall		0.49

D. Banas-Chambal Habitat Block

Table 7: Range-wise transect details in Banas-Chambal

Range	No. of transects	Total walks	Mean transect length (km)	Minimum length (km)	Maximum length (km)	Total (km)
Baler	9	36	2.05	2	2.1	73.8
Khandar	7	28	1.8	1.6	2	50.4
Nain ya ki	3	12	2	2	2	24
Talra	3	12	2	2	2	24

Table 8: Range-wise encounter rates of ungulate species in Banas-Chambal

Range	Total transect length (km)	Species	Total animal sighted	Encounter rate (no./km)
Baler	72.4	Nilgai	19	0.26
		Overall	19	0.26
Khandar	54.4	Nilgai	64	1.18
		Sambhar	13	0.24
		Wild pig	19	0.35
		Overall	**96**	**1.76**
Nain ya ki	24	Nilgai	22	0.92
		Wild pig	2	0.08
		Overall	**44**	**1.00**
Talra	24	Nilgai	1	0.04
		Sambhar	11	0.46
		Overall		**0.50**

Talwas Habitat Block

Table 9: Range-wise transect details in Talwas

Range	No. of transects	Total walks	Mean transect length (km)	Minimum length (km)	Maximum length (km)	Total (km)
Indragarh	9	36	2	2	2	72
Falaudi	1	4	2.4	2.4	2.4	9.6
Nainwa	4	16	1.8	1.6	2	28.8

Table 10: Range-wise encounter rates of ungulate species in Talwas

Range	Total transect length (km)	Species	Total animal sighted	Encounter rate (no./km)
Indragarh	72	Nilgai	68	0.94
		Wild pig	11	0.15
		Overall	**79**	**1.10**
Falaudi	9.6	Nilgai	34	3.54
		Sambhar	16	1.67
		Wild pig	19	1.98
		Overall	**69**	**7.19**
Nainwa	1.8	Nilgai	35	19.44
		Overall	**35**	**19.44**

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STATUS REPORT ON TIGER AND ITS PREY IN WESTERN INDIA TIGER LANDSCAPE

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