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MONITORING OF TIGER AND ASSOCIATED SPECIES

KOSI RIVER CORRIDOR, UTTARAKHAND, INDIA

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Cover Image: © Debmalya Chowdhury / WWF-India
A Tiger photographed in Kosi River Corridor

All maps and photographs except camera trap photos courtesy Meraj Anwar/WWF-India

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MONITORING OF TIGER AND ASSOCIATED SPECIES

KOSI RIVER CORRIDOR, UTTARAKHAND, INDIA

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A tiger photographed in the Kosi corridor

FOREWORD

Home to more than fifty percent of the world's wild tigers, India occupies a crucial position in global efforts to secure the long term future of this charismatic carnivore. However, the rise in organized poaching and rate of habitat loss threaten to undermine hard fought conservation gains. The degradation and loss of corridor forests, which serve as critical linkages between different source populations of tigers is a major cause for concern. In such a scenario, the present report provides, for the first time, some much needed information on the important role played by corridors by monitoring tigers and associated species in the Kosi River corridor in the state of Uttarakhand.

The Kosi River corridor is situated in the Nainital and Almora districts of Uttarakhand and connects the Corbett Tiger Reserve with the forests of Ramnagar Forest Division. This corridor serves as a vital link between the source population of tigers in Corbett and the adjoining forest areas and enables them to move across. However, this connectivity is threatened by the rapid development of resorts and infrastructure along the Ramnagar-Ranikhet highway (NH 121) adjoining the banks of the Kosi River. Such development, if left unchecked, can threaten the long term survival of tigers in the region by isolating source populations. The Terai Arc Landscape (TAL), of which the Kosi River corridor is a part of, has been identified as one of the global priority tiger conservation landscapes and is key to the survival of India's wild tiger population.

The study detailed in this report fills an important gap by systematically sampling tigers and associated species in the Kosi River corridor. The results should help government authorities and conservationists to devise and implement appropriate measures to ensure the long term survival of the wildlife in this region. We hope these results will further spur the protection and conservation efforts underway in the TAL.

Ravi Singh
Secretary General & CEO
WWF-India

Teak forest (plantation) in Kosi River corridor

TABLE OF CONTENTS

Sign Survey

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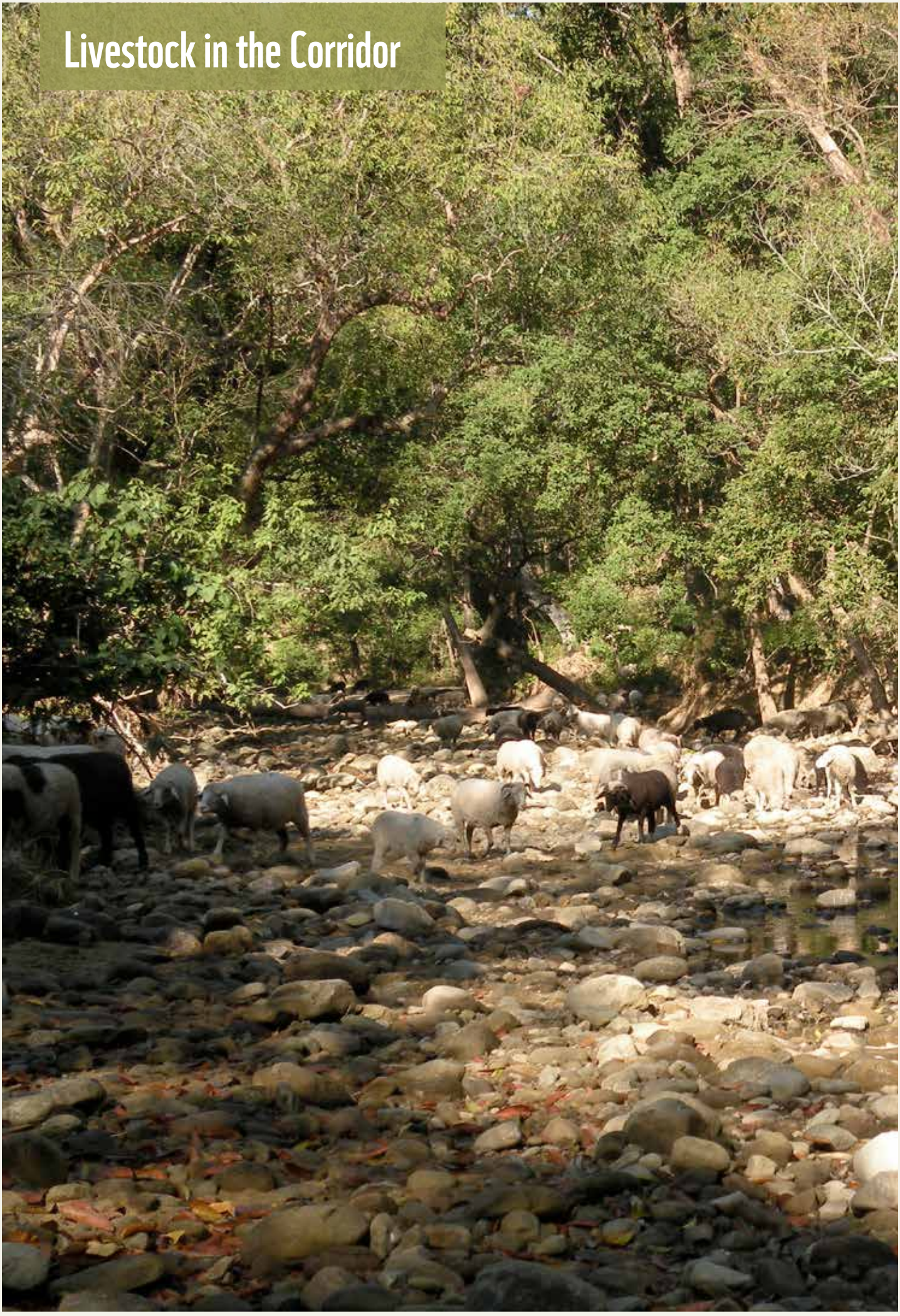
-Authors

Livestock in the Corridor



1. INTRODUCTION

India's national animal 'tiger' despite being accorded the highest protection under Schedule I of the Wildlife (Protection) Act of India, 1972, has been forced to lose ground in recent decades (Johnsingh *et al.*, 2010; Jhala *et al.* 2011). Tiger is not only a flagship species for conservation but also an umbrella species for a majority of the eco-regions in the Indian sub-continent. Its role as a top predator is vital in regulating and perpetuating ecological processes and systems (Terborgh 1991; Sunquist *et al.* 1999; Jhala *et al.*, 2011). Despite this, the numbers have continued to decline across its range because of shrinking habitats, expanding human populations, and poaching.

THE INDIAN PART OF TERAI ARC LANDSCAPE (TAL) COVERS 42,700 KM² FROM YAMUNA RIVER IN THE WEST TO VALMIKI TIGER RESERVE IN THE EAST

As conversion of natural habitats continues, the Protected Areas established to conserve the species have become insular and interspersed within matrices of human land use (Johnsingh *et al.* 2004, Wikramanayake *et al.* 2004, Ranganathan *et al.* 2008). Further, most of the Protected Areas established are rarely large enough to ensure the long-term conservation of the declining population of tigers (Woodroffe and Ginsberg 1998, Karanth and Nichols 1998, Johnsingh *et al.* 2004, Wikramanayake *et al.* 2004). In response, conservation biologists are promoting the concept of meta-population management to conserve this wide-ranging species (McCullough 1996; Mech and Hallett 2001). The objective is to protect the breeding populations as source pools and provide dispersal opportunities by linking habitat patches across the landscape mosaic to maintain a larger population (Wikramanayake *et al.* 2004).

One example comes from the Terai Arc Landscape which spans the base of the Himalayan foothills in northwestern India and southern Nepal, where conservationists are working to restore, reconnect, and manage wildlife corridors to link 12 important wildlife reserves and national parks that harbor wild tigers across the 49,000 km² landscape (Wikramanayake *et al.* 2004; Dinerstein *et al.*, 2007). The goal is to manage tigers as a single meta-population in which dispersal between core refuges can help maintain genetic, demographic, and ecological integrity.

The Terai Arc Landscape has also been identified as one of the global priority tiger conservation landscapes (Dinerstein *et al.* 2006, Sanderson *et al.* 2006) and as one of the 200 globally important eco-regions for its fairly intact large mammal assemblages (Olson and Dinerstein 1998). The Indian part of Terai Arc Landscape (TAL) covers a 42,700 km² from Yamuna River in the west to Valmiki Tiger Reserve (Bihar) in the east (Johnsingh *et al.* 2004). Three of India's 42 Tiger Reserves are located in this Landscape, namely Corbett, Dudhwa, and Valmiki. Several other Protected Areas lie within this zone under the administration of 20 Forest Divisions (FD). The human population density of >500 people/km² in TAL exceeds the national average of 300 people/km² (Johnsingh *et al.* 2004). Consequently, populations of tigers are confined to forest patches interspersed within a matrix of Protected Areas, multiple-use forests or Forest Divisions (FD), agricultural land, and human habitations.

The most significant tiger population within this landscape is in the Corbett Tiger Reserve and adjoining areas having tiger presence in 2,287 km² with an estimated population of 214 tigers out of an average of 353 tigers in the entire Terai Arc landscape on the Indian side (Jhala *et al.* 2011). The Corbett population has the highest density of tigers (17.8 ±1.4/100 km²) in the world and serves as a source from where tigers are likely to disperse both westward as well as eastward to maintain the populations in the Rajaji National Park and Pilibhit Forest Division. The Corbett population comprises Corbett National Park (NP), Sonanadi Wildlife Sanctuary, Lansdowne FD, Ramnagar FD, and Haldwani FD. The high tiger population density in this region is restricted to parts of the Corbett Tiger Reserve (Corbett NP, Sonanadi WLS, parts of Kalagarh FD, and Ramnagar FD). However, the population outside the Tiger Reserve (TR) is also of great significance with the Ramnagar FD having a density of approximately 15 tigers per 100 km² and evidence of breeding individuals (Jhala *et al.*, 2011).

Such a high density of tigers in the Ramnagar FD (Jhala *et al.*, 2011) rivals some of the Tiger Reserves in India. This large population of tigers is an indicator of good forest health in terms of ungulate prey and cover resulting out of good management practices. Moreover, the major reason for such a high occurrence is the proximity of the Ramnagar FD to the source population i.e. Corbett NP (Johnsingh 2006). Furthermore, the connectivity between Corbett and Ramnagar is of great significance as it allows the spillover population from Corbett to disperse eastward to the FDs of Terai West, Terai East, Haldwani and finally connect to another source i.e. Dudhwa-Kheri-Pilibhit tiger population, which is essential for maintaining genetic linkage (Johnsingh *et al.* 2004; Jhala *et al.* 2008 & 2011). Due to its size and extent, this single population has a high chance of long term persistence and thus holds high conservation priority in this landscape.

The tiger population of Corbett and Ramnagar currently forms a single unit with important connectivity provided by the Kosi River which flows between Corbett TR and Ramnagar FD, and certain stretches of forests along the river. However, in recent times, this connectivity has been threatened by development along the Ramnagar-Ranikhet highway (NH 121). Rapid construction of resorts and hotels along the highway from Ramnagar to Ranikhet along the banks of the Kosi River has made the intervening habitat matrix hostile to movement of wildlife. Considering the importance of this vital link and fragmentation therein caused by the ongoing development activities, it is imperative to monitor the status, distribution, and trends in the populations of tiger and associated species in the Kosi River corridor. The present study has been formulated keeping this in view and deals with monitoring tigers, co-predators and prey species using camera traps in the Kosi River corridor. It is envisaged that results of this monitoring would help in planning future tiger conservation strategies in the Terai Arc Landscape and also help in mainstreaming conservation priorities in regional development policy and planning for managing priority areas like the Kosi River corridor identified in the landscape. Such an approach would ensure that breeding tiger populations have a possibility to share genetic material and exist in a meta-population framework, thereby enhancing the possibility of their survival over a longer period.

2. STUDY AREA

2.1 LOCATION & TOPOGRAPHY

The Kosi River corridor includes part of Almora Forest Division, Sarpduli Range of CTR and Kosi Range of the Ramnagar FD, all along the Kosi River. From north to south, the corridor is approximately 23 km long and width of the corridor is approximately 2.5 km. Broadly, this corridor connects CTR with the forests of Ramnagar FD and administratively comes under Nainital and Almora districts of Uttarakhand. The Kosi River and Chinal, Dhangadi and Bangajhala streams are the perennial sources of water in the corridor which attracts wildlife from the CTR as well as from the Ramnagar FD. There are also many seasonal streams coming down to Kosi River such as Sukha, Tedha and Panod sot which also act as source of water for wildlife in the dry season.

2.2 VEGETATION

Vegetation is mainly comprised of sal *Shorea robusta* dominated forests and teak (*Tectona* grandis) plantations. Other important tree species in the corridor are bankuli (*Anogeissus latifolia*), bel (*Aegle marmelos*), ber (*Zizyphus* sp.), jamun (*Syzigium cumini*), rohini (*Mallotus phillipensis*), and khoda (*Ehretia laevis*). Kuri (*Lantana camara*) dominates the corridor as an exotic weed which is a major part of the under story but it is not preferred by the herbivores.

2.3 DEVELOPMENTAL PRESSURE

This corridor is perforated by human settlements which obstruct free movement of wildlife (Figure 1A). Villages along this corridor include Kunkhet, Mohan, Chukam, Dhikuli and Tedha and *khattas* include Ringoda, Amdanda and Tedha *khatta* whereas another small settlement is Sunderkhal. There are more than 80 resorts constructed along this corridor. Further, National Highway 121 (Ramnagar-Ranikhet) runs along the Kosi River in the corridor.

2.3.1 Tourism & Manufacturing Industry

The rapid development of resorts and hotels along the highway has made the intervening habitats matrix in this corridor hostile to movement of wildlife. Economic opportunities are the major factor that has triggered immigration of people into the area. Due to demand for space to accommodate tourists, construction of low cost housing

has sprouted in the area. The major concentration of tourism resorts is at Mohan and Dhikuli villages. Moreover, two commercial units i.e. the Indian Medical Pharmaceutical Company and Garjia Chemical Factories have further added to the disruption of connectivity in the area (Johnsingh 2006).

2.3.2 Human Habitations & their Dependence on Forest

Because of habitable area and lack of clear government policy in dealing with the occupants, communities near the forest fringes have slowly, but steadily, encroached upon the forest area along this corridor. Ringora, Amdanda, and Tedha villages originated as cattle camps and together now have more than 80 households. Similarly, Sunderkhal, an encroachment since 1974, is now a 3.5 km long habitation, along the right bank of the Kosi River. The people in these villages depend on the adjacent areas of the Corbett TR for fuelwood, fodder and small timber (Mazoomdar 2012). This dependency is causing considerable damage to the productive land system and is a serious impediment for animals moving from the Corbett TR to the Kosi River for water.

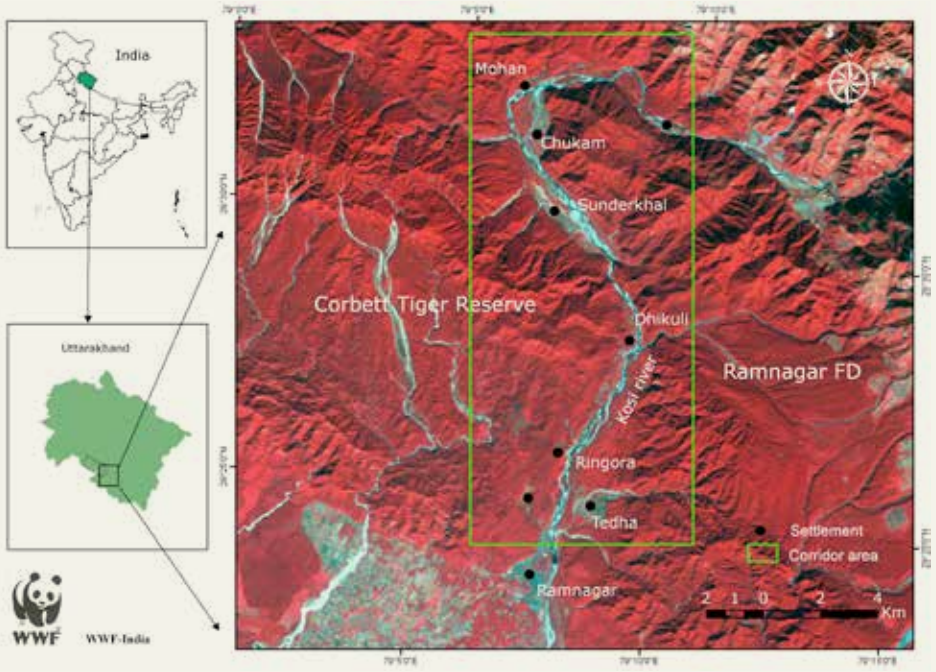
2.3.3 Connectivity between Forests of Corbett Tiger Reserve and Ramnagar Forest Division

In the recent past, connectivity between forests of the Corbett TR and Ramnagar FD through this corridor has been reported (Figure 1B) at (i) about 5 km between Mohan and Kumeria villages, (ii) 1.5 km between Dhangadi Forest Gate and Sunderkhal habitation, (iii) 100 m between the two blocks of Sunderkhal habitation, and (iv) 6 km between Infinity resorts and Bijrani Forest Gate (Johnsingh *et al.* 2004). The above patches are the only remaining vital linkages for gene flow between the Corbett TR and Ramnagar FD and beyond to the eastern populations of tigers and elephants in the

FIGURE 1 A

Corbett-Ramnagar forests and Kosi River corridor

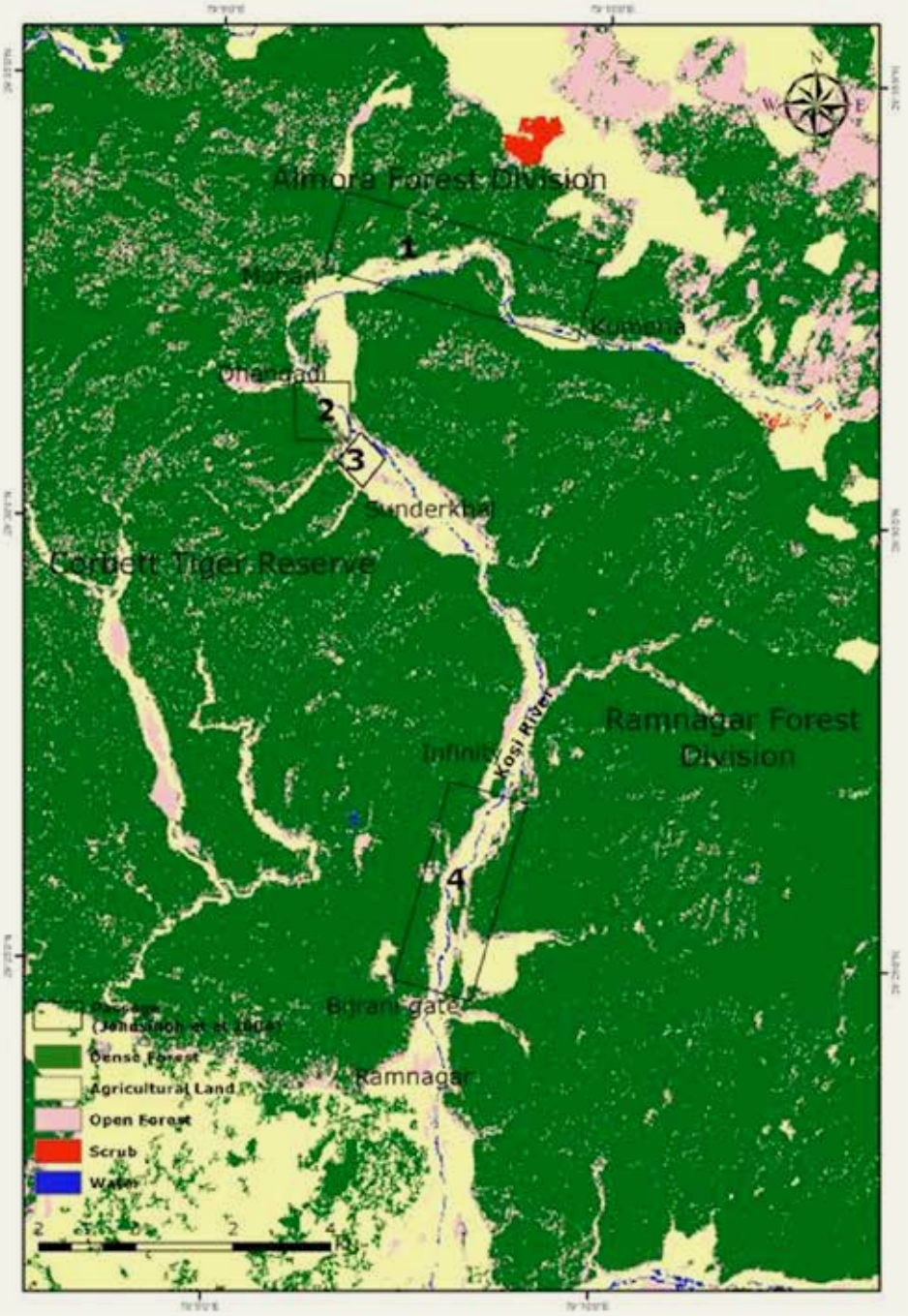
(False Color Composite of Landsat ETM+, 2009, red color fed area shows forest cover)



state of Uttar Pradesh in India and further to Nepal. It is therefore important to secure and maintain this connectivity for long term viability of this globally important tiger population.

FIGURE 1 B

Habitat connectivity in the Kosi River corridor



Sal Forest in Kosi River Corridor

3. STUDY OBJECTIVES AND METHODOLOGY

3.1 STUDY OBJECTIVES

Present study in the Kosi River corridor was carried out with the following two objectives:

i) Assess current functionality of the corridor with reference to tigers, and

ii) Establish baseline for the mammalian fauna present along the Kosi River corridor

3.2 METHODOLOGY

Prior to the camera trapping, a preliminary survey was carried out between 20th September and 30th October 2011 by two teams with a field biologist and two trained field assistants in each team. Carnivore signs such as scats, scrapes, rake marks and pugmarks were recorded during the survey. Herbivore usage of areas was also recorded based on direct sighting, tracks and pellets/dung piles. A distance of 88 km was walked approximately by the two teams on both banks of the river during the sign survey. Based on the above assessment, the animal path likely to have the maximum probability of capture for tigers was selected. Along the selected animal path, a suitable camera trap site was selected and the location was marked using a handheld Garmin eTrex GPS unit.

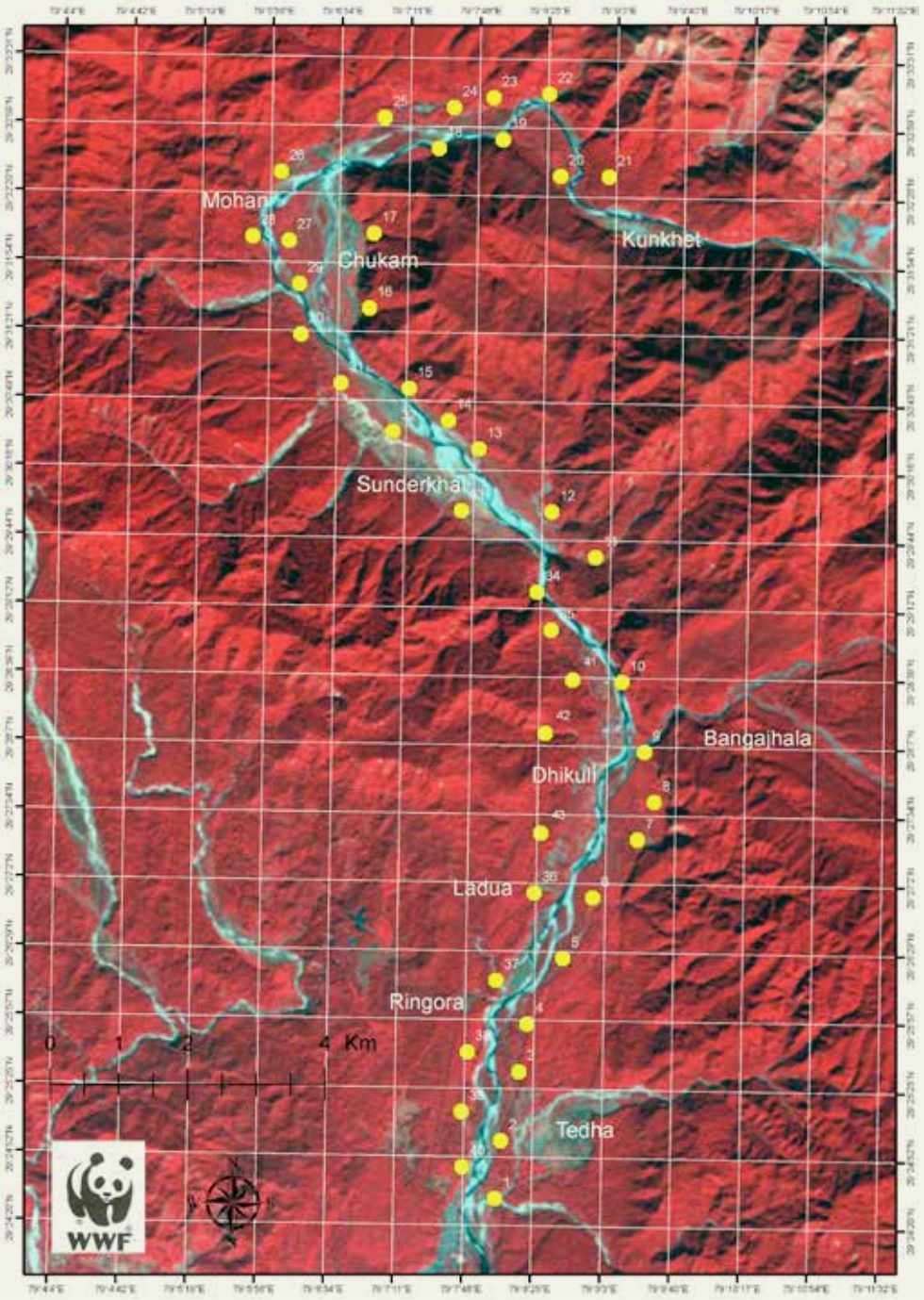
3.2.1 Data Collection

Grids of 1x1 km^2 were overlaid over the Landsat image (ETM$^+$, 2009) of the corridor area and collected GPS points were plotted over it. A total of 43 grids covered the corridor and camera trap sites were selected and sampled within all 43 grids (Figure 2). A total of 43 pairs of camera traps were deployed at selected sites for a period of 42 days from 4th November to 15th December 2011. Forty pairs of Cuddeback 'Attack' and three pairs of Moultrie (D-40, Moultrie Feeders, Alabama) camera traps were used for this purpose. Moultrie had a minimum event delay of 1 minute while for Cuddeback attack, the minimum delay was kept at 15 seconds. Cameras were placed 3 to 6 m away from the centre of the animal path to photograph the entire animal when triggered. The time interval between successive captures of pictures was kept at a minimum to maximize the chance of taking photographs of two animals moving close together or the cubs following the mother. In case of seasonal wide streams or on river bed, an area near the trap site was channelled using fallen tree branches to enable the animal to pass through the path of a pair of traps. Cameras were regularly checked to verify their proper functioning, orientation and status of the battery. Any malfunctioning camera was replaced immediately to avoid loss of data.

FIGURE 2

Camera trap sampling locations in Kosi River .

(Landsat ETM+, 2009)



3.2.2 Data Analysis

Photographs were downloaded from memory cards of the camera traps and stored in numbered folders created for each trap site with date and direction of the camera. Each camera was given a specific code number with location information so data could be collected systematically. Individual tigers were given a unique identification code (eg; RMT for Ramnagar Male Tiger, RFT for Ramnagar Female Tiger and RUT for Ramnagar Unidenti-

fied Tiger) after visually examining the pictures for stripe pattern on the flanks, limbs, forequarters and sometimes even the tail (Schaller 1967, McDougal 1977, Karanth 1995). Sexes were segregated by absence/presence of testicles. In case of absence of a clear photograph for ascertaining sex of any individual, it was designated as unidentified. Common individuals of present study and previous study (Jhala *et al*. 2011) were allocated same IDs. Minimum number of tigers (M_{t+1}) using the corridor area was assessed.

For describing the functionality of the corridor, minimum convex polygons (MCP) based on the spatial recapture of individual tigers were generated using ArcGIS 9.3 and Hawth's analysis tool 3.27 (Beyer 2007). Beside tiger, all other wild animals photo captured were identified and unique captures were considered for calculation of relative abundance index (RAI) (Carbone *et al.* 2001). To minimise scoring of the same individual multiple times and as a compromise for missing individuals (Rovero *et al.* 2005), instances where individual of a species was captured more than once at a camera station within 1 hr was excluded from the calculations (Bowkett *et al.* 2007). To calculate the number of days required to capture a photograph of a species (RAI_1) the total number of trap days was divided by total number of photographs of a species. RAI_1 is expected to decrease with an increase in density of the animal within the study area. RAI_2 is expressed in terms of number of captures per 100 trap days for which unique captures of a species from all of the trap locations were summed up and divided by total number of trap days and it is expected to increase with an increase in density of the animal within the study area (Carbone *et al.* 2001).

Camera Trap Deployment

4. RESULTS

Camera trapping revealed a healthy tiger population and a rich mammalian assemblage, highlighting the conservation significance of the Kosi River corridor.

4.1 TIGERS IN THE KOSI RIVER CORRIDOR

The total sampling effort of 1849 trap days over 42 occasions yielded 286 photographs of tiger with a 83.7% photo capture success rate over traps (36 out of 43 stations) while 9.5% occasions resulted in no capture of tiger. Out of the 286 tiger photographs, 32 photos which were overexposed were discarded. Average trapping effort was 18.1 trap days per usable photo of tiger.

Altogether, 13 tigers (M_{t+1}) were identified in the corridor area, out of which five were males, six were females and sex of two individuals could not be determined in the absence of clear photographs (Figure 3). Curve for cumulative new tiger capture stabilised on the 13th occasion while total number of captures for tiger were steady throughout the session (Figure 4). For the X-matrix, 14 and 13 photos by two individuals each, 12 by three individuals, 9 and 6 by two individuals each, 4 and 3 by two individuals each and 1 by two individuals each were contributed. Two individuals were captured only once but rest of them were captured more than twice indicating localised population in the corridor area. One female with at least three cubs was also captured (RFT32).

Identified tigers in Kosi River corridor were as follows

RMT2 (R)

RMT2 (L)

RMT3 (R)

RMT3 (L)

RMT4 (R)

RMT4 (L)

RMT27 (R)

RMT27 (L)

RMT28 (R)

RMT28 (L)

RFT21 (R)

RFT21 (L)

RFT29 (R)

RFT29 (L)

RFT22 (R)

RFT22 (L)

RFT30(R)

RFT30 (L)

RFT31 (R)

RFT31 (L)

RFT32 (R)

RFT32 (L)

RUT33 (R)

RUT33 (L)

RUT34 (R)

RUT34 (L)

FIGURE 3

Individual tigers camera trapped with their unique IDs in Kosi River Corridor

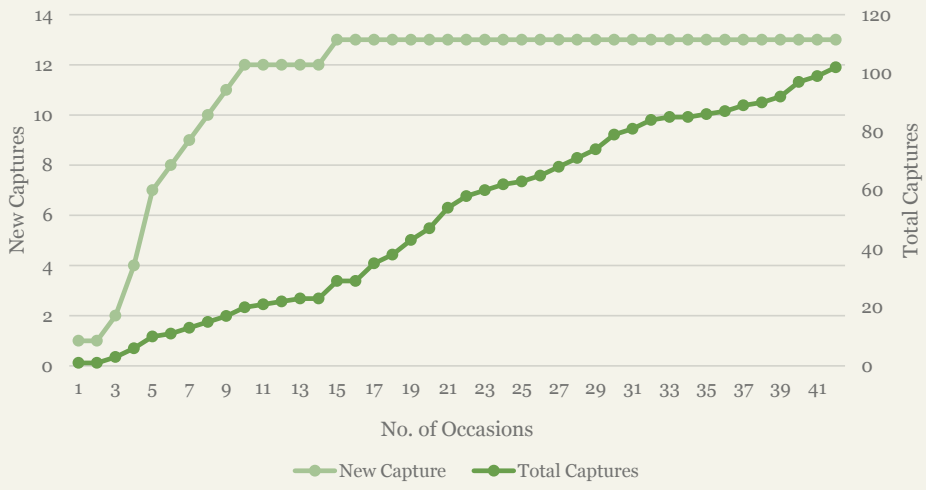


FIGURE 4

Cumulative rate of new captures of tiger in Kosi River corridor

4.2 FUNCTIONALITY OF THE CORRIDOR WITH REFERENCE TO TIGER

Camera trap captures provided a rare insight into the movement of tigers in the Kosi River corridor. Thirteen tigers were captured by camera traps in the corridor area out of which two tigers were captured once during the entire session of 42 days. Out of five males photo-captured, two were found having movements on both banks of the Kosi River. A tiger (RMT27) was found using left bank of the northern portion of the corridor intensively and crossed the corridor twice (Figure5); while another tiger (RMT3) was found crossing the southern part of the corridor frequently (Figure 5). All of the females were found settled either on right or left bank of the River and never found crossing the corridor during the entire session of camera trapping (Figure 6). Tigers did not cross from the middle portion of the corridor during entire session, neither from Dhikuli nor from Sunderkhal and Garjia area (Figure 9) though presence of tigers was recorded in narrow forest patches, one between Sunderkhal and Garjia settlements and second near suspension bridge down of Garjia chowki of Corbett Tiger Reserve. Both the patches are not more than 100 m wide but are promising crossing points for wildlife including tigers. Based on the data, tigers cross the corridor through forest patches available between Kunkhet and Mohan settlements, here IMPCL complex is an obstruction (Figure 7). Tigers use the entire land surrounding Chukam village (Figure 8). Forested area between Mohan and Sunderkhal also showed presence of tigers. Southern part of the corridor which includes green belt between Ladua and Aamdanda gate was also found providing connectivity between CTR and Ramnagar Forest Division (Figure 10).

FIGURE 5

Locations and tiger individuals observed to cross the corridor.

RMT27 (R)

RMT27 (L)

RMT3 (R)

RMT3 (L)

FIGURE 6

Minimum convex polygons (MCP) for individual tigers in Kosi River corridor

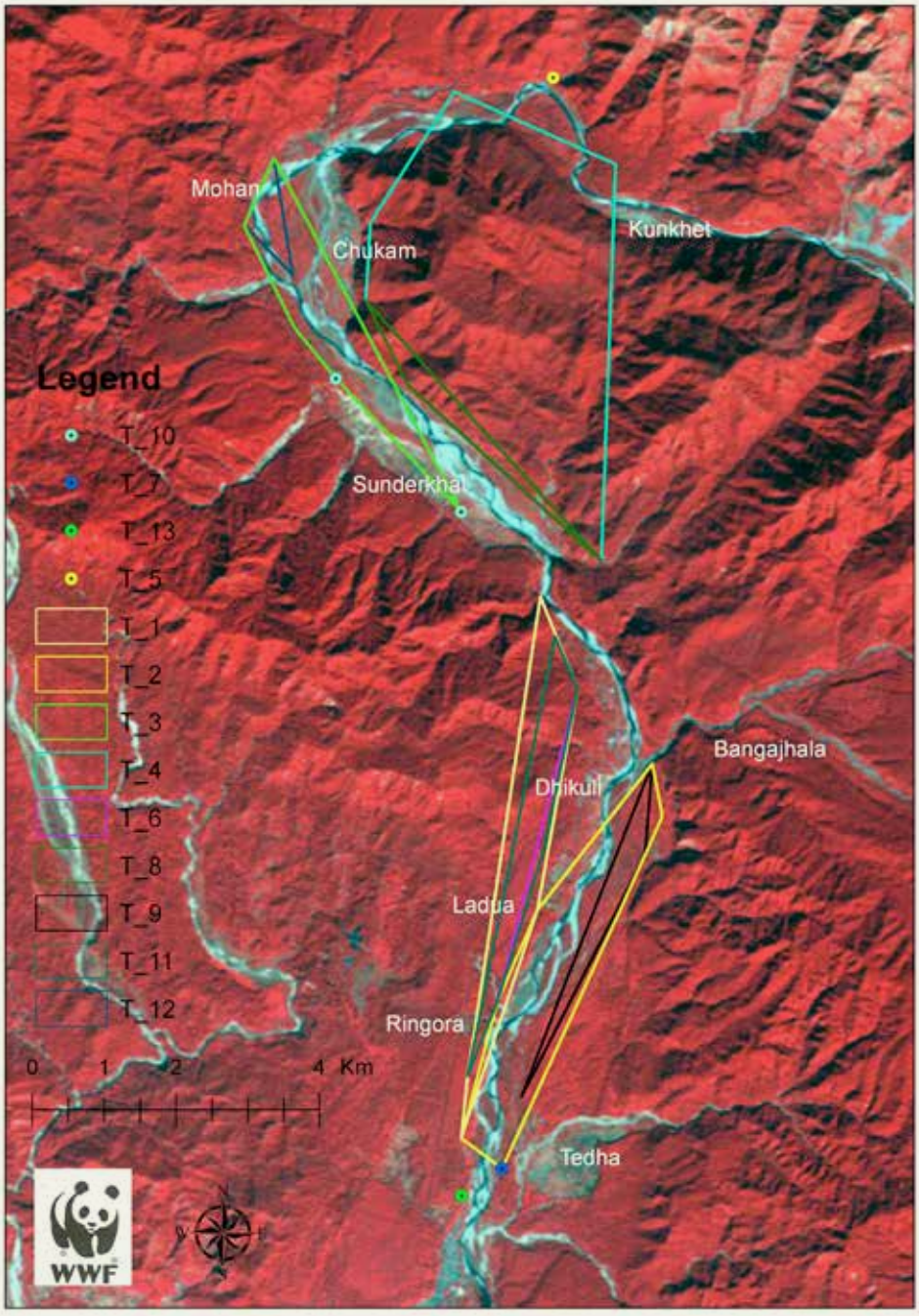


FIGURE 7

Indian Medicines Pharmaceutical Company Limited is posing a blockade along the corridor.

Red dots show camera trap locations while a yellow dot shows camera stations where tiger was captured.

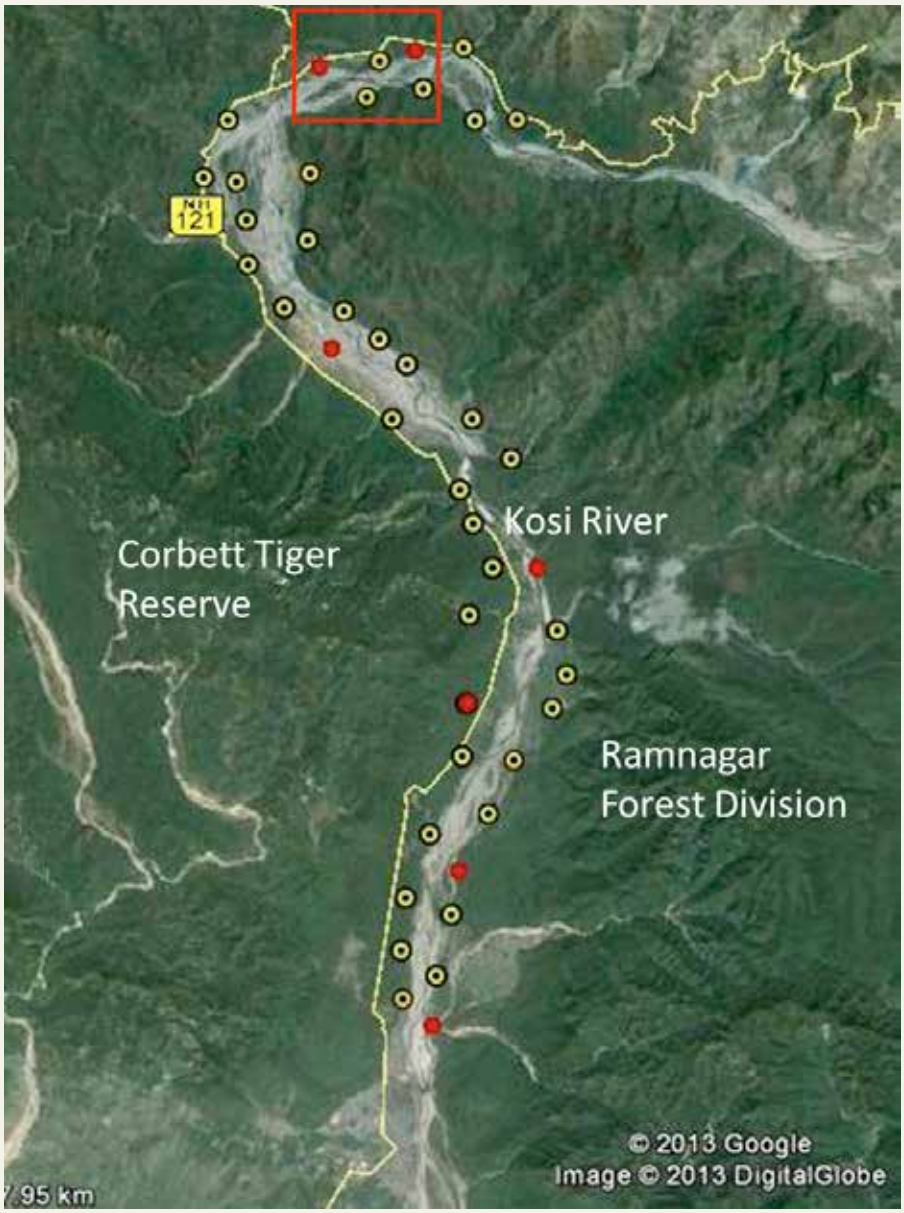


FIGURE 8

Chukam village Adjacent to the Kosi river corridor

Red dots show camera trap locations while a yellow dot shows camera stations where tiger was captured.

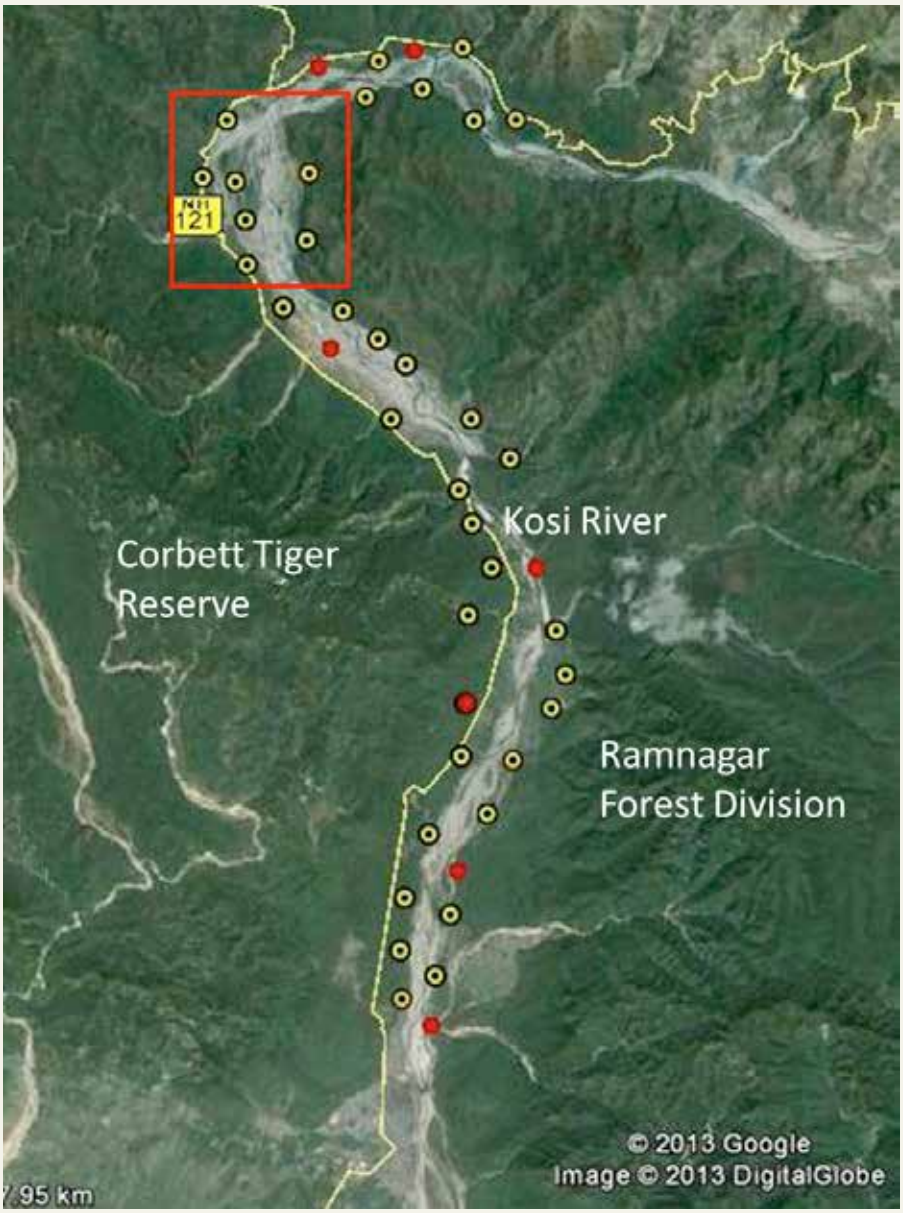


FIGURE 9

Sunderkhal encroachment along the Kosi river corridor.

Red dots show camera trap locations while a yellow dot shows camera stations where tiger was captured.

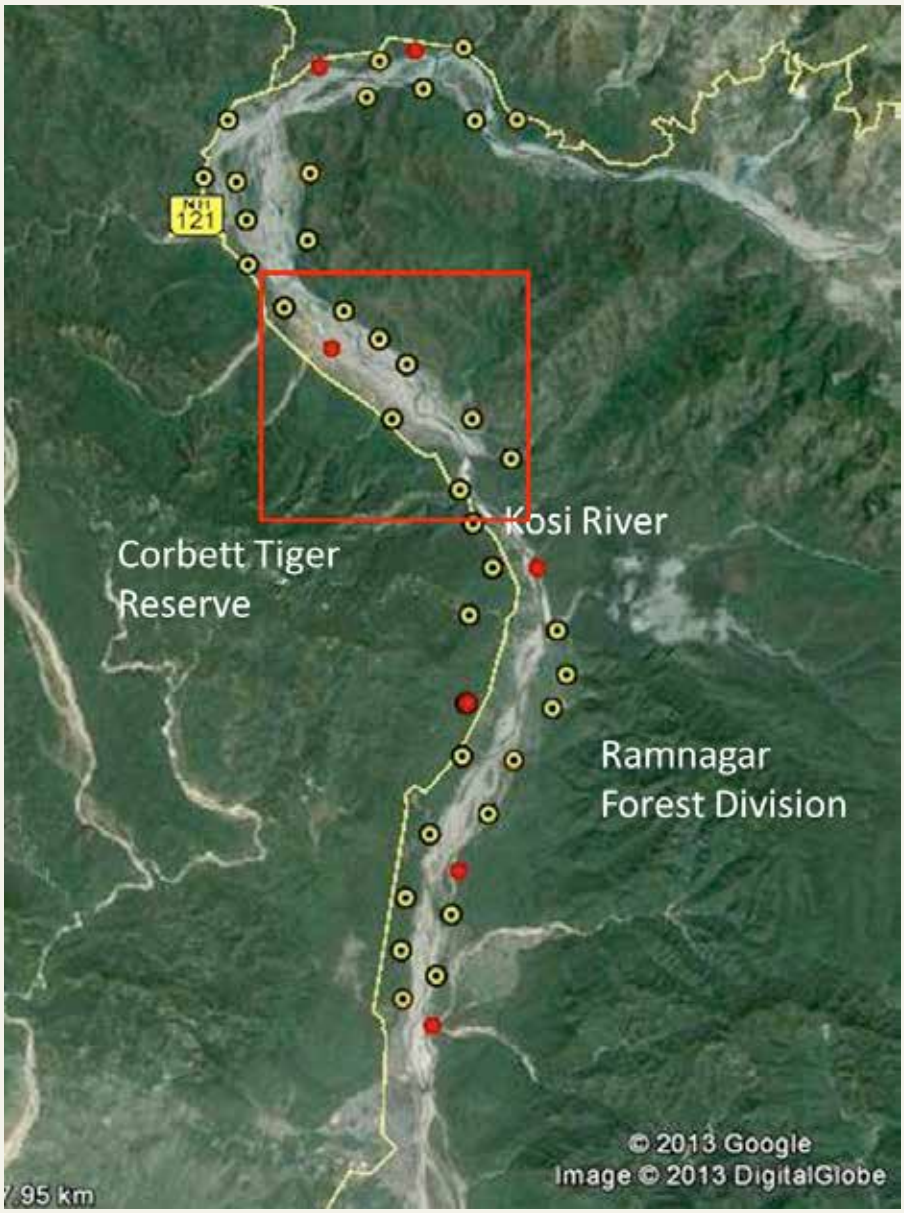
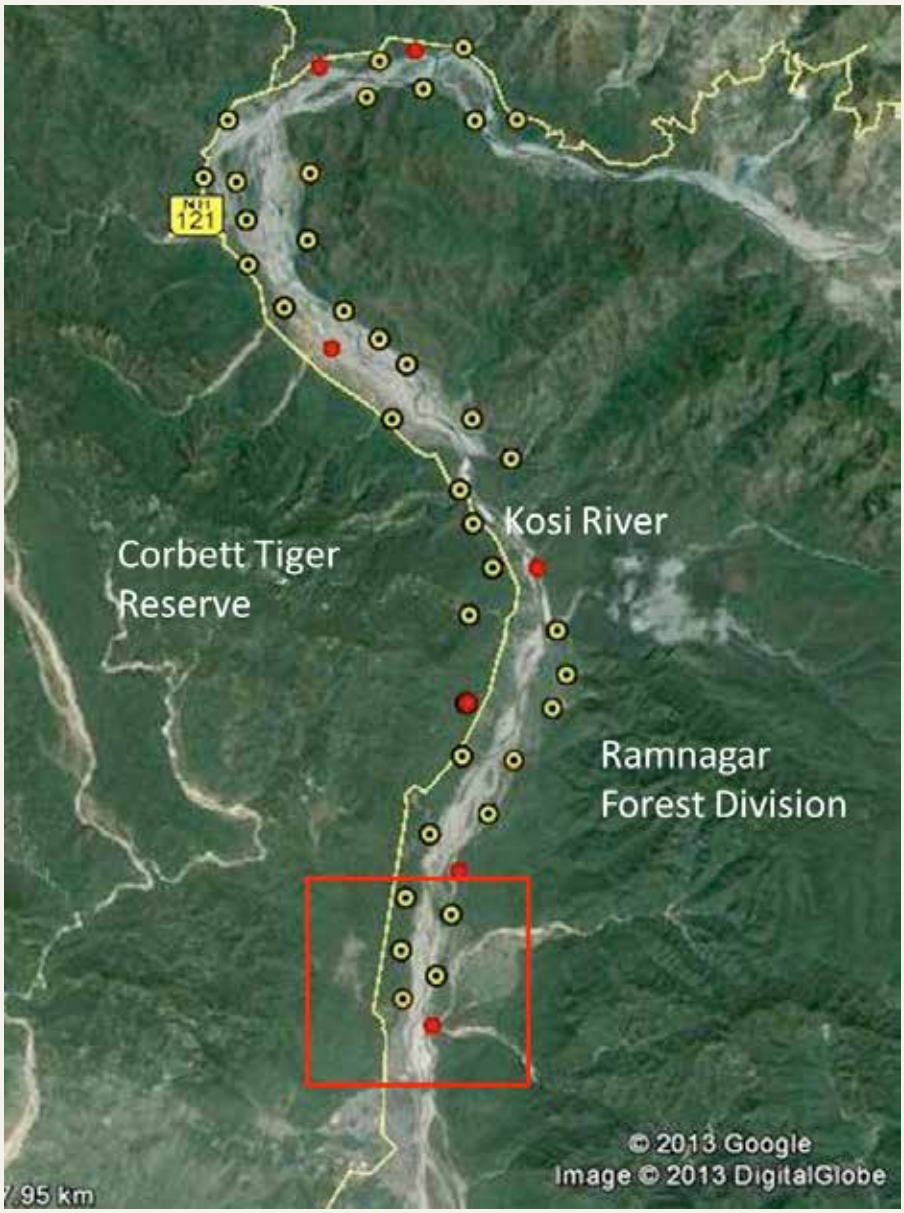


FIGURE 10

Habitation in the southern portion of the corridor puts anthropogenic pressure on the forest

Red dots show camera trap locations while a yellow dot shows camera stations where tiger was captured.



4.3 MAMMAL ASSEMBLAGE AND ABUNDANCE

Camera trapping in the Kosi River corridor recorded 21 species of wild mammals (Figure 11). Six of the 21 mammal species photo-captured were of high global conservation significance and are categorised as Endangered (2), Vulnerable (2) and Near Threatened (2) presenting this corridor as ecologically important. The northern part of the corridor is contiguous with the upper hills of Almora FD, thus five species with Himalayan affinity are also known to occur here. Among these, the present study recorded the red fox. It is the first time that this species has been recorded at such a low altitude (505m above msl) in TAL as well as in India. The camera traps also captured yellow-throated marten and Asiatic black bear. The yellow-throated marten has only occasionally been seen in this area and Asiatic black bear observes altitudinal migration here. The largest mammal recorded was elephant, which are also known to raid crops in nearby human settlements and the smallest mammal recorded was Indian hare. Among large carnivores, other than tigers, the study recorded leopards. Their presence in the area has been well documented as they depredate livestock and cattle belonging to villagers residing inside the corridor area (Bose *et al.* 2011). Among small cats, only leopard cat and jungle cat were captured although traps in the corridor did not detect fishing cat and rusty-spotted cat. Among small carnivores, Himalayan palm civet, small Indian civet and jackals were recorded. Wild prey for tigers and co-predators recorded from the corridor were three deer species (chital, sambar and muntjac), two antelopes, (nilgai and goral), and wild pig. Besides these, rhesus monkey and hanuman langurs were photo captured among non-human primates and Indian porcupine among rodents.

Mammalian species photo-captured in the Kosi River corridor are depicted in the photos below

Carnivores

TIGER

LEOPARD

LEOPARD CAT

JUNGLE CAT

BLACK BEAR

YELLOW-THROATED MARTEN

RED FOX

JACKAL

HIMALAYAN PALM CIVET

SMALL INDIAN CIVET

CHITAL

MUNTJAC

GORAL

NILGAI

SAMBAR

WILD PIG

ELEPHANT

LANGUR

RHESUS MACAQUE

PORCUPINE

INDIAN HARE

FIGURE 11

Mammal species camera trapped in Kosi River corridor

Among carnivores, relative abundance index (RAI_2) was found to be highest for tiger since the trapping was designed primarily for tigers. Red fox, Himalayan palm civet and Asiatic black bear were captured only once. In the present study, capture of a tiger photo in the corridor required 11.35 trap days. Compared to tiger, leopards were recorded in low number in the corridor (Table1).

Among ungulates, spotted deer or chital was found to be most abundant (95.48 ± 17.72) followed by sambar, wild pig, and muntjac. The lowest RAI (0.06 ± 0.06(SE) captures / 100 trap days) was recorded for goral. Chital was photo captured almost every day (1.05 trap days / capture) and for a capture of sambar, 2.25 trap days were required. RAI_2 for rhesus monkey was found to be higher than hanuman langur (Table1).

TABLE 1

Relative abundance index (RAI_2)and number of trap days required to capture a faunal species (RAI_1) in Kosi River corridor

Mammalian Fauna	IUCN category	# of captures	Mean (RAI_2) ± SE (RAI_2)	Trap days / capture (RAI_1)
Large Carnivores				
Tiger	EN	148	8.81 ± 0.96	11.35
Leopard	NT	12	0.71 ± 0.35	155
Asiatic black bear	V	1	0.06 ± 0.06	1680
Small Carnivores				
Leopard cat	LC	18	1.07 ± 0.35	93.33
Jungle cat	LC	4	0.24 ± 0.14	420
Yellow-throated marten	LC	5	0.30 ± 0.21	336
Himalayan palm civet	LC	1	0.06 ± 0.06	1680
Small Indian civet	LC	6	0.36 ± 0.16	280
Medium sized Carnivores				
Jackal	LC	13	0.77 ± 0.35	129.23
Red fox	LC	1	0.06 ± 0.06	1680
Ungulates				
Goral	NT	1	0.06 ± 0.06	1680
Nilgai	LC	2	0.012 ± 0.12	840
Chital	LC	1604	95.48 ± 17.72	1.05
Muntjac	LC	113	6.73 ± 1.94	14.87
Sambar	V	748	44.52 ± 6.60	2.25
Wild pig	LC	109	6.49 ± 3.46	15.41
Primates				
Rhesus monkey	LC	342	20.36 ± 5.76	4.91
Hanuman langur	LC	125	7.44 ± 2.67	13.44
Others				
Indian hare	LC	30	1.79 ± 1.09	56
Indian porcupine	LC	15	0.89 ± 0.37	112
Asian elephant	EN	121	7.20 ± 2.51	13.88

NT=Near threatened, LC=Least concern, V=Vulnerable, EN=Endangered,

RAI_1: Number of trap days required to get one photo of a species-an index of effort required

RAI_2: number of captures of a species/100 trap days-an index of relative abundance
Both indices reflect relative commonness or rarity of a species

4.4 PEOPLE & LIVESTOCK

Humans contributed the largest number of photos (102.2± 26.28 capture/100 trap days) during the sampling. The capture required less than a trap day (0.98 trap day/ capture). This is indicative of anthropogenic disturbance in the corridor. Furthermore, the presence of domestic animals (goat, sheep & mule), cattle and dog was also found to be high (Table2), which again pointed towards the high level of human interference in the corridor.

TABLE 2

Relative abundance index (RAI_2) and number of trap days required to capture a disturbance regime (RAI_1) in Kosi River corridor

Disturbance regime	# of captures	Mean (RAI_2) ± SE (RAI_2)	Trap days / capture (RAI_1)
Human	1717	102.2± 26.28	0.98
Cattle	107	6.37± 1.95	15.70
Domestic dog	69	4.11± 1.25	24.35
Others (Sheep, goat, mule)	121	47.20± 2.88	13.88

Lantana camara weed covers the floor of the Kosi River corridor

5. DISCUSSION

The present study attempted to comprehend the functionality of the Kosi River corridor with reference to tigers and in addition it recorded the corridor being used by 20 other wild mammal species.

5.1 KOSI TIGERS IN THE PERSPECTIVE OF CORBETT LANDSCAPE

The high photo-capture success rate in the traps put along the Kosi River corridor showed frequent movement of tigers. Although cumulative curve for capture of new tigers stabilised on the 15th occasion, single captures of two individuals provided a basis for their one-way movement using the corridor during study duration. These one way movements by two tigers were through northern and southern portions of the corridor. High density of tigers in the Corbett Tiger Reserve (17.8±1.4 SE tigers/100 km^2) and also in the Ramnagar Forest Division (15.2±2.1 tigers/100 km^2) (Jhala *et al* 2011) made this corridor important for regular exchange of genetic material among the individuals of the population in and around the Corbett Tiger Reserve.

5.2 FUNCTIONALITY AND CONSERVATION IMPORTANCE OF THE CORRIDOR

For the ease of understanding, the Kosi River corridor can be divided into three parts viz. northern portion that comprises areas between Kunkhet and Sunderkhal settlements, middle portion that starts from Sunderkhal and ends at Dhikuli settlement and southern portion that includes areas from Dhikuli settlement to the Bijrani gate of Corbett Tiger Reserve. Based on the results of the present study, it could be said that the Kosi River corridor was found to be functional at the northern and southern portions. According to the spatial recaptures, a tiger was found to cross the corridor in the northern portion between Mohan and Kunkhet villages. It was found that the IMPCL factory poses a significant blockage along the corridor (Johnsingh *et al.* 2004). Similarly, the southern portion of the corridor was also found to be used by another tiger to access the forests across the Kosi River contiguous to that of the Corbett Tiger Reserve. In addition, this corridor supported a rich mammal assemblage, many of them of high conservation value such as leopard, elephant and Asiatic black bear. Therefore, the conservation value of this corridor cannot be overlooked while planning for long term conservation programmes in the Terai Arc Landscape.

5.3 THREATS TO CONTINUED FUNCTIONALITY OF THE CORRIDOR

In the recent past, the Kosi River corridor witnessed rapid infrastructure development and an increase in anthropogenic pressure in the forests around it.

5.3.1 Infrastructure Development

In the last two decades, infrastructure development occurred at a tremendous rate along the corridor and drastic changes came about in land use pattern in villages such as Dhikuli and Mohan. Commercial centres in the form of resorts and tourism facilities mushroomed in the corridor posing threat to the connectivity. Most of the disruptions in the corridor were found along the middle portion, as no to and fro movement of the tiger recorded in that area whereas the northern and southern portions remained functional as far as tiger movement was concerned. Camera traps put behind the chain of resorts in Dhikuli village across the Kosi River did not result in any photo-capture of tigers. As mentioned before, human settlements dominated this part of the corridor. Multi-storied buildings have been constructed along this corridor which along with their extensive tourism facilities pose significant disturbance to wildlife in the nearby areas. Furthermore, bright lights put up in those resorts were spotted in many photographs triggered by prey species (Figure 12), which might be one of the limiting factors for the movement of predators in this portion of corridor. In addition, extensive sand and boulder mining was recorded during the sign surveys which disturb the habitat. A snare was found placed at a strategic location behind the IMPCL factory in the riverine patch which was most likely meant for the poaching of wild prey species. What is more worrying is that resorts and road side restaurants are being constructed along the left bank of the river (Tedha *Khatta* and Tedha village) in the southern portion of corridor which are likely to increase pressures on the surrounding forests.

5.3.2 People and Livestock

Intensive human interference was recorded and less than a trap day was required to get a photo capture of a human being in the corridor. Relative abundance indices were also high for cattle and other domestic animals. *Bhotia* pastoralists with their goats, sheep and mules who descend from upper part of Himalayas were also found using this corridor for temporary grazing area for their livestock. During the study period, an incident of prey poaching was reported from the southern portion of the corridor. During regular monitoring of the camera traps, two persons were found trying to flush out porcupines from their burrow by lighting fire near the Ringora forest village. Intensive human interference in the corridor were also found to give rise to human – animal conflict along the corridor. For the long term survival of tigers, co-predators and prey, special regulatory measures are to be taken up for protecting this corridor.

Tiger presence was also detected in the small island forest patches along the Kosi River. These riverine forest patches serve as stepping stones or stop overs for the spill over population of tigers in the landscape. Over the period of monitoring this corridor, it was found that these patches were being intensively exploited by fuelwood collec-

tors and shepherds from nearby villages. If the trend of human interference in these patches remains same, it would have an effect on the functionality of the northern and southern portion of the corridor in the near future.

FIGURE 12

A sambar with bright lights of resorts of Dhikuli in the background along the Kosi river corridor.

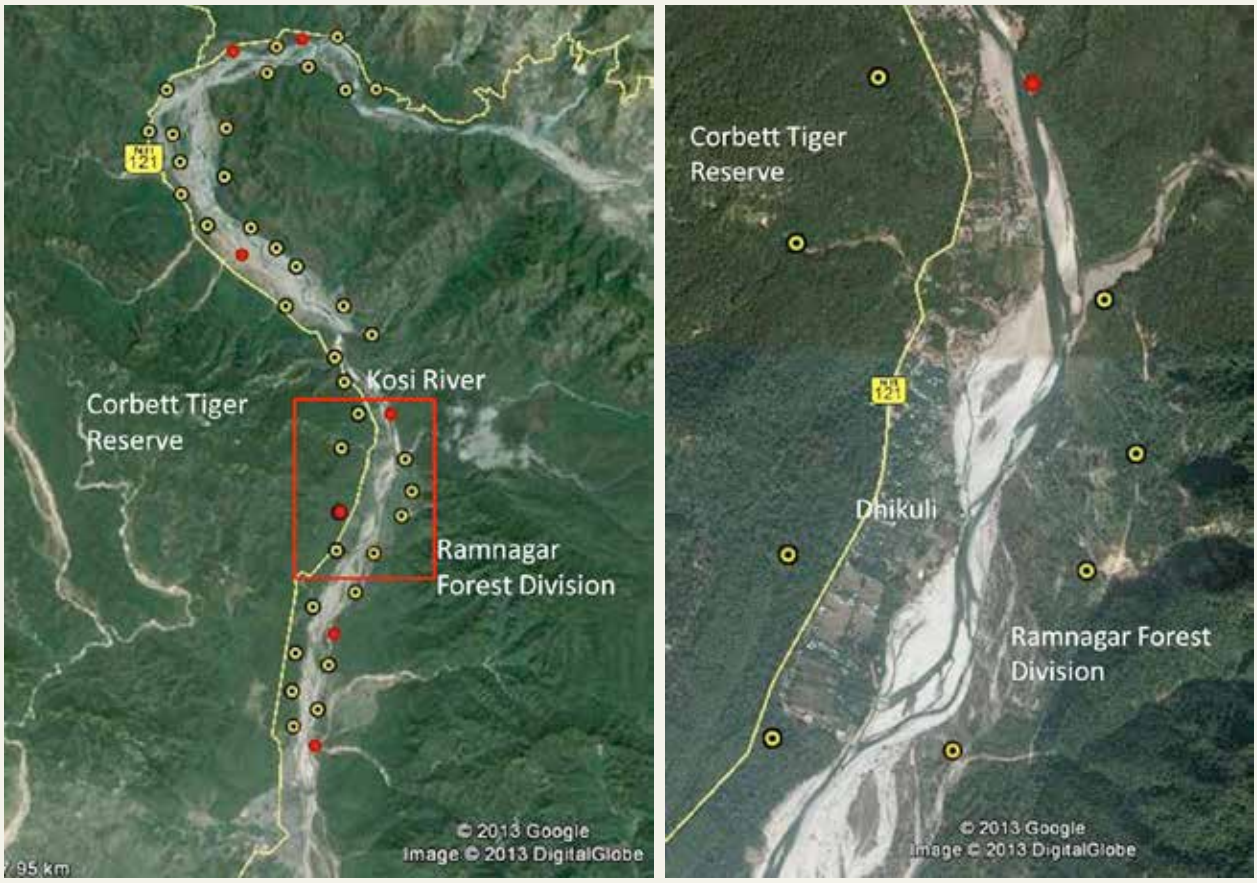


FIGURE 13

Dhikuli village in Kosi river corridor.

Red dots show camera trap locations while a yellow dot shows camera stations where tiger was captured.

BOX

i) A total of 13 tigers were recorded along the Kosi River corridor with an effort of 1,849 trap days which yielded 286 photographs of tigers.Two male tigers were found to move across the Kosi River.

ii) Tigers crossed the river only in the northern and southern portions of the corridor. Central portion of the corridor is now seriously threatened due to presence of a continuous chain of resorts and houses and is likely to become unsuitable for tiger movement in the near future.

iii) The forest in this corridor reported a rich array of mammals - 21 species including tiger, leopard, elephant, black bear and red fox.

iv) Red fox was recorded for the first time from this corridor.

v) Among indicators of disturbance, RAI_2 was highest for the humans followed by other animals (goat, sheep & mule), cattle and lowest for dog.

5.4 RECOMMENDATIONS

i) Development and Implementation of Corridor Management Plan

A Corridor Management Plan needs to be developed immediately for managing this corridor to ensure that wildlife movement doesn't get affected by any further development along the corridor. With growing human population pressure, it is likely that more open areas will be converted to tourism facilities which would threaten functionality of this corridor in the long term. This needs to be regulated. The Corridor Management Plan needs to be prepared and implemented jointly by the authorities of the Corbett Tiger Reserve, Ramnagar and Almora Forest Divisions and local administration. The role of the district administration is very important as only they will be able to regulate development along the corridor, especially along the revenue land.

ii) Strategies for reclaiming forest land, relocation of villages and minimise impact of commercial establishments in the corridor

There is a need to minimise disturbance around the cluster of villages of Dhikuli, Mohan, Ringora, and Tedha settlements and around the Indian Medicines Pharmaceutical Company Limited, Mohan. Fuel wood collection and extensive boulder and sand mining needs to be controlled in the corridor. The relocation of Sunderkhal settlement and Chukam village would strengthen the connectivity in northern portion of the corridor. Tiger presence was recorded around these habitations which were surrounded by rich forest. For maintaining the connectivity of southern portion of the corridor, Tedha *Khatta* settlement on the left bank of Kosi River should be reclaimed by the Uttarakhand Forest Department to increase the green belt in this part of the corridor. Construction of resorts next to the timber depot near Bijrani Forest Gate should be discouraged as well as the barbed-wire fencing should also be reduced by about 30% towards the north because tigers were found using the area under broken barb wire fence. Relocation of Aamdanda *Khatta* and Ringora settlements would also go a long way for maintenance of the connectivity.

The stone wall around the Indian Medicines Pharmaceutical Company Limited, Mohan (IMPCL) has affected free movement of both tigers and elephants and as such that wall needs to be removed. The lease agreement between the IMPCL and Uttarakhand Forest Department needs to be rechecked as 27 years before when IMPCL land was leased by the then Almora Forest Division, it did not hold so much importance in terms of tiger conservation within the Terai Arc Landscape.

iii) Regulation of open grazing and minimise risk of disease spread in the corridor

This corridor is being used by villagers and migrant shepherds for grazing their livestock. Domestic animals were found as abundant as wild prey species and it is likely that they might be competing with each other for resources. Permits should not be issued to the migrant shepherds for grazing their livestock along the cor-

ridor area. Vaccination of the cattle in the villages around this corridor should be carried out on regular basis to avoid spreading of any cattle borne disease to the wild ungulates in the corridor.

iv) Regulation of traffic on National Highway 121

The traffic movement across the Ramnagar-Ranikhet road needs to be regulated during night along the corridor. In order to minimise road kills of animals, suitable measures need to be undertaken.

v) Enhancing Protection in the corridor

The Kosi River corridor gets anthropogenic pressures from both sides and most of its area was found to be used by people for livestock grazing, extensive sand and boulder mining, collection of fuelwood and fodder and also for recreation. These seemingly non-threatening interferences at times might also provide opportunities to poachers to operate along the corridor. Therefore, intensive foot patrolling and setup of local community based informer network across the corridor are needed to enhance the level of protection along the corridor.

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Elephant in Kosi River corridor

43

Pairs of camera traps operated round the clock for 42 days

13

Number of tigers recorded from the corridor

1st

First photographic evidence of red fox and Asiatic black bear from the Kosi River corridor

23

Approximate length (in km) of the Kosi River corridor

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