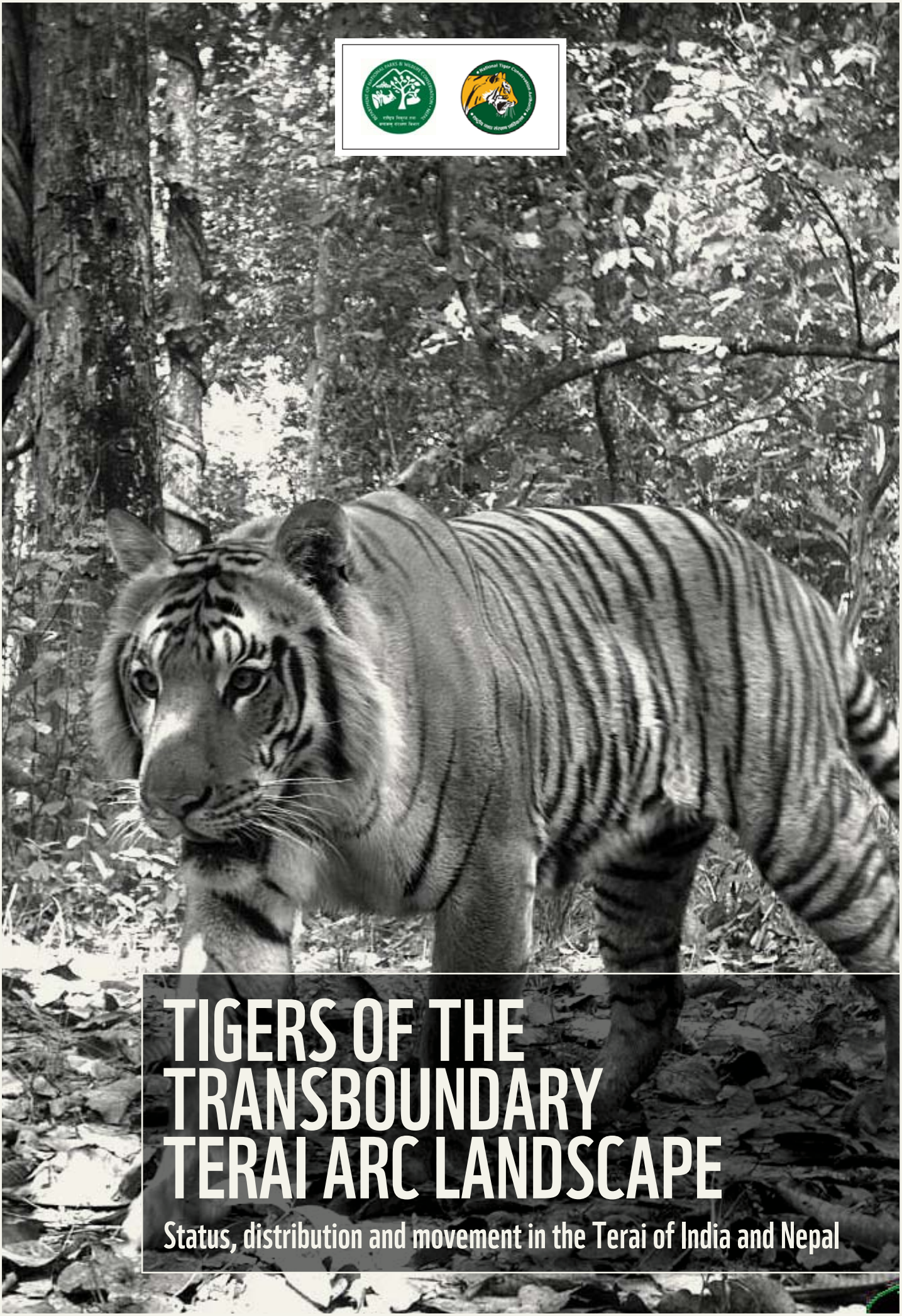

TIGERS OF THE TRANSBOUNDARY TERAI ARC LANDSCAPE

Status, distribution and movement in the Terai of India and Nepal

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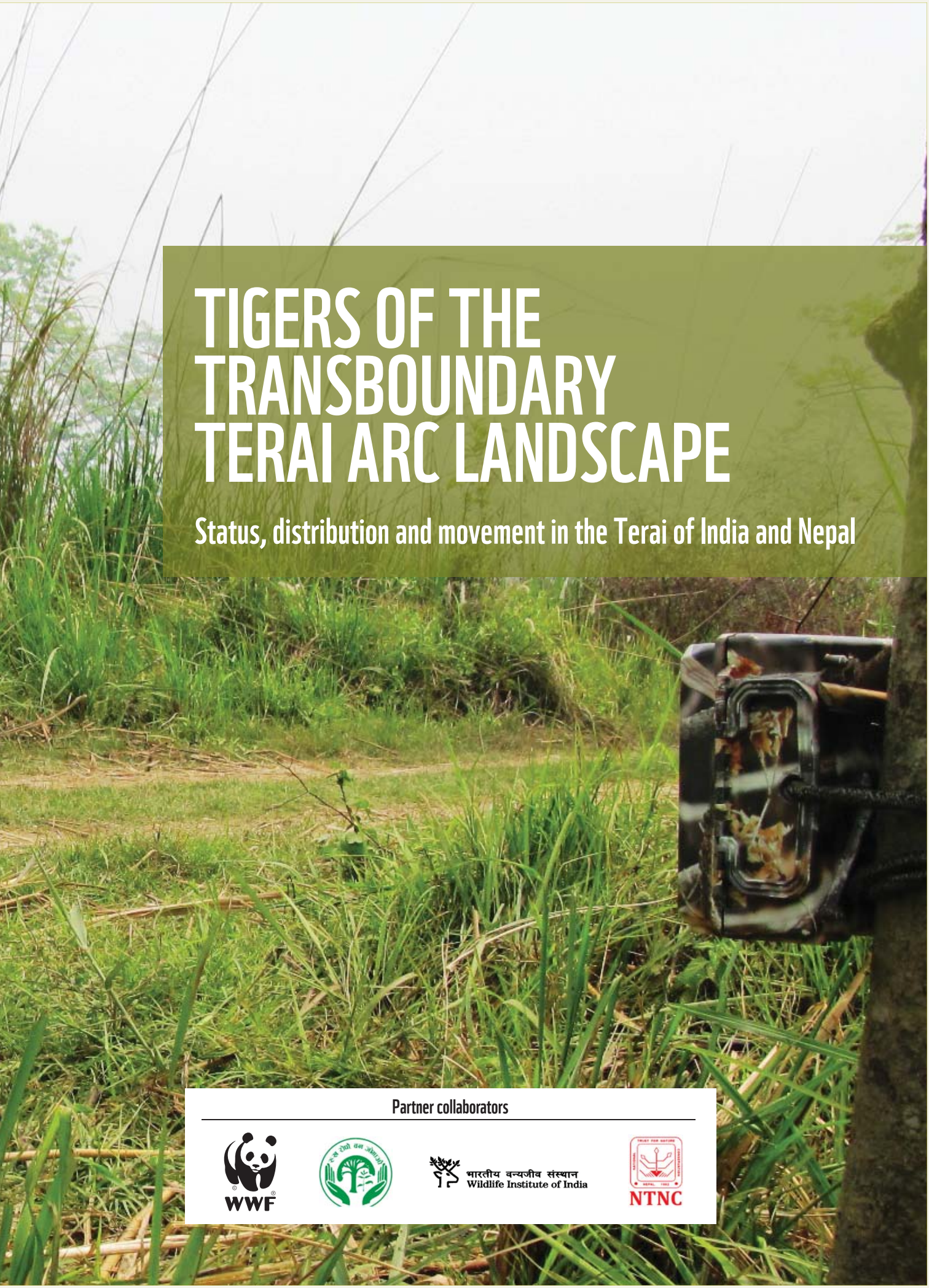

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Wildlife Institute of India

NTNC

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September 9, 2014

FOREWORD

This publication is an outcome of the bilateral understanding between India and Nepal on transboundary illegal trade in wildlife and conservation. The transboundary terai landscape has as many as twelve protected areas, which belong either to Nepal or India. These have a good occupancy of tiger, co-predators, prey and other mega-herbivores like rhino and elephant.

The terai transboundary landscape is characterized by diverse habitats with varied land uses and human pressure. Wild animals, including the tiger frequent between both countries, which necessitate a collaborative effort to address areas of mutual concern.

This joint effort provides a profile of protected areas in the transboundary terai landscape, its land use, socio-economic features and status of tiger and its prey. The significance of some crucial India-Nepal corridor linkages, viz. Chitwan-Valmiki, Berdia-Khata-Katerniaghat, Suklaphanta-Lagga Bagga-Pilibhit has been highlighted, besides flagging the areas of for field actions.

This study would be of immense use to both the tiger range countries to strengthening in-situ wildlife conservation in the landscape.

Dr Rajesh Gopal
Addl. Director General (Project Tiger)
& Member Secretary,
National Tiger Conservation Authority

FOREWORD

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Date :- September 9, 2014

Foreword

Five protected areas and surrounding forests located in the Terai Arc Landscape (TAL) are tiger habitat in Nepal. These areas are adjoined to the Nepal and Indian border. Though the TAL is rich for faunal and floral biodiversity, it is under tremendous human pressure. Habitat fragmentation and loss, poaching, human-wildlife conflicts are the major challenges to the tiger habitat in TAL.

The Government of Nepal in partnership with National Trust for Nature Conservation and WWF Nepal carried out a nationwide tiger survey in 2012-13. The survey showed a 63% increase in tiger population: from 121 in 2008-09 to 198 in 2012-13. The survey also revealed that tigers are living in the habitat of both Nepal and India.

I am happy that concern authorities of Nepal and India have prepared this survey report on tiger of the trans-boundary: status, distribution and movement in the Teari of Nepal and India. The report is prepared following the 6th trans-boundary meeting between Nepal and India in 2013. The report is the results of the tiger and prey base survey carried out during 2012-13 in Nepal and India. The report highlights the status of tigers in the TAL and importance of tiger habitats and corridors between Nepal and Indian border (Chitwan-Parsa Complex and Valmiki Tiger Reserve, Banke-Bardia Complex and Katerniaghat, Shuklaphanta Wildlife Reserve and Lagaa Bagga and Pilibhit). This report has also emphasized the authorities of Nepal and India to coordinate at landscape level for the conservation of the tigers.

I would like to express my sincere thanks to the Department of National Parks and Wildlife Conservation and Department of Forests, especially to the technical committee members for their tedious field work, data analysis, and preparing the report. The National Trust for Nature Conservation, WWF Nepal and the USAID/Hariyo Ban Program deserves special thanks for their support. I hope this report will serve as a milestone to strengthen the trans-boundary cooperation between Nepal and India in the days to come.

Sharad Chandra Paudel
Secretary

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We thank Dr. Rajesh Gopal of the National Tiger Conservation Authority (NTCA), Government of India; Mr. Megh Bahadur Pandey and Mr. Bishwonath Oli from Ministry of Forests and Soil Conservation (MoFSC), Government of Nepal; Dr. Ghana Shyam Gurung and Mr. Shiv Raj Bhatta, WWF Nepal; Dr. Sejal Worah, and Dr. Dipankar Ghose, WWF-India and Mr. Ganga Jung Thapa, National Trust for Nature Conservation (NTNC) for encouraging collaborative surveys, and for steering dialogue between Nepal and India for tiger conservation in the Terai Arc Landscape.

In India, this study was made possible by the Uttar Pradesh and Bihar Forest Departments. As well as granting research permits, they provided logistical support in many other ways. We are grateful in particular to the Chief Wildlife Wardens of Uttar Pradesh and Bihar, Dr. Rupak De and Mr. B. A. Khan, whose support was instrumental for these studies. We also acknowledge support from the Field Directors of Dudhwa Tiger reserve, Sh. Sailesh Prasad and Valmiki TR, Sh. Santosh Tewari, their kind support interest. The Divisional Forest Officers Sh. Ganesh Bhat (Dudhwa), Sh. R.K. Singh (Katerniaghat), Sh. A.K Singh (Katerniaghat), Sh. Kamaljeet Singh and Sh. Nand Kishor (both Valmiki) and Sh. M. Mittal (Suhelwa) were all enthusiastically involved in the monitoring and facilitated the work in numerous ways. We are also grateful for the support of Range officers and foresters who aided us with the camera trapping. Finally, credit is due to the many dedicated forest guards and watchers (too numerous to name here) who proudly led us to tiger signs in their beats, and worked with us to ensure that the monitoring exercise was implemented effectively and to meet its objectives. These studies were funded by WWF-India (through grants from WWF-UK and WWF-Sweden), and by the United States Fish and Wildlife Service. We thank Dr. B. R. Noon for his involvement and support.

In Nepal, we highly appreciate the lead taken technical committee and Dr. Chiranjibi Prasad Pokheral in overall co-ordination and field implementation. We are highly grateful to Chief Conservation Officers, Mr. Fanindra Kharel, Chitwan National Park, Mr. Jagannath Singh and Mr. Nilamber Mishra, Parsa Wildlife Reserve, Mr. Tulsi Ram Sharma, Bardia National Park, Dr. Jhamak Bahadur Karki, Banke National Park and Mr. Yuvaraj Regmi, Shuklaphanta Wildlife Reserve for leading the field survey team and facilitating field work in various ways. We thank the District Forest Officers of all 14 Terai districts of the Terai Arc Landscape Nepal for extending their full support and co-operation for field work. We are extremely thankful to our field team members: staff of DNWPC, DOF, NTNC, WWF Nepal, Nepal Army, International Trust for Nature Conservation (ITNC), Nature Guide Association, local communities from Buffer Zones and Community Forests, and volunteer students from Tribhuvan University, Pokhara University and Kathmandu University who spend numerous days and nights inside the jungle to collect data. This study was made possible by the funding support we received from USAID funded Hariyo Ban Program, DiCaprio Foundation, United States Fish and Wildlife Service, WWF US, WWF UK and WWF Australia. We are highly thankful to Ms. Judy Oglethorpe, Hariyo Ban Program, WWF Nepal and Mr. Netra Sharma, USAID for financing the last minute funding crunch.

Mr. Ravi Singh, Secretary General and CEO of WWF-India, Anil Manandhar of WWF Nepal, and Mr. Juddha Gurung, NTNC are thanked for their leadership and

immense support for the program. Dr. Ghana Shyam Gurung and Mr. Shiv Raj Bhatta of WWF Nepal, Dr. Sejal Worah and Dr. Dipankar Ghose, from WWF-India, Dr. Eric Wikramanayake and Shubash Lohani from WWF US are thanked for their instrumental role in building the program, and guiding its progress. We also thank WWF Tigers Alive Initiative (TAI) for coordination and technical support provided as and when required.

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EXECUTIVE SUMMARY

While the conservation of tigers is emphasized in protected areas throughout their range countries, the species continues to be distributed in forests of varying protection status, and in habitats that span international borders. Although India and Nepal share a long border in the Terai belt, this area that was once forested is now largely agricultural, and wildlife is restricted to remnant forest patches. This study details the status of tiger and ungulate prey species populations in around 5300 km² transboundary Terai Arc Landscape (TAL), documents the movement of tigers between forests in India and Nepal based on camera trap data and makes specific recommendations for the conservation of tigers and their prey in Transboundary TAL. Notable protected area within the study area includes Chitwan and Bardia National Parks in Nepal and Dudhwa and Valmiki Tiger reserves in India.

This study was carried out in 7 protected areas and reserve forests in India, and 5 protected areas, three biological corridors (protected forests) and adjoining forest patches in Nepal. Occupancy surveys for animal signs involved 4496 kilometres of foot surveys in Nepal and India. Between November 2012 and June 2013, these sites were sampled with a total of 1860 camera trap stations, with a total sampling effort of 36,266 trap nights. Nearly 9000 km² of tiger habitat was sampled with camera traps. 3370 kilometres of line transects (n=239) were sampled in the landscape. Cumulatively, this sampling exercise is the largest survey effort of its kind in the Terai Arc Landscape to date, and involved partnerships between National and State government agencies, research institutions, non-governmental organizations and members of local communities who participated in the research.

Data analysis was carried out using contemporary analytical methods including site occupancy models, spatial explicit capture recapture models and distance sampling framework. Site occupancy was estimated to be 0.55 (0.44-0.66) in Nepal and 0.77 (0.67-0.85) in the region between Nandhaur WLS and Suhelwa WLS in India. A total of 239 individual adult tigers were identified from camera trap photos, of which 89 were adult males and 145 were adult females. 5 animals could not be ascribed a gender from camera trap data. Site-specific minimum tiger numbers varied from 3 in Banke National Park in Nepal to 78 in Chitwan National Park, also in Nepal. Tiger numbers and/or abundances in other sites within the Transboundary landscape were estimated to lie within this range, with notably large populations in Bardia National Park and Pilibhit Tiger Reserve, and smaller populations in Dudhwa National Park, and Kishanpur Wildlife Sanctuary and Shuklaphanta Wildlife Reserve. Tiger densities in the Transboundary Terai Arc Landscape range between 0.16/100 km² in Banke National Park, Nepal to 4.9/ 100 km² in Kishanpur Wildlife Sanctuary, India. Spatial heterogeneity in tiger densities has been mapped for the entire study area. Densities of principal ungulate prey species of tigers were found to vary widely across sites, and while density estimates in some protected areas in Nepal were as high as 92.6/km² (Bardia National park), they were seven fold lower in other sites in India and Nepal (13.6 in Dudhwa National Park and 10.7 in Banke National Park).

While habitat connectivity has severely been compromised in this landscape, tigers exist as one wholly-connected population in the protected areas of Chitwan National Park,

Nepal and Valmiki Tiger Reserve, India as well as in Shuklaphanta Wildlife Reserve, Nepal and the Lagga-Bagga Block of Pilibhit Tiger Reserve, India. Other than these sites we photo-documented movement of tigers between Nepal and India along the Khata corridor (between Bardia National Park and Katerniaghat Wildlife Sanctuary) and Shuklaphanta - Tatarjanj - Pilibhit Corridor. We failed to document tiger movement in four other corridors: Boom-Brahmadev, Laljhadi, Basanta, and Kamdi. Forest connectivity has severely been compromised in these corridors by land use change. There are notably large differences in tiger and prey densities within and between sites. This study points to the influence of habitat (forest-grassland mosaics and riparian areas) on the distribution and density of tigers and their prey. However, these factors alone are likely to provide incomplete explanations for observed patterns. Observed patterns of tiger and prey densities are likely to also be on account of anthropogenic pressures on wildlife and their habitats in the form of poaching, livestock grazing and the entry of large numbers of wood and grass collectors deep into wildlife habitats. Another significant threat to the survival of tigers and other mammals arises from the proposed development of new roads in Nepal and India that may severely degrade the region's fragile corridors. The establishment of new settlements near existing tiger habitats constitutes encroachment, and poses a significant challenge for conservation in some parts of this landscape.

The continued use of two forest corridors between Nepal and India by tigers and other large mammals is encouraging. The dispersal of tigers between sites plays an important role in maintaining demographically stable and genetically robust populations. The most pressing task for conservation is to protect these corridors and to re-establish connectivity between other sites by restoring corridors that have been eroded by development and land-use change. There are also significant opportunities to build conservation and development programs that emphasize the protection of the Terai's remnant wilderness areas, while also attending to legitimate needs of forest-dependant human communities.

This report also identifies key interventions that are needed to secure the future of tigers in the Terai. These include policy initiatives, important interventions to create functional biological corridors, key enforcement and protection measures, prescriptions for community involvement in conservation and identifying important themes for future research and monitoring. To set tangible management and conservation targets, recommended actions under these themes have been listed separately for twenty four sites in the transboundary TAL.

The future of tigers and other large mammals in Nepal and India are intertwined, as is the wellbeing of the peoples of the Terai who live along this forested frontier. Building effective partnerships for conservation between the governments, conservation organizations and civil society of India and Nepal, and working toward common goals are imperative to maintain and promote populations of tigers and other endangered wildlife in this unique eco-region.

1. INTRODUCTION

Animals and plants do not recognize the political and administrative boundaries that intersect their habitats. This is true for the multitude of organisms including insects, birds, mammals and species of other taxonomic groups that move or migrate across boundaries separating regions, countries and even continents. Wildlife conservation can therefore be deemed as a global responsibility, with the survival of species often being dependent on protected habitats that are distributed across national and geo-political boundaries. Modern conservation practice has recognized the importance of the 'landscape approach' that scales up conservation initiatives across larger areas, and seeks to combine both protection and sustainable management of biological diversity.

TERAI ARC LANDSCAPE IS A BIOLOGICALLY DIVERSE ECO-REGION THAT IS HOME TO

86
SPECIES OF MAMMALS,

>600
SPECIES OF BIRDS,

47
SPECIES OF HERPETO-FAUNA,

126
SPECIES OF FISH, AND OVER 2,100 SPECIES OF FLOWERING PLANTS

A transboundary landscape presents us with an opportunity to conserve biodiversity across a large area which extends well beyond the boundaries of smaller protected areas within it. One such unique and significant transboundary landscape exists along the southern boundary of Nepal and the sub-Himalayan region of North India, alluded to as the "Terai Arc Landscape" (TAL). This unique landscape spans the Himalayan foothills and adjacent flood-plain areas, and holds populations of a variety of endemic and endangered flora and fauna. The Indo-Nepal border allows for the movement of people and animals that is not impeded by fences or walls. India and Nepal's 'open' border arrangement provides significant opportunities and challenges for the co-ordinated conservation of large mammals and other wildlife. This report presents the findings of extensive monitoring that was conducted to ascertain the status of tigers and their prey in protected areas and other forests in the transboundary Terai region of India and Nepal.

1.1 THE TERAI ARC LANDSCAPE

The 49,500 km² Terai Arc Landscape (hereafter referred to as TAL) is situated in the foothills of the Himalayas and proximate plains, and includes around 15 protected areas of Nepal and India. The Indian portion of TAL, stretching from the Yamuna River in the west to Valmiki Tiger Reserve, Bihar in the east, spreads across five states along the Shivaliks and Gangetic plain. The Nepal part is distributed across 14 districts from Rautahat in the east to Kanchanpur in the west and contains six protected areas. The landscape contains almost all the forests of the Shivalik and Terai regions of India, and over 75% of the remaining forests of the Terai, and Churia and Shivalik foothills in Nepal. Since its recognition as a conservation landscape of global importance by various scientists and NGOs (WWF, 2000; Wikramanayake et al., 2004; Sanderson et al., 2006), numerous projects have been developed to conserve populations of threatened wildlife and ecosystems in the landscape. Pioneering long-term studies on the ecology of tigers and other large mammals have been carried out in Chitwan National Park (NP) and other sites in Nepal since the 1970s (Seindensticker, 1976; Laurie, 1978; Sunquist, 1981; Dinerstein & Price, 1991; Jnawali, 1995), and more recently in India (Johnsingh et al., 2004; Harihar et al., 2009; Jhala et al., 2011). These and other studies have been the basis for the formulation of creative strategies to conserve biodiversity through scientific understanding and partnerships among multiple stake-holders including local communities, government agencies, academic institutions, NGOs and donors. Conservation efforts in recent years have largely focussed on populations of large

mammals such as tiger, elephant and rhino that range over large areas. These species are often described as charismatic, and there is global concern for their conservation. They therefore serve as umbrella species and enable promotion of wider biodiversity conservation objectives at regional scale, while also generating funds for conservation and sustainable development in areas close to wildlife habitats.

This remarkable transboundary landscape comprises of three distinct geographical and physiographical zones (Johnsingh et al., 2004):

(i) Shivaliks (known as *Churia* in Nepal) are the southernmost and geologically youngest range of the Himalayas and are characterized by sandstone and conglomerate rock formations. They run parallel to the southern boundary of the lesser Himalayan ranges, and are sometimes indistinguishable from them.

(ii) Bhabar is characterized by a low gradient terrain with coarse alluvium and boulders, and Sal (*Shorea robusta*), mixed and miscellaneous vegetation communities. Such areas are associated with the lesser Himalayan ranges, and the lower slopes of the Shivaliks. Wide, rocky, porous streambeds (*raus*) are a defining feature of the Bhabar zone.

(iii) Terai is characterized by fine alluvium and clay rich swamps which support a mosaic of tall grasslands, wetlands and mixed deciduous forests dominated by Sal (*Shorea robusta*) forest. These habitats exist along the flood-plains of many streams and rivers that originate in the Himalayas.

Of these zones within the TAL, the Terai in particular has been listed among the globally important 200 ecoregions for its unique Terai-Duar Savannas and Grasslands (Olson and Dinerstein, 1998). These alluvial floodplain grasslands are regarded as the world's tallest grasslands, with some grass species growing higher than seven meters. TAL is a biologically diverse eco-region that is home to 86 species of mammals, >600 species of birds, 47 species of herpeto-fauna, 126 species of fish, and over 2,100 species of flowering plants (Flemming et al., 1976; lnskipp and Inskipp, 1991 Maskey, 1989 and Shah, 1995). Three Level I Tiger Conservation Units (TCUs) (Chitwan-Parsa-Valmiki, Bardia-Banke, and Rajaji-Corbett) and two Level II TCUs (Dudwa-Kailali and Shuklaphanta-Kishanpur) form part of this landscape (Dinerstein et al., 1997). The tall alluvial floodplain grassland and subtropical deciduous forests of TAL support one of the highest recorded densities of tiger (*Panthera tigris*) in the world (Sunquist, 2010), and the second largest population of greater one-horned rhinoceros (*Rhinoceros unicornis*) (Dinerstein and Price, 1991). Other notable wildlife species include Asiatic elephant (*Elephas maximus*); gaur (*Bos gaurus*); sloth bear (*Ursus ursinus*); dhole (*Cuon alpinus*); 12 species of wild cervids and bovids; 11 species of canids and felids; and the critically endangered Gangetic dolphin (*Palatanista gangetica*) and gharial (*Gavialis gangeticus*). These and other plant and animal species contribute to the Terai Arc Landscape's global biodiversity significance. Given that tiger and other species exist in populations that are small, fragmented and threatened by various anthropogenic pressures, the TAL has also been recognized as a high priority conservation landscape (Johnsingh et al., 2004, Wikramanayake et al., 2004).

TAL lies between the Mahakali (Sharda) River in the west and the Bagmati River in the east, and contains four forest management categories: protected areas, reserve forest,

protected forest (corridors) and community-managed forests. In Nepal, Parsa Wildlife Reserve, Chitwan National Park, Banke National Park, Bardia National Park and Shuklaphanta Wildlife Reserve sustain tiger populations. In India, Dudhwa National Park, Pilibhit Tiger Reserve (formerly Forest Division), Kishanpur Wildlife Sanctuary (WLS), Katerniaghat Wildlife Sanctuary, Valmiki Tiger Reserve, and Nandhaur Wildlife Sanctuary hold resident tiger populations. Other sites such as Suhelwa and Sohagibarua WLSs appear to have sporadic tiger presence.

TERAI ARC LANDSCAPE HAS ALSO BEEN RECOGNIZED AS A HIGH PRIORITY CONSERVATION LANDSCAPE

The conquest of malaria, and subsequent large-scale expansion of agriculture and human settlement, particularly over the past five decades, has resulted in fragmentation and degradation of forest and grassland habitats in the landscape. Consequently the distribution of species such as one-horned rhinoceros, swamp deer (*Cervus duvauceli*), hog deer (*Axis porcinus*), gaur and wild buffalo (*Bubalus bubalis*) are now greatly restricted. The continuing loss of forests and grasslands in the Indian TAL, and more commonly in Nepal, poses daunting challenges for wildlife conservation efforts. There is an urgent need to arrest the loss of wildlife habitats through proactive conservation measures and policy interventions that recognize and seek to maintain functional ecosystems and biodiversity in the Terai. In particular, there is a need for government support to restore and maintain habitat connectivity by protecting fragile corridors, and to protect remnant forest and grassland patches in the TAL from the impacts of ongoing and proposed infrastructure development and encroachment.

Recognizing these threats, conservation groups and government research agencies agree that an overarching vision for conservation in the TAL is to restore connectivity between large habitat blocks and to connect habitat islands with the Churia-Shivalik hill forests in Nepal and India (Johnsingh et al., 2004; Wikramanayake et al., 2004; Jhala et al., 2011). Achieving these targets will provide dispersal corridors and migration paths for tiger, rhino, elephant and many other species, which are crucial for maintaining functional eco-systems and gene flow.

Currently, there are thirteen protected areas and various other forests with lower protection status (Table 1) in the transboundary landscape, and they serve as key sites for tiger conservation. Some of these forests are contiguous with one another (e.g. Chitwan NP in Nepal and Valmiki TR in India). Connectivity between other forests in India and Nepal is through well delineated forest corridors (e.g. the Khata corridor between Bardia NP and Katerniaghat WLS). However, most corridors between the two countries now exist in the form of narrow wilderness patches and water channels that have been hemmed in by human settlements and agriculture development, and dissected by roads and highways (e.g. the Laljhadi corridor between Dudhwa NP and Shuklaphanta WR; Basanta corridor between Dudhwa NP and Bardia NP via National Forests in Nepal, and Kamdi corridor connecting Banke NP and Suhelwa WLS).

Transboundary conservation is important both because some TAL wildlife populations and ecosystem functions are shared across the border, and because forests in both nations serve to provision fuel wood, fodder and other resources for the region's large and rapidly growing human population. While there are significant opportunities for wildlife conservation in the transboundary TAL, such as the restoration of important corridors and improved protection and community conservation initiatives, there are daunting challenges as well. Notably, several new infrastructure development projects

have been conceived or initiated in both countries in the interest of national security and development. However, these projects (e.g. highways and railways in the border districts of Nepal and India) can have severe adverse effects on wildlife populations and habitats. The development of new roads will further fragment wildlife habitats (WWF-India, 2014), and adversely affect the behavior and survival of tigers and other species (Kerley et al., 2002; Fahrig and Rytwinski, 2009). Encroachment of wildlife habitats and hunting are also complicated threats of great concern.

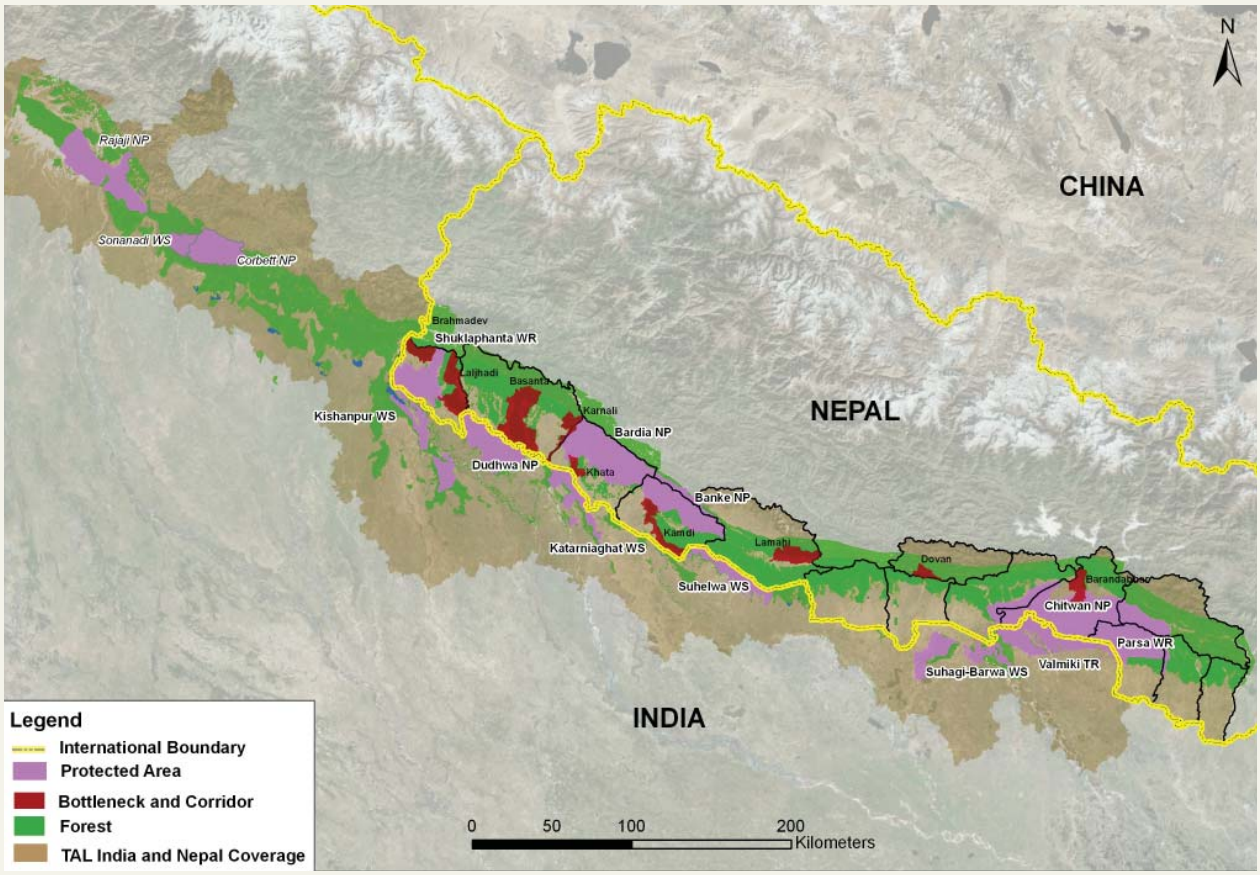


FIGURE 1
Terai Arc Landscape

At the time of its conception, this conservation vision for the TAL was merely an idea on paper and needed a lot of work make it a reality. A feasibility study for the entire TAL was conducted in 2001 by WWF's tiger conservation program. This preliminary study identified potential corridors, described their status and pin-pointed 'bottleneck areas' where forest connectivity was severely compromised. The Government of Nepal endorsed the Terai Arc Landscape Program in 2001 in Nepal, which was a landmark for conservation in the region. In the Indian part of TAL, a more detailed study at landscape scale was conducted by Johnsingh et al. (2004). From that survey, 9 tiger habitat blocks (THBs) were identified in the Indian part of TAL, which were pooled into five larger tiger units (TUs) using connectivity through forests.

While the conservation strategy envisaged for the TAL is centered on habitat and connectivity (see Wikramanayake et al., 2004; Johnsingh et al., 2004), there is a general consensus that there is an urgent need to extend conservation efforts and

CONSERVATION VISION FOR THE TERAI ARC LANDSCAPE

By the late 1990s it was becoming clear that conserving tigers in protected areas which were becoming increasingly isolated from surrounding forest patches was not an adequate strategy in itself. At this time, the Save the Tiger Fund (STF) commissioned World Wildlife Fund (WWF) and Wildlife Conservation Society (WCS) to develop a new paradigm for tiger conservation. The outcome was the identification of a suite of prioritized Tiger Conservation Units. TCUs are habitat blocks across the tiger's global range that likely hold the best hope for recovering and securing tiger populations at the scales necessary to conserve tigers. This shift from the business as usual approach of protecting tiger populations in protected areas to a landscape level approach required connecting the protected areas through corridors to allow tigers to disperse between the protected areas that served as refuges for breeding tiger populations. Maintaining habitat connectivity and affording protection to tigers both within and outside protected areas would allow the refuge populations to be managed as meta-populations. This paradigm served not only to selectively conserve tiger populations within key protected areas, but also to ensure their persistence at landscape and regional scales by facilitating ecological and behavioural characteristics such as dispersal, and hence enhancing demographic and genetic viability.

The TCU analysis originally identified six units across south-central and western Nepal and north-western India. The units were large blocks of tiger habitat that were separated from one another by degraded habitat that was likely a barrier to tiger dispersal. During the global tiger conservation strategy meeting held in Java, Indonesia in September 1999, it was agreed that conservation efforts should be focussed on creating habitat connectivity between these six TCUs by restoring forest habitats to facilitate dispersal. This would result in a large and connected landscape extending from Nepal's Bagmati River in the east to India's Yamuna River in the west. This landscape was named the Terai Arc Landscape (Figure 1).

protect all the forest patches of the landscape (both inside and outside PAs). In addition to serving as important habitats for the region's wildlife, conserving forest outside protected areas and restoring degraded forests will ensure the continued provisioning of fuel-wood and other forest resources for millions of forest-dependent people who live in and around TAL's forests.

1.2 MOTIVATION FOR COORDINATED MONITORING AND JOINT REPORTING

Though regular tiger monitoring programs have been institutionalized in both Nepal and India, there has been very little formal collaboration or data sharing to date between the two countries. As a result, there has been a paucity of information on the actual status of corridors that lie along the international border and their use by tigers and other large mammals. In order to develop a better understanding of the distribution, abundance and movement of tigers in this transboundary landscape and develop effective conservation strategies, coordinated surveys were planned and implemented in the transboundary TAL. Several consultative meetings involving the

two governments and their NGO partners were organized to streamline and coordinate a joint tiger survey in 2013, and to promote other collaboration for conservation.

This report presents findings on the status of tiger population in the trans-border Terai Arc Landscape (TAL). It provides the most comprehensive information to date on the status, distribution and movement of tigers in a large portion of the Terai Arc Landscape. Estimates of prey populations have also been included where available. The survey was made possible by the cooperation and shared vision for conservation among the Governments of India and Nepal, and organizations and agencies that partnered in the monitoring exercise, namely WWF Nepal, WWF-India, National Trust for Nature Conservation (NTNC) and the state forest departments of Uttar Pradesh and Bihar in India, along with National Tiger Conservation Authority (NTCA) of the Government of India and Wildlife Institute of India.

OBJECTIVES

Objectives of the coordinated surveys were:

1. To estimate tiger abundance and density in protected areas and other tiger habitats in the trans-border Terai Arc Landscape
2. To estimate prey density in protected areas and other tiger habitats in the trans-border Terai Arc Landscape
3. To identify individual tigers which occupy forests in both India and Nepal, and delineate functional corridors, and corridors that have been severed and need restoration.
4. To identify opportunities and challenges for transboundary conservation and make specific recommendations for future action.

2. STUDY AREA

The focal area of this study, the transboundary TAL, extends from the Bagmati River in the east to the Mahakali River (Sharda River in India) in the west. Within this region, there are five tiger bearing protected areas in Nepal: Parsa Wildlife Reserve, Chitwan National Park, Banke National Park, Bardia National Park and Shuklaphanta Wildlife Reserve; and seven protected areas in India: Valmiki Tiger Reserve, Sohagibarwa Wildlife Sanctuary, Suhelwa Wildlife Sanctuary, Katerniaghat Wildlife Sanctuary, Dudhwa National Park, Kishanpur Wildlife Sanctuary and Pilibhit Tiger Reserve (formerly Pilibhit Reserve Forest) (Figure 2). These PAs lie along the international border and are connected via several north-south forest corridors that extend between the two nations (Table 1). On the 600 km long international border in TAL, 250 km have forested habitat located in PAs and surrounding forest.

TABLE 1
Transboundary Protected Areas in Nepal and India in the Terai Arc Landscape

Sl. No.	Site	Nation	IUCN category	Area (km^2)	Year of establish-ment	Charismatic large mammals	Total no. wild mam-mal species (based on camera trap results)	Elevation (m)	Physiography and habitat types
1.	Parsa WR	Nepal	II	499	1984	Tiger, leopard elephant, gaur, dhole	29	435-950	Shivalik, Bhabar and Terai
2.	Chitwan NP	Nepal	II	932	1973	Tiger, leopard, rhino, elephant, gaur, dhole	35	150-815	Shivalik, Bhabar and Terai
3.	Valmiki TR	India	II	901	1994	Tiger, leopard, rhino, gaur, dhole	27	140-874	Shivalik, Bhabar and Terai
4.	Banke NP	Nepal	II	550	2010	Tiger, leopard and elephant	29	153-1247	Shivalik, Bhabar and Terai
5.	Sohagibarwa WR	India	II	482	1987	Tiger, leopard	No survey	94-106	Bhabar and Terai
6.	Suhelwa WR	India	II	636	1988	Tiger leopard, dhole	25 (based on sign survey)	106 - 261	Bhabar and Terai
7.	Bardia NP	Nepal	II	968	1984	Tiger, leopard, rhino, swamp deer and elephant	34	150-1441	Shivalik, Bhabar and Terai
8.	Katerniaghat WS	India	II	400	1975	Tiger, leopard, rhino and elephant	22	126 - 183	Terai
9.	Dudhwa NP	India	II	680	1977	Tiger, leopard, rhino and elephant	28	134 - 214	Terai
10.	Kishanpur WS	India	II	227	1972	Tiger, leopard and swamp deer	25	151- 195	Terai
11.	Pilibhit TR (for-merly RF)	India	II	1074	2014	Tiger, leopard and swamp deer	25	164 -226	Terai
12.	Shuklaphanta WR	Nepal	II	305	1976	Tiger, leopard, rhino, elephant, swamp deer	20	174-1386	Shivalik, Bhabar and Terai
13.	Nandhaur WS and Brahmadev corridor	India	II	260	2013	Tiger, leopard and elephant	29	275 - 175	Shivalik, Bhabar and Terai

TABLE 2

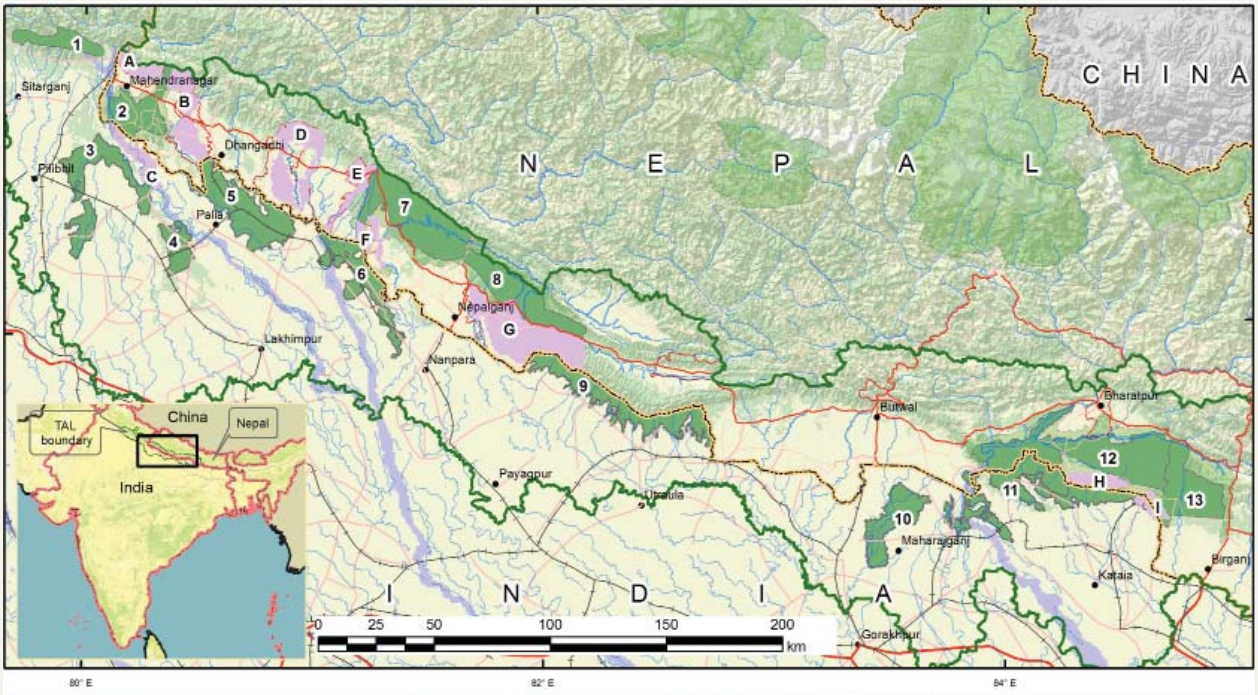
Transboundary corridors in Nepal and India in the Terai Arc Landscape

Sl.N	Corridor/Reserve Forest/National Forest	Sites connected by corridor	Corridor habitat/ land use (riparian, forest, agriculture/ settlement)	Species using corridor (mega-fauna)	Status of corridor (habitat contiguity, recorded use by tigers in last two years)	Major threats
1.	Boom-Brahmadev	Nandhaur and Shuklaphanta	Forest and agriculture	Leopard, elephant	Occasionally used	Grazing, encroachment, proposed border road in India.
2.	Laljhadi	Dudhwa and Shuklaphanta	Forest	Elephant	Occasionally used	Grazing, encroachment, extensive human use, proposed border road in India.
3.	Basanta	Dudhwa and Churia forest contiguous with Bardia	Riparian, forest, agriculture/settlement	Tiger, rhino, elephant	Occasionally used	Grazing, encroachment, resource extraction, Hulaki road construction and proposed border road in India.
4.	Laggabagga-Tatarganj	Pilibhit TR and Shuklaphanta WR	Forest and riparian	Tiger, rhino, elephant	Frequently used	Grazing and high human presence in forests, proposed border-road in India
5.	Karnali	Bardia NP and Katerniaghat WS	Riparian	Tiger, rhino, elephant	Frequently used	Grazing, encroachment, resource extraction including sand/gravel mining, Hulaki road construction, proposed border road in India.
6.	Khata	Bardia NP and Katerniaghat WS	Forest and riparian	Tiger, rhino, elephant	Highly functional community managed corridor	Grazing, encroachment, resource extraction, Hulaki road construction, proposed border road in India.
7.	Kamdi	Suhelwa WS and Banke NP	Forest and riparian	Tiger, elephant	Occasionally used	Grazing, encroachment, resource extraction, Sikta irrigation canal, proposed border road in India
9	Thoria corridor	Parsa WR and Valmiki TR	Agriculture/settlement	Elephant	Frequently used	Encroachment and infrastructure development
10	Someshwor forest	Chitwan NP and Valmiki TR	Forest	Tiger, leopard, elephant	Frequently used	Grazing/fire/encroachment/ resource extraction

2.1 PROTECTED AREAS IN THE TRANSBOUNDARY TAL

2.1.1 Parsa Wildlife Reserve (PWR)

PWR (N: 27.1330 to 27.5498; E: 84.6581 to 85.0245) is located in the south central lowland of Nepal (Figure 2) and covers an area of 499 km². It occupies parts of Chitwan, Makwanpur, Parsa and Bara districts of Nepal and is contiguous with Chitwan National Park in the west and Valmiki Tiger Reserve in the southwest via Chitwan forest and therefore provides potential habitat for dispersing tigers from Chitwan NP.



Symbol	PA name	Symbol	PA name
1	Nandhaur WLS	8	Banke NP
2	Shuklaphanta WR	9	Suhelwa WLS
3	Pilibhit TR (Formerly FD	10	Sohagibarwa WLS
4	Kishanpur WLS	11	Valmiki TR
5	Dudhwa NP	12	Chitwan NP
6	Katerniaghat WLS	13	Parsa WR
7	Bardia NP		

Symbol	Corridor	Symbol	Corridor
A	Boom-Bhrahmadev	F	Khata
B	Laljhadi	G	Kamdi
C	Laggabagga-Tatargunj	H	Someshwor
D	Basanta	I	Parsa Valmiki
E	Karnali		

Legend

- TAL Protected Areas
- Corridors
- Rivers
- TAL boundary
- International boundary
- Major city/towns
- Railway
- Highway
- Metalled roads
- Other roads

FIGURE 2
Protected areas and corridors in Transboundary TAL

2.1.2. Chitwan National Park

Chitwan NP (N: 27.2836 to 27.7038; E: 83.8457 to 84.7472) has an area of 932 km² and is situated in south-central lowland Terai (Figure 2). It was gazetted as Nepal's first national park in 1973 and is a UNESCO World Heritage Site. The Chitwan NP is contiguous with PWR to the east and Valmiki Tiger Reserve to the south, forming the Chitwan-Parsa-Valmiki Tiger Conservation Landscape. This landscape forms a level I Tiger Conservation Unit and supports one of the largest tiger populations in South Asia (Wikramanayake et al., 1998; Dinerstein et al., 2007). The Rapti, Reu and Narayani rivers flow through the park and form the northern, southern and western boundary of the park respectively.

2.1.3. Valmiki Tiger Reserve

Valmiki TR (N: 27.1667 to 27.50000; E: 83.8333 to 84.1667) has an area of 901 km². The only tiger reserve of Bihar State, India, VTR is located in the extreme north-eastern corner along the international border with Nepal (Figure 2) in West Champaran district. In the west the reserve is bounded by the Gandak River. It is contiguous with Nepal's Chitwan National Park to the north, sharing a boundary of approximately ~100 km along which is forested habitat. It is also tenuously connected with Sohagibarwa Wildlife Sanctuary in Uttar Pradesh, India.

2.1.4. Sohagibarwa Wildlife Sanctuary

Sohagibarwa WLS (N: 27.27143 to 27.17232; E: 83.82282 to 83.44178) covers an area of 482 km². The Sanctuary is located in Maharajganj District of eastern Uttar Pradesh in India (Figure 2) and is a major visitor place in the district. The sanctuary sometimes acts as corridor for wildlife between PAs of Nepal and India. The Sanctuary is connected with the western part of Valmiki Tiger Reserve.

2.1.5. Banke National Park

Banke NP (N: 27.9686 to 28.3384; E: 81.6603 to 82.2054) was declared as Nepal's tenth national park in 2010. It covers an area of 550 km² and is surrounded by a buffer zone of 344 km², in the districts of Banke, Salyan and Dang. It is bordered by two rivers, Rapti and Babai. Contiguous to Bardia National Park in the west (Figure 2), Banke NP provides additional habitat for breeding tigers to support the Nepal Government's commitment of doubling tiger numbers by 2022 (DNPWC, 2009; NTRP, 2010). Banke National Park is connected with Suhelwa Wildlife Sanctuary via national and community forests in Nepal.

2.1.6. Suhelwa Wildlife Sanctuary

Suhelwa WLS (N: 27.8723 to 27.5594; E: 81.9259 to 82.7431) has an area of 636 km². The Sanctuary lies in Balrampur and Shravasti districts of eastern Uttar Pradesh, India (Figure 2). Along its north-south axis the forests are narrow (3-7 km wide), and the habitat is part-Bhabar, part Terai. The northern boundary of Suhelwa (about ~100 km in length) lies on the Indo-Nepal border, and the forests of Suhelwa are contiguous with forests in Nepal along this border. The western flank of the sanctuary is connected with the newly created Banke National Park through a corridor in Nepal.

2.1.7. Bardia National Park

Bardia NP (N: 28.2630 to 28.6711; E: 81.1360 to 81.7645) covers an area of 968 km² and is located in the mid-western lowlands in Bardia and Banke districts, Nepal (Figure 2). The park comprises two distinct units, the Karnali floodplain and the Babai valley. The former is situated in the western part of the park and is a biodiversity hotspot with a large mammalian assemblage. The Babai river valley extends from Parewaodar to Chepang and is a wilderness zone comprised of alluvial grasslands and forests, covering more than 50% of the park.

2.1.8. Katerniaghat Wildlife Sanctuary

Katerniaghat WLS (N: 28.365699 to 28.151679; E: 81.036230 to 81.364464) covers an area of 400 km² located in the Upper Gangetic Plain in the Terai in Bahraich District, Uttar Pradesh, India (Figure 2). It is connected with Bardia National Park via the Khata corridor in Nepal. The Girwa (Karnali) river and a major canal flow through this sanctuary, which is a part of Dudhwa Tiger Reserve. Other areas of the sanctuary are disturbed because the narrow forest is dissected by a railway line and several roads.

2.1.9. Dudhwa National Park

Dudhwa NP (N: 28.3000 to 28.7000; E: 80.4667 to 80.9500) covers an area of 680 km². The park is located in Lakhimpur Kheri District of Uttar Pradesh, India (Figure 2). The park has a number of large wetlands and alluvial grasslands. Historically, this park was famed for its Sal timber, and later as a premier hunting area. Dudhwa NP is a part of Dudhwa Tiger Reserve.

2.1.10. Kishanpur Wildlife Sanctuary

Kishanpur WLS (N: 28.453158 to 28.229001; E: 80.340415 to 80.471578) straddles Gola Tehsil in Lakhimpur District and the Powayan Tehsil in Shahjehanpur District in Uttar Pradesh, India (Figure 2). It lies on the southern side of the Sharda river and covers an area of 227 km². The area of the Sanctuary was once part of the South Kheri Forest Division, and the Sharada River flows along a section of its eastern boundary. This site is also a constituent area of Dudhwa Tiger Reserve, and is connected with South Kheri Forest Division.

2.1.11. Pilibhit Tiger Reserve (formerly Forest Division)

Pilibhit Tiger Reserve (N: 28.8667 to 28.7667; E: 79.9167 to 82.2500) covers an area of 1074 km² and is located in Pilibhit District of Uttar Pradesh, India (Figure 2). It is connected with the terai-bhabar forests of the Surai range in the Terai East Forest Division (FD) in the north-west, and with Kishanpur WLS in the south-east. This reserve also provides connectivity to Shuklaphanta Wildlife Reserve, and with Kishanpur WLS in India, through the Lagga-Bagga forest block, and Tatarganj area of North Kheri FD.

2.1.12. Shuklaphanta Wildlife Reserve

Shuklaphanta WR (N: 28.7193 to 29.0515; E: 80.0609 to 80.4120) covers 305 km². Located in the far-western lowland of Nepal (Figure 2) it is bordered by the Chaudhar river to the east and Mahakali river to the west. It is connected with two tiger reserves in India: Pilibhit and Dudhwa in the south via narrow links of Churia forests and the Laljhadi and Basanta corridors; and the eastern part of Indian Terai Arc Landscape across Mahakali River through the Brahmadev corridor.

2.1.13. Nandhaur Wildlife Sanctuary

Nandhaur WLS (N: 29.191 to 29.046; E: 79.675 to 80.032) covers 260 km² in the State of Uttarakhand, India (Figure 2) and was created in 2012. Located in the Bhabar zone and the lower Himalayas, the sanctuary contains steep mountains and rocky valleys with montane and lowland deciduous forests. Nandhaur WLS shares boundaries with Haldwani, Champawat and Terai East Forest Divisions in India and the Brahmadev forests across the Sharda (Mahakali) river in Nepal. Connectivity between Nandhaur and the Corbett Forest complex to the West and the Pilibhit-Kishanpur Forest Complex to the south is thought to have been severely disrupted by land use changes in recent decades.

2.2 VEGETATION TYPES

According to Dinerstein (1979), Terai vegetation is sub-tropical and can be broadly classified into six major types. These are listed below, along with other vegetation communities in transboundary TAL.

2.2.1. High Density Sal forest

More than 70% of the Terai forest is dominated by Sal (*Shorea robusta*), a Dipterocarp species dominant in the region's climax-stage forests. Common Sal associates are *Buchnania latifolia*, *Terminalia arjuna, T. latifolia, Dillinia pentagyna* and *Lagerstromia parviflora*. The understorey comprises primarily of *Clerodendron viscosum, Colebrookia oppositifolia, Callicarpa macrophylla, Flemengia* spp, *Phylanthus* spp and *Pogostemon bengalensis*.

2.2.2. Hill Sal forest

Hill Sal forest occurs along the southern slopes of the Shivaliks to the north, mostly in Nepal. The major dominant tree species in Hill Sal Forest are *Shorea robusta*, *Terminalia alata*, *Careya arborea, Buchanania latifolia, Lagerostroemia parviflora*, *Semicarpus anacardium* and *Syzygium cumini.*

2.2.3. Riverine forests

Forests on flood plains and riverine alluvium along the major river systems of the Terai belt primarily contain *Acacia catechu* and *Dalbergia sissoo,* which withstand flooding and are early woody colonizers of grassland vegetation during the process of natural succession. Riverine forests occur along the banks of the Rapti, Reu, Pandai, Manor, Pachnand and Narayani (Gandak in India) rivers in eastern TAL; Khauraha, Karnali (Geruwa in India), Babai, Rapti and Bheri rivers in central TAL; and Mahakali (Sharda river in India), Mohana and Suheli rivers including several rivulets of these river systems in the western portion of TAL. Moist riverine forests are also characterized by evergreen tree species such as *Ficus racemosa, Cassia fistula, Syzygium cumini* and *Mallotus philippensis.* Other tree species associated with riverine vegetation include

Ehretia laevis and *Trewia nudiflora* along with a shrub layer of *Murraya koenigii, Callicarpa macrophylla, Coffia* spp. and *Colebrookia oppositifolia.*

2.2.4. Mixed hardwood forests

The Terai has several belts of mixed hardwood forest dominated by *Shorea robusta, Bombax ceiba, Mallotus philippensis, Adina cordifolia, Lagerstroemia parviflora* and *Dalbergia sissoo*. The understorey layer is dominated by coarse grasses such as *Imperata cylindrica, Erianthus ravennae* and *Vetiveria zizanioides*. This vegetation differs from wooded grassland on the basis of the remarkable tree density and the conspicuous shrub layer dominated by *Colebrookia oppositifolia, Pogostemon plectranthoides, Clerodendron viscosum* and *Murraya koenigii* (Dinerstein 1979).

2.2.5. Grasslands and Phantas

There are three types of grassland in TAL: tall floodplain grassland, open grassland and wooded grassland. These vegetation types are at different successional stages and under certain conditions will progressively change into shrub lands, woodlands and forest.

2.2.5.1. Tall floodplain grassland

The floodplain grasslands are established and maintained as a secondary seral stage as a result of monsoon flooding and other fluvial actions (Dinerstein 1979). Prominent species of the tall grass community are *Saccharum spontaneum*, *Narenga porphyrocoma*, *Themeda arundinacea* and *Phragmitis karka*. These riparian grasslands provide good habitat for hog deer.

2.2.5.2. Open grasslands

Areas that were previously cultivated fields often develop into "*phanta*" grasslands. Several villages were relocated when Nepal hunting reserves were upgraded to national park or wildlife reserve status. *Phantas* include: Baghaura, Khauraha, Lamkauli, Sanoshree, Thuloshree, Chepang and Guthi in Bardia NP; Rambhori in Parsa WR; Padampur in Chitwan NP; and Hirapurphanta in Shuklaphanta WR. Some grasslands of this type are also found near Kishanpur village in Kishanpur WLS and in the portions of Dudhwa National Park and Pilibhit Forest Division. The dominant grass species in *phantas* are *Imperata cylindrica*, *Desmostachya bipinnata*, *Arundo donax, Phragmites karka, Cymbopogon* spp, *Eragrostis* spp and *Sporobolus* spp.

2.5.3. Wooded grasslands

This type of vegetation is defined by sparsely-distributed *Bombax ceiba* (silk cotton) and associated tree species, with various grasses in the under storey. The role of *Bombax ceiba* in the succession patterns of this particular habitat is of utmost importance since it is resistant to fire, grazing and flooding, the three important factors which play the role in shaping the vegetation composition in Bardia NP (Dinerstein 1979), and other flood-prone areas in the Terai. Associated tree species that occur sporadically in such grasslands include *Shorea robusta, Bombax ceiba, Mallotus philippensis, Adina cordifolia, Lagerstroemia parviflora* and *Dalbergia sisso*. The understorey layer is

dominated by the coarse grasses such as *Imperata cylindrica, Erianthus ravennae* and *Vetiveria zizanioides*.

2.2.6. Cane Brakes

Cane (*Calamus tenuis*) occurs in dense thorny tangles that often grow up to the trunks of trees, particularly in water-logged areas and along river courses. Such forest is found in the western flank of Valmiki Tiger Reserve along the various tributaries of Gandak River, along the Girwa River in Katerniaghat WLS, and in the Sathiyana Range of Dudhwa NP.

2.2.7. Plantations

In each of the PAs and Reserve Forests in the transboundary TAL in India, several hundred hectares of plantation have been established. Plantations are primarily even-age stands of teak (*Tectona grandis*) or *Eucalyptus* spp, and more occasionally *Dalbergia sissoo, Terminalia* and *Syzygium cumini*. Although the planting of such species has been discontinued in PAs, plantations continue to be actively managed and promoted in Reserve Forests such as Pilibhit and South Kheri Forest Division in India and in some community managed forests in Nepal.

2.3 LAND USE AND MANAGEMENT PRACTICES

This section outlines historical and current land use and management practices for the TAL in each country.

2.3.1. TAL Nepal

Prior to the 1950s forests in Nepal Terai were continuous in their extent from east to west and were popularly known as *charkose jhadi* (miles of forest). These forests were maintained as a defensive frontier to deter invasion from British India during 19th and 20th centuries (Basnet, 1992). The Terai forests were also famous as hunting grounds of the ruling class and visiting dignitaries; several anecdotal records talk about the large-scale hunting expeditions in Nepal (Smythies, 1942). Historical records of King George-V's imperial visit to Nepal in 1991 detail a hunting expedition when as many as 39 tigers were killed over a week long period. However, after the malaria eradication in the Terai region, followed by a government resettlement program, large tracts of Terai forest were cleared and almost 100,000 ha converted for other land uses between 1978 and 1991. This translates to an annual deforestation rate of 1.3% (MFSC, 2010). Rampant poaching has also taken a heavy toll on wildlife in the Terai.

Realizing the urgency to protect wildlife, the National Park and Wildlife Conservation Act, 1973 was enacted, which envisioned the creation of national parks and other protected areas. Chitwan National Park (CNP) was established as the country's first national park in the same year. This Act also led to the creation of the Department of National Parks and Wildlife Conservation (DNPWC). DNPWC manages three types of protected areas in the Terai: national parks, wildlife reserves, and their buffer zones

and a conservation area that together cover approximately 14% of the land in Nepal's Terai region. Management in the core areas is regulated by DNPWC and protection is provided by the Nepal Army in collaboration with park staff (Appendix III). With regard to access of local human populations to forest resources, each park/reserve has its own specific set of regulations that has been endorsed by the government. Some parks grant access to local people for certain periods each year to collect grass and thatch. A number of buffer zone forests are managed by buffer zone community forest user groups (to whom such areas are handed over for management by the government). In these areas communities have access to fuel-wood, fodder and timber based on buffer zone community forest operational plans. In addition 30-50% of a park's annual revenue is provided to the buffer zone communities through the buffer zone management council and buffer zone user committees.

Other forests outside protected areas in Nepal are managed by the Department of Forests under six different categories: government managed forest (national forest), protection forest (corridor forest in Terai), leasehold forest, collaborative forest, religious forest and community forest. Community forests are the forests handed over to community forest users groups (CFUGs) by district forest offices for development, protection, utilization and management of natural resources (Appendix III).

2.3.2. TAL India

TERAI ARC LANDSCAPE IS POPULATED BY **8,048,006** PEOPLE WITH A POPULATION DENSITY OF 346.91 PEOPLE PER KM^2

In British India, forestry operations were well established in Kheri, Pilibhit and Bhariach districts by the last quarter of the 17th century. In their aspiration to administer the Terai more efficiently and make it productive, the British encouraged settlement and provided incentives to people to move into the Terai and clear its forests to establish farmland. At the time of India's independence large patches of forest had already been cleared, and existing forests were under the management regime of the government's Forest Service, guided by lengthy working plans. For the first three decades following India's independence the government continued to actively settle migrants in the Terai, and with the aid of bulldozers and modern insecticides, they 'sanitized' the Terai and transformed large portions of wilderness into a productive agricultural belt. Tigers were hunted as a sport through the imperial period and for about two decades after independence. While there is little evidence of large-scale loss of forest cover in the Terai following India's independence in 1947, it is evident that extensive patches of swamp and primary-succession riparian habitats along streams and rivers have been drained and converted into agricultural areas. With this land conversion and growing human settlements, connectivity between several prominent forests in India such as Dudhwa, Kishanpur-Pilibhit and Katerniaghat via riparian tracts and grasslands was lost by the 1980s.

In India, forests in the Terai are managed either as protected areas (tiger reserves, national parks and sanctuaries) or as reserve forests. While protected areas are designated as exclusive zones for the preservation of wildlife, reserve forests permit extraction of some forest resources by the public, and government sanctioned selective felling of Sal and other trees. Protected areas comprise core and buffer zones, and while core zones are largely out-of-bounds for local populations and tourists, buffer zone forests are used extensively by local populations, primarily for extraction of fuel-wood and fodder. The management of each protected area (protection, habitat management,

tourism and community rights) is guided by a management plan that is periodically updated (Appendix III). Eco-development committees (EDCs) involving collaboration between Forest Department and forest dependent village communities have been created in the tiger reserves. However, in many areas these EDCs do not function as envisioned, and there is thus limited community involvement in conservation and forest management.

2.4 SOCIO-ECONOMIC

Originally the only indigenous communities living in Terai were Tharu and Buxa. Today, on the Nepal side communities also include Madhesi, Brahmin, Chettris, Magars and Gurung. In India, in addition to the indigenous Tharu communities, there are many other groups including Sikh, Bengalis and migrants from other areas. The Nepal portion of the TAL is populated by 8,048,006 people with a population density of 346.91 people per km^2 (CBS, 2011). The population in TAL Nepal has increased by 126% since the 1980s, with an annual growth rate of 3.15% (CBS, 2011). Another 20 million people reside in TAL India, where the population has increased by as much as 54.2% which is 9% above the national average (WWF-India, 2014). The average annual income for a person is US $100.

Forests are used extensively for livestock grazing and also for fodder and fuel wood collection. The majority of people rely on fuel wood as their main source of energy for cooking, i.e. 61% and 93% of households in TAL-Nepal and TAL-India respectively (WWF-India, 2014). Animal husbandry is integral to the livelihoods of communities practicing subsistence agriculture. The livestock population in TAL Nepal is 3.5 million as per the most recent census (CBS, 2011). In TAL India, Uttar Pradesh has a livestock population of approximately 3.5 million, and in West Champaran district of Bihar there are about 810,000 livestock (www.indiastats.com, 2011 livestock census).

2.5 INSTITUTIONAL SETUP FOR TIGER SURVEY

The following sections describe the institutional arrangements for the survey in each country.

2.5.1. Nepal

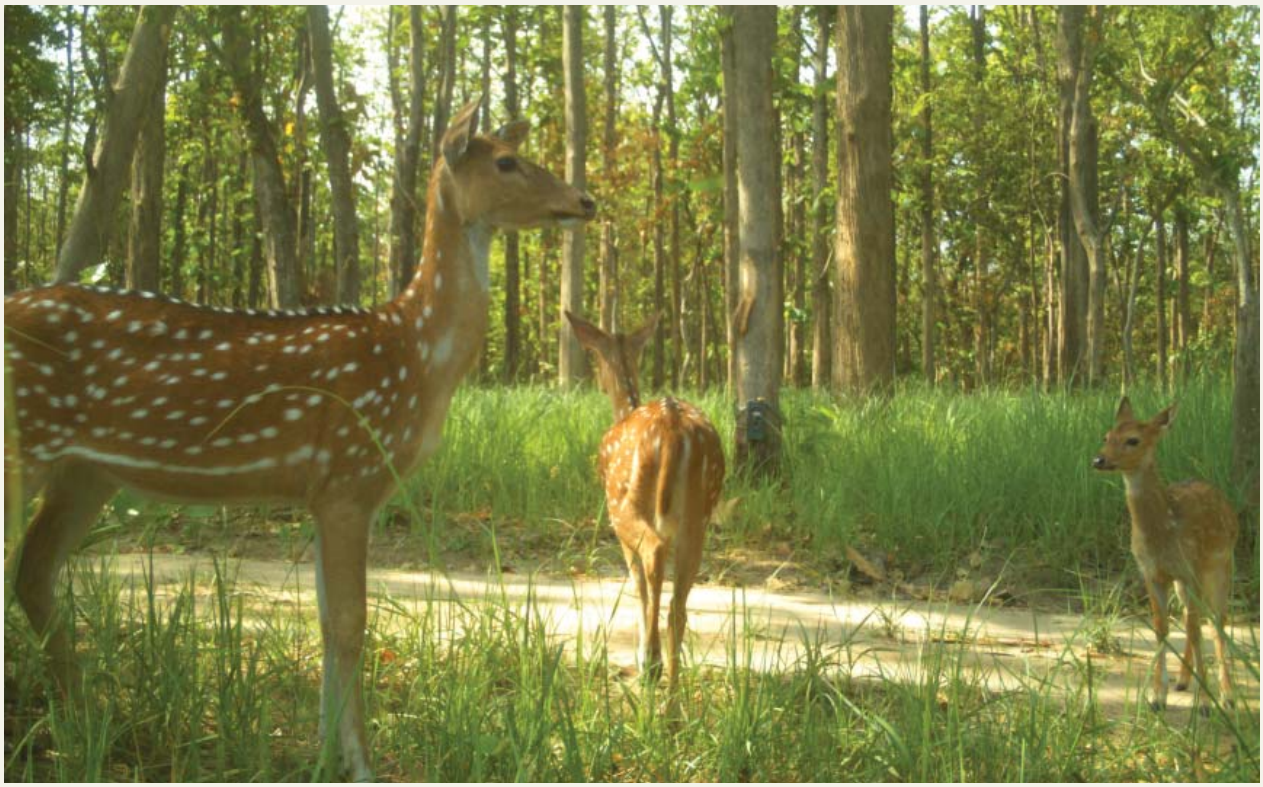
Under Nepal's nationally approved tiger monitoring protocol, the tiger survey was planned to establish monitoring standards and implement the first of a series of four-yearly surveys. The Fourth National Tiger Coordination Committee (NTCC) meeting chaired by the Prime Minister formally endorsed the 2013 national tiger and prey monitoring in Nepal. The survey involved formation of advisory and technical committees at the central level and field task forces at each protected area level. The advisory committee played an overall counselling role, and comprised the Director General, DNPWC, Member Secretary of the National Trust for Nature Conservation (NTNC), and the Country Representative, WWF Nepal. The technical committee, comprising the Ecologist of DNPWC, Under Secretary of DoF and Biologists from WWF Nepal and NTNC, co-ordinated and facilitated all planning and implementation

of the field work. WWF Nepal Biologists were an integral part of designing the study. The field task force was led by the Chief Conservation Officer of each protected area, and Biologists from WWF Nepal and NTNC. Outside protected areas, District Forest Officers were the focal persons for co-ordinating the tiger occupancy survey. This team took responsibility for training field personnel, mobilizing the field operation, and overall monitoring and supervision of the survey. The database was maintained at NTNC field offices and centrally at NTNC, WWF Nepal and DNPWC.

2.5.2. India

Sampling in the tiger reserves was carried out broadly adhering to the guidelines of the National Tiger Conservation Authority, New Delhi for phase IV monitoring, or the intensive monitoring of 'source' populations (NTCA, 2012). In non-PA areas, surveys were part of the on-going conservation and monitoring programs of WWF-India. The Forest Departments of Uttar Pradesh and Bihar were partners in these surveys and extended permits and provided logistical support. The Chief Wildlife Wardens of each state, and the Field Directors and Deputy Directors of the parks were nodal officers from the Government of India. The surveys in UP were designed by researchers from WWF-India, in collaboration with Biologists from Colorado State University, and the Wildlife Institute of India. Fieldwork was carried out by a WWF-India team, which was aided by field staff of the State Forest Departments.

More recently, identities of individual tigers from both countries have been integrated into the WII-NTCA tiger database (http://projecttiger.nic.in/whtsnew/Protocol_Camera_trap.pdf).



3. FIELD METHODS

3.1. TIGER HABITAT OCCUPANCY

A tiger habitat occupancy survey was conducted across TAL Nepal covering all potential tiger habitats. Ninety-six grid cells, each 15 x 15 km², were laid across TAL from Rautahat in the east to Kanchanpur in the west (Figure 3). Fifty-three grid cells fell outside PAs and buffer zones; the rest were inside.

The field team walked transects along trails, roads, ridgelines, and river and stream beds searching for tiger signs (scats, scrapes, pugmarks, kills and urination sites); prey signs (dung, footprints, calls, sightings); and signs of human disturbance (wood cutting, lopping, grazing, poaching, etc.) in the area. Data were recorded every 100 m along the transects, giving a total sampling effort of 2,319 km. The field work started on 5th February in Kanchanpur and ended on 5th April, 2013 in Rautahat.

FIGURE 3
Tiger habitat occupancy survey design, Terai Arc Landscape Nepal

In India, the most recent occupancy surveys in TAL were done in 2010, and involved a survey of 60 cells (166 km²) lying between and including Nandhaur WLS and Suhelwa WLS (Chanchani et al., unpublished report). Similar to Nepal, cells were intensively sampled by observers on foot who searched for tiger signs. Surveys used two groups of independent observers for each cell, and the cumulative survey effort was approximately 2000 km. Details of occupancy surveys in other areas of TAL India are documented in Jhala et al. (2008 and 2011).

3.2. TIGER POPULATION ESTIMATION

The estimation of population parameters such as abundance (N) and density (D) forms an integral part of wildlife monitoring programs. In the case of the tiger which is an elusive species, and has unique identification patterns in individual animals, photographic capture-recapture is a reliable method for estimating population

abundance. Capture-recapture models provide a statistically robust framework for this, particularly when a population is said to be closed to births, deaths and the immigration or emigration of animals during the survey period (Karanth and Nichols, 2002).

3.3. CAPTURE-RECAPTURE SAMPLING FOR TIGERS

Tiger populations were sampled with camera traps distributed in ca. 9000 km² of the Shivalik, Bhabar and Terai habitats across the transboundary Terai Arc Landscape. Our sampling was determined by the size of the protected area (PA), availability of camera units and field personnel, other logistical constraints, and study design (Karanth and Nichols, 2002). Because large areas were sampled, camera trapping was conducted in shifting blocks (similar to Royle et al., 2009a) in each PA including the surrounding forests which were divided into 3-4 blocks. Pairs of cameras were placed in a total 1,804 locations, in 12 protected areas and reserve forests along the border between the two nations (Table 3 & Appendix IV). To maximize spatial coverage and achieve a near-uniform distribution of camera traps, we placed camera traps in most cells of a 2x2 km grid overlaid on a map of the study region. In each station, two cameras were placed facing each other at a height of 45 cm above ground and were mounted on trees or posts on either side of a forest trail or road, with a distance of 6-8 m between the two cameras. Camera trap sampling was carried out in the period between December 2012 and June 2013.

PAIRS OF CAMERAS WERE PLACED IN A TOTAL
1,804
LOCATIONS

Sites for camera trap stations were selected on the basis of extensive field surveys for signs of tiger, including pugmarks, scrapes and scats, as well as the presence of water. Detailed site-specific information on camera trapping is presented in Appendix IV. Sign surveys in Suhelwa Wildlife Sanctuary indicated that the area was unlikely to support a resident population of tigers; because of constraints of resources (available camera traps and time) we did not conduct camera trapping in Suhelwa, nor in Nandhaur or Sohagibarwa sanctuaries in 2013.

3.4. SAMPLING EFFORT

Camera trapping was conducted with an intensive effort of 36,266 trap days covering 9111.78 km² across the PAs in transboundary TAL. Six different models of camera were used (Reconyx 500, Reconyx 550, Bushnell Trophy Cam HD, Moultrie, Stealth Cam and Cuddeback Attack).

Nepal: A total of 268 trained personnel affiliated with DNPWC, DoF, NTNC, WWF Nepal, International Trust for Nature Conservation (ITNC), Nepal Army, nature guides, buffer zone user committees and students from various universities were involved in data collection over 17,628 man days. In several sites, sampling was conducted in remote areas with very limited road access.

India: In Uttar Pradesh, field work was carried out by field biologists affiliated to WWF-India. These biologists were aided by field assistants from forest-fringe villages. Staff of the state Forest Department contributed to the monitoring exercise by regular patrolling to protect cameras from theft and vandalism. In Bihar, monitoring was

designed, led and coordinated by field biologists of WWF-India and implemented by staff of Valmiki Tiger Reserve.

3.5. LINE TRANSECT SURVEYS FOR PREY-BASE DENSITY ESTIMATION

Densities of prey species in the protected areas were estimated using variable distance line transect sampling (Buckland et al. 2005). In Nepal, line transects were placed systematically in the camera trapping grid cells, avoiding areas with hilly terrain that were relatively inaccessible. The length of transects varied from 2 to 4 km. GPS locations of the start and end points of each transect were uploaded into a GPS prior to the survey and the straight line was navigated following the actual bearing using a Suunto compass and GPS. Two people surveyed each transect on foot or from the elephant-back between 0630 hrs and 0930 hours, and each were repeated twice. Elephants were used in tall flood plain grasslands. 985 line transects were surveyed across the Terai PAs and the overall sampling effort was 2,470.25 km of transect (Table 4).

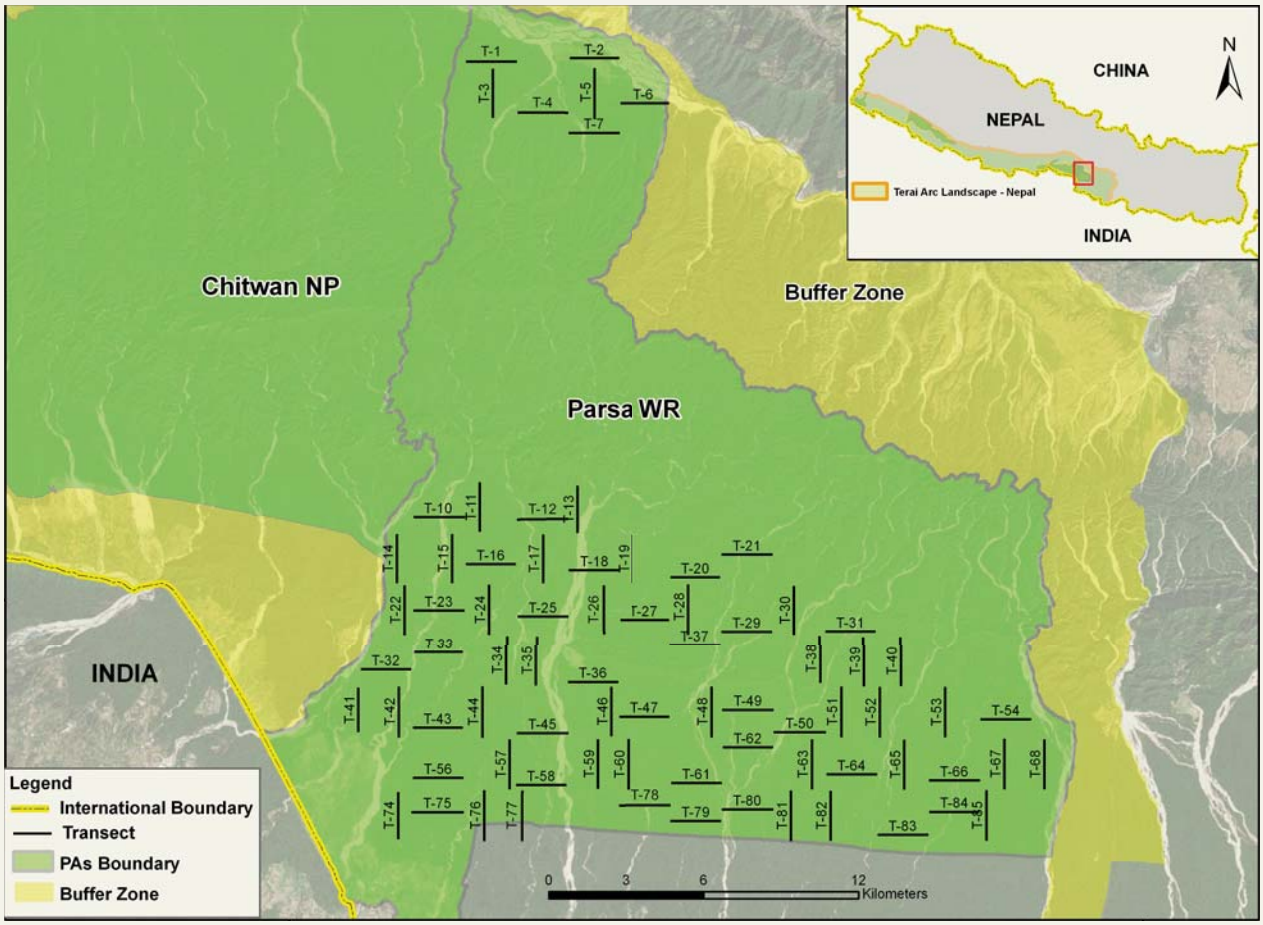


FIGURE 4
Line Transect survey design (Example from Parsa Wildlife Reserve in Nepal)

As a part of WWF's ongoing wildlife monitoring program, line transect sampling was undertaken in Dudhwa Tiger reserve in India. In total, around~ 100 transects were sampled, each 2-4 km long. Lines were marked before-hand and each line was sampled 3-5 times, by 2-3 observers on foot, or on elephant-back in tall grasslands. Transect

lines were placed systematically within major habitat types (strata), represented by grasslands/riparian forests and Sal-dominated forests. Lines were sampled in the morning and evening hours, and records were made of animal attributes (sex, group size), and distances and angles from the observer's location on transect to the animals. The total sampling effort was around~ 900 km.

3.6. DATA ANALYSIS

Individual tigers were identified from the photographs by three observers independently, and capture histories were generated. Only animals that were classified as adults (>2 years old/individuals that had dispersed from natal territories) were included in capture-recapture analysis. We did not perform formal tests for population closure because data used in these analyses are restricted to a maximum period of 60 days for each site. This period is small relative to the life span of a tiger. The spatially explicit capture-recapture models we have employed are thought to address the issue of geographic closure (Royle et al., 2009a).

3.6.1. Tiger Habitat Occupancy

A detection history matrix was generated using field information on presence (1) and absence (0) of tigers in MS-Excel and this information was imported into the program PRESENCE 5.9 (Hines, 2006). This program implements the maximum likelihood approach of site occupancy models developed by MacKenzie et al. (2002). In addition to providing an estimate of site occupancy (proportion of sampled area in which tigers occur) and the detection probability, these models also allow occupancy to be modeled as a function of environmental covariates that were sampled along trails or derived from remotely sensed data. This helps us ascribe underlying causes for observed heterogeneity in site occupancy between sampled cells.

We ran a single season model to estimate the parameters: proportion of area occupied (ψ) and detection probability (p). A number of models were fitted to the observed data with the covariates human disturbances (H), prey (P) and Observer Experience (O), and ranked by their Akaike information criterion (AIC) values to determine the most parsimonious model (Burnham & Anderson, 2002; Hines et al., 2010).

3.6.2 Tiger Population Estimation

Capture-recapture models have proved to be a reliable means of analyzing data from camera traps for large carnivores (Karanth and Nichols 1998). This involves identification of tigers based on their unique stripe patterns; developing a capture history matrix detailing tiger ID, capture location, and sampling occasion over the sampling period; and analysis of capture history data using maximum likelihood or Bayesian estimators.

We report the minimum tiger numbers (Mt+1) from the transboundary TAL area, which is the total number of individual tigers photo-captured from each of the sampled sites. We also present the total 'independent' captures from each site, as well as the total number of males and females photo-captured. For details of parameter estimates for

abundance from closed capture-recapture models, spatially explicit capture-recapture (SECR) models and "super population" (Nsuper) of tigers from Bayesian capture-recapture analyses, please refer to Appendix II.

3.6.3. Tiger Density Estimation

We used SECR models and Bayesian estimators to estimate tiger density (Royle et al., 2013). To define the state space (S) within which activity centers for animals exposed to camera traps are likely to be located, we added habitat buffers to the area that contained the camera trap array. Buffer distances varied between 5 km and 15 km. Where a site sampled with camera traps is embedded in a larger habitat block, the use of large buffers (15 km) helps specify a state space that is large enough to account for the capture of tigers in the camera trap array, even when only a small portion of their territory may lie within the camera trap array region. Potential tiger activity centres were represented by regularly spaced points at 580 m (each point representing an area of 0.3664 km^2) (Gopalaswamy et al., 2012b). Given that a number of these points were located in non-habitat areas (such as settlement or agriculture), we overlaid a land-use map of TAL to delineate habitat (forests and grasslands) which were assigned value 1, or non-tiger habitats (areas of human land use including agricultural and built-up areas) which were assigned value 0.

3.6.4. Prey-base abundance using distance sampling

Line transect data were 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. We used two approaches: a) pooling data for all prey species for fitting global detection function curve; and b) 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.

3.6.5. Identification of common individuals

We visually compared tiger photographs between sites in Nepal and India, to identify animals moving across the border. As a second step, to validate visual identification and append these data to a database, we utilized the software Extract Compare (v1.20) (Hiby et al., 2009) which fits tiger images to a 3D surface model, captures a pattern and encodes it in a binary system (Figure 5). To enter data into this software, users have to 'digitize' the left and right flanks, and hind limbs of tigers. The program then compares stripe patterns in its database of images, identifies putative matches, and assigns a score reflecting the degree of similarity for each pair of pictures. Where the software indicates a 'strong' match, users are required to visually confirm whether or not the images in question are of the same animal. In addition to aiding the process of identifying tigers, the database associated with the program serves as a repository of images which can then be used to record inter-annual survival, dispersal events and movements, and aid law enforcement efforts that seek to determine the origin of seized tiger skins.

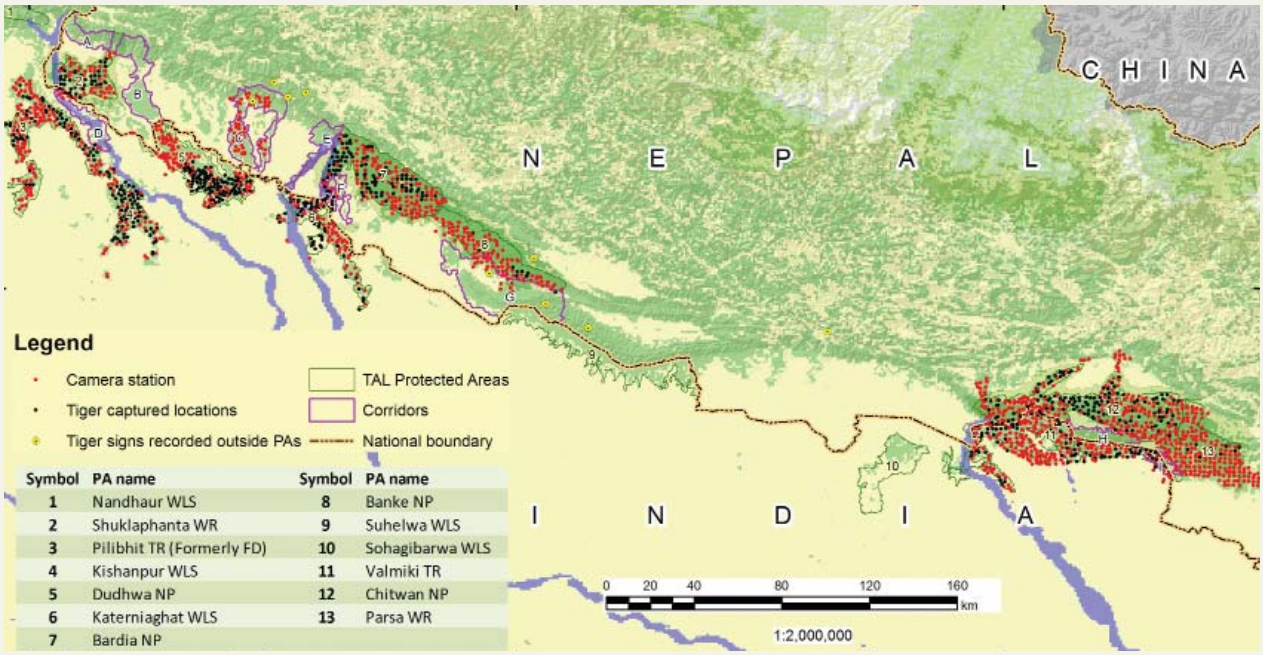
FIGURE 5

Tiger of Chitwan NP (top) and Valmiki TR (bottom) showing 100% match

4. RESULTS

4.1. TIGER DISTRIBUTION

Tigers were captured from 675 locations (37%) out of 1804 camera locations in transboundary TAL (Figure 6).



Symbol	PA name	Symbol	PA name
1	Nandhaur WLS	8	Banke NP
2	Shuklaphanta WR	9	Suhelwa WLS
3	Pilibhit TR (Formerly FD)	10	Sohagibarwa WLS
4	Kishanpur WLS	11	Valmiki TR
5	Dudhwa NP	12	Chitwan NP
6	Katerniaghat WLS	13	Parsa WR
7	Bardia NP		

FIGURE 6
Tiger capture locations in transboundary TAL (black dots: tiger capture location; red dots: camera location)

In Nepal, tiger presence has been confirmed in 12 of the 14 Terai districts surveyed (Rautahat, Bara, Parsa, Makwanpur, Chitwan, Nawalparasi, Kapilvastu, Dang, Banke, Bardia, Kailali and Kanchanpur). A naïve occupancy of 0.44 and model averaged occupancy of 0.55 were estimated from a total of 96 grid cells (S) where tigers were detected in 44 cells (Figure 7). The naïve occupancy estimate has increased from 0.34 in 2009 to 0.44 in 2013 (30% increase); i.e. occupancy in 44 out of 96 grid cells compared to 33 out of 96 cells surveyed in 2009 (Barber-Meyer et al., 2013). Model averaged tiger occupancy increased positively by 50% during the last five years from 0.37 to 0.55.

In India, results for a comprehensive occupancy survey spanning all PAs and Reserve Forests in the TAL are presented in Jhala et al. (2011). This study estimated tiger occupancy in the entire TAL-India as 0.44 (se=2.9) while the estimated detection probability was 0.4 (se=1.2). More recent surveys that sampled large (166 km^2) grid cells in a portion of this landscape calculated the naive occupancy to be 70% (Chanchani et al., unpublished report). The occupancy estimate from the model $\Psi(.),\Theta(.),\Theta'(.),p(.)$ was 0.77 (0.67-0.85) in the region between Nandhaur WLS and Suhelwa WLS in India (Figure 8).

FIGURE 7
Tiger habitat occupancy in Terai Arc Landscape, Nepal (top)

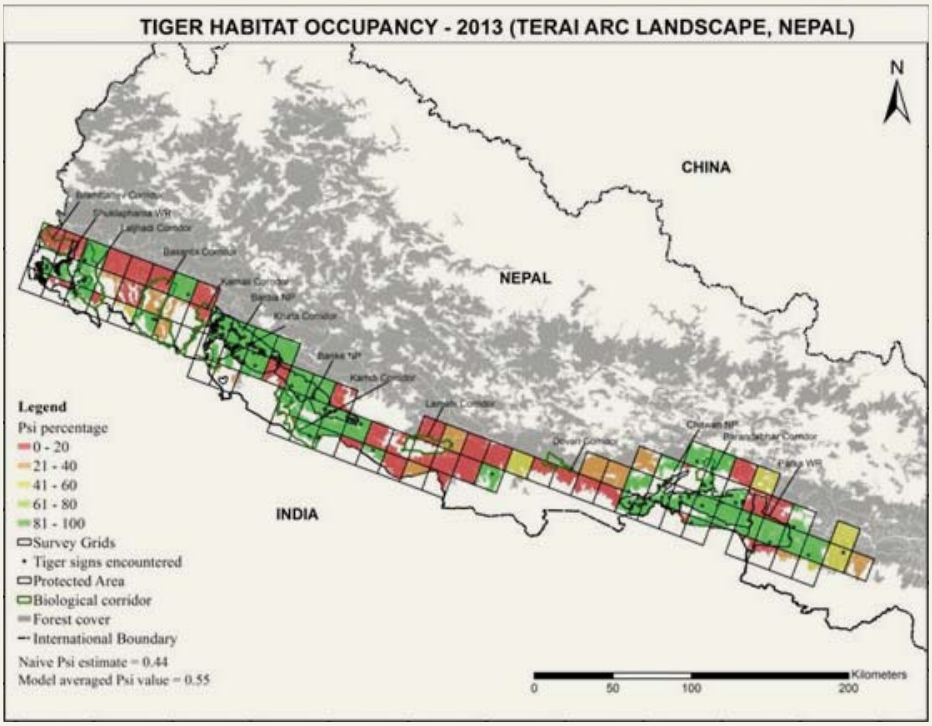
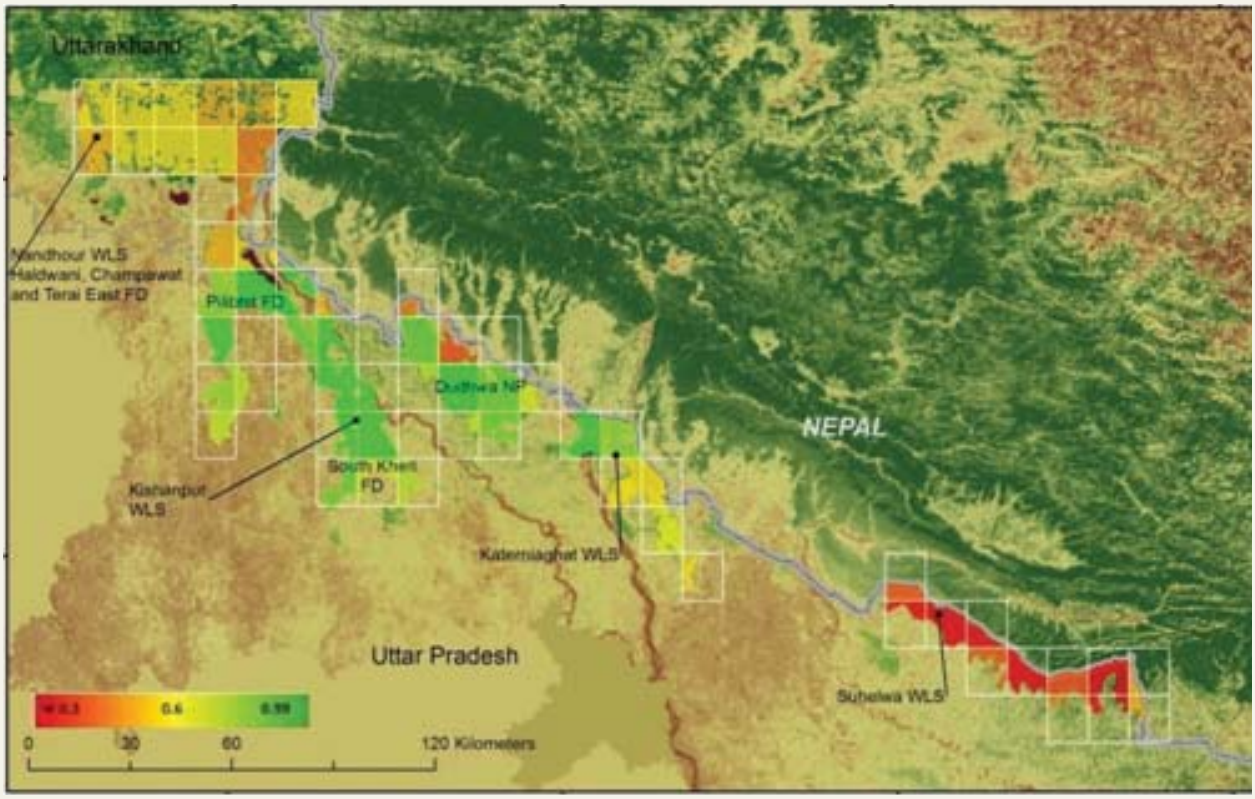


FIGURE 8
Site occupancy for tigers in a portion of the transboundary TAL in India (bottom)



4.2. INDIVIDUAL IDENTIFICATION

We obtained 9,731 tiger pictures and identified a total of 239 individual tigers, including 89 males, 144 females and 5 of unknown sex. A site-wise break-down of minimum tiger numbers for prominent PAs is provided in Table 3, and additional details are given in Chanchani et al. (2014a and b); Maurya and Borah (2013); and DNPWC (2014).

4.3. TIGER ABUNDANCE AND DENSITY

TOTAL OF
239
INDIVIDUAL TIGERS
WERE IDENTIFIED

There is high variability in tiger abundance (Appendix II) and density in sites sampled with camera traps in Nepal and in India (Table 3). The Chitwan-Valmiki and Bardia-Katerniaghat complexes support the largest and second largest populations of tiger respectively in the transboundary TAL, followed by the Pilibhit-Kishanpur complex. Besides the minimum tiger numbers, we have reported two estimates of population size, N and Nsuper (Appendix II). These have to be interpreted differently. The estimate N from program MARK is an estimate of the tiger population size for the region that was camera trapped, and utilizes data of all adult tigers that were photo-captured by one or more camera traps in each site. The parameter Nsuper, on the other hand, cannot strictly be interpreted as the estimate for a specific PA. Rather, it is an estimate of all the tigers within the camera trap array, as well those tigers that could be captured within the array, but are associated with an 'activity centre' that lies outside the trapping grid. Thus Nsuper will typically be > N. This is relevant for areas such as Chitwan NP, which shares a common boundary with other forests that cumulatively measure more than its own area (Valmiki TR and Parsa Sanctuary). The Nsuper estimate for Chitwan is therefore an estimate for the entire forest block, comprising of all these protected areas, which lie within the buffered region (or state space) used in the Bayesian SECR model.

Tigers were found to occur at densities ranging between 3 and 5 tigers/100 km^2 in 5 of the 12 sites sampled, namely Kishanpur WS, Chitwan NP, Pilibhit TR, Shuklaphanta WR and Bardia NP (Table 3). However, within and between sites, there were marked differences in tiger densities measured at the 'pixel' scale (tigers/.336 km^2). In general, the highest tiger densities were concentrated in areas of riverine flood plains, grasslands, riparian forest and around wetlands such as the Rapti, Reu and Narayani floodplains in Chitwan NP; Karnali flood plains and along Babai river in Bardia NP, along Mahakali river and phantas of Shuklaphanta, and along Sharda and Mala rivers in Pilibhit TR and Kishanpur WS, Khata corridor - Trans-Girwa in Katerniaghat WLS and around the Suheli river and large wetlands in Dudhwa NP. These areas are coloured red in Figure 9. Forest areas dominated by other vegetation types such as Sal forest, mixed hardwood forest and hill Sal forest support lower tiger densities in the Transboundary TAL.

TABLE 3

Minimum tiger numbers and density estimates in PAs of transboundary TAL

Sl. No.	Site	No of 'independent' captures	Minimum tiger number (no. of unique individuals captured)	Sex (Male / Female / Unidentified)			Density CI (Bayesian SECR)
				M	F	U	
1	Parsa WR	10	4	1	2	1	0.65 (0.38-1.24)
2	Chitwan NP	255	78	23	55	-	3.84 (3.15-4.46)
3	Valmiki TR	114	22	11	8	3	1.05 (0.88-1.28)
4	Banke NP	18	3	1	2	-	0.16 (0.1-0.29)
7	Bardia NP	224	44	18	26	-	3.38 (3.02-.3.7)
8	Katerniaghat WS	265	17	6	11	-	2.22 (1.50 - 2.69)
9	Dudhwa NP	274	14	7	7	-	1.89 (1.27 - 2.54)
10	Kishanpur WS and South Kheri Forest Division	256	21	8	13	-	4.92 (3.37 - 6.58)
11	Pilibhit TR (Formerly FD)	94	23	9	13	1	3.44 (3.37 - 6.58)
12	Shuklaphanta WR	57	13	5	8		3.4 (2.67 - 4.32)
Total		**1567**	**239**	**89**	**145**	**5**	

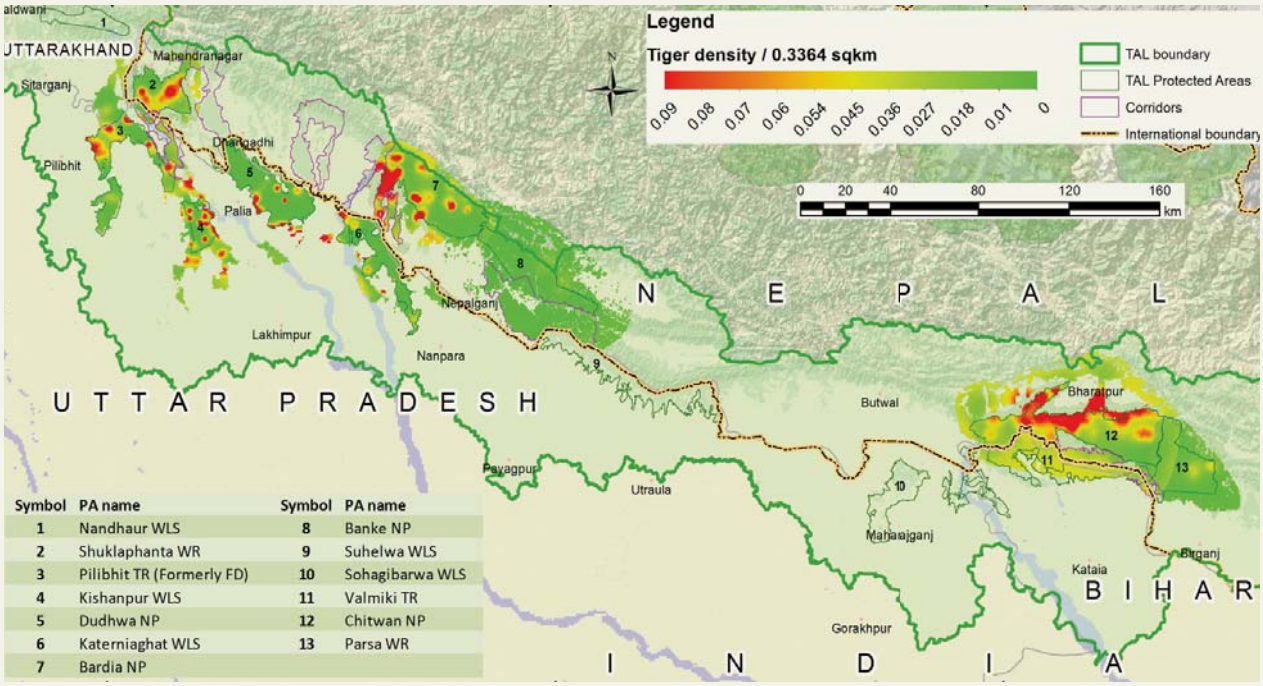


FIGURE 9

Tiger density across the transboundary Terai Arc Landscape

This map is composed of pixels representing potential activity centres of individual tigers. Each pixel represents the density of tigers/0.336 km2.

4.4. PREY DENSITY

Over 20 prey species were detected during the line transect survey. In general, estimates of prey density in PAs in Nepal were considerably higher than areas in the Indian TAL. Among the PAs in TAL, Bardia NP, Shuklaphanta WR and Chitwan NP support the highest prey densities in the landscape (estimated to be between 73 and 92 ungulates/km^2) (Table 4).

Sl. No.	Sites	No. of transects	Sampling Effort (km)	No of detections (ungulates and primates)	Density estimates (SE)/sq.km	Density (CI)
1.	Parsa WR	147	286.05	133	25.33 (3.9)	18.71-34.28
2.	Chitwan NP	261	497.73	376	73.63 (9.08)	57.84-93.74
3.	Valmiki TR	-	-	-	-	-
4.	Banke NP	75	333.74	55	10.27 (6.34)	3.3-31.8
5.	Sohagibarwa WR	-	-	-	-	-
6.	Suhelwa WR	-	-	-	-	-
7.	Bardia NP	319	397.58	571	92.6 (8.8)	76.87 - 111.54
8.	Katerniaghat WS	33	251	85	Stratum 1: 4.41 (1.55) Stratum 2: 22.4	2.29-8.74 10.65-47.09
9.	Dudhwa NP	51	370	115	13.64 (4.28)	6.46-28.78
10.	Kishanpur WS	17	180	126	29.81 (5.69)	20.37-43.62
11.	Pilibhit RF * (Now TR)	41	288	313	40	-
12.	Shuklaphanta WR	82	154.15	114	78.62 (16.44)	52.98 - 118.22

* Estimates from Bista, 2011.

TABLE 4
Prey base density estimates in PAs of transboundary TAL

4.5. COMMON INDIVIDUALS BOTH IN INDIA AND IN NEPAL

A total of ten individual tigers were found to be 'common' between forests of India and Nepal in the transboundary TAL between 2012 and 2014. From the joint survey in 2013 we identified five individual tigers using habitats on both sides of the border, through visual comparisons. The software Extract Compare confirmed that these individuals were indeed matches, and did not suggest any further matches. Information on the ten individuals is presented below, including the other five common tigers detected outside the current survey.

4.5.1. Chitwan-Valmiki Complex

Four tigers (three males and one female) were captured from the western part of Chitwan National Park and Valmiki Tiger Reserve (Figure 10) during the 2013 survey

FIGURE 10
Common Tigers between Chitwan NP, Nepal and Valmiki Tiger Reserve, India

a) VTR-Tiger 8 (Left)

b) CNP-Tiger 4 (Left)

c) VTR-Tiger 8 (Right)

d) CNP-Tiger 4 (Right)

e) VTR-Tiger 9 (Left)

f) CNP-Tiger 38 (Left)

g) VTR-Tiger 16 (Left)

h) CNP-Tiger 02 (Left)

i) VTR-Tiger 16 (Right)

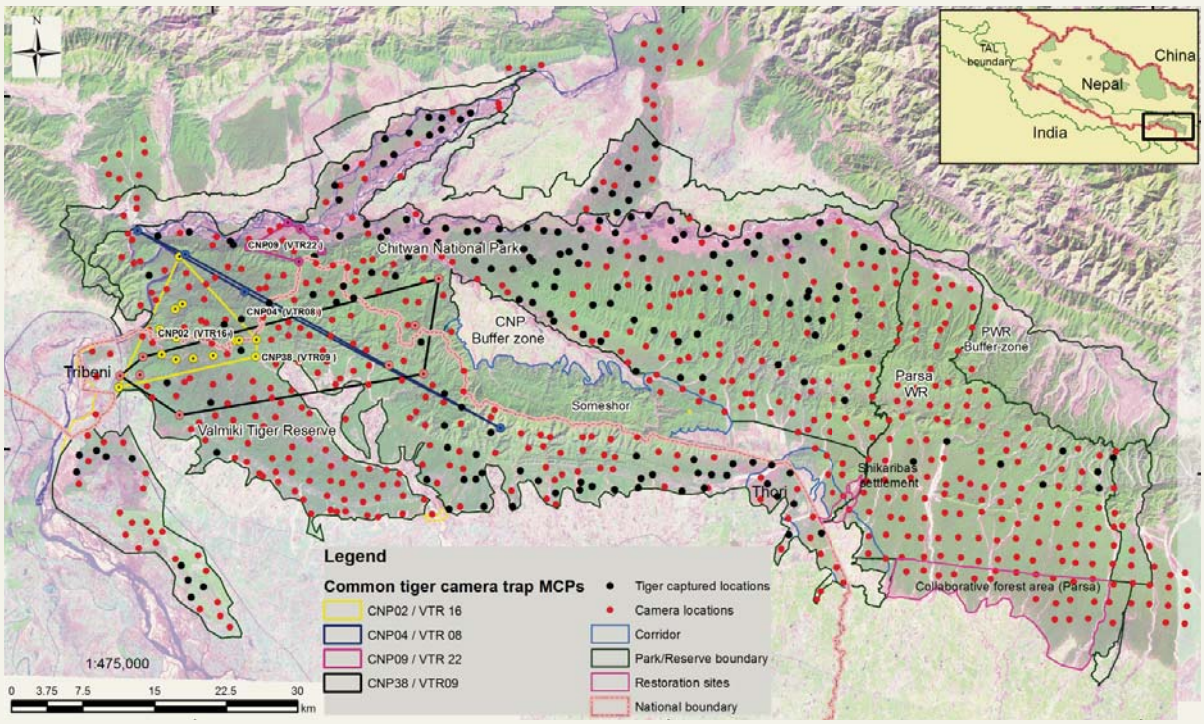
j) CNP-Tiger 02 (Right)

k) VTR-Tiger 22 (Right)

l) CNP-Tiger 09 (Right)

FIGURE 11
Movement of common tigers detected in Chitwan-Valmiki Complex

Three male tigers (CNP-02/VTR-16; CNP-04/ VTR-8 and CNP-38/ VTR-09) common between CNP and VTR occupied large territories while the female tiger was found along the border of Chitwan-Valmiki with a smaller territory (Figures 10 and 11).



4.5.2. Bardia-Khata-Katerniaghat Complex

Four tigers (three males and one female) were captured both in the Bardia area (Khata corridor) and in Katerniaghat WLS during camera trapping in 2012-2014, including the transboundary survey. Of these four tigers, two were adult males 'Khata male' (named 'Khata' since it was photo-captured in Khata corridor and another transient-aged male and one was a transient-aged female. However, only one adult male tiger was common between Bardia National Park and Katerniaghat Wildlife Sanctuary during the 2013 joint tiger survey (the others were found to be common in 2012). Photographs of tigers captured on both sides of the border during the last two years appear in Figure 12.

FIGURE 12
Common tigers between Katerniaghat WLS and Khata corridor (Bardia)

a) ID no 5- Pipalghat -2013

b) BNP-Tiger 23 (Right)-2013

c) ID no 5- Pipalghat (Left)-2013

d) BNP-Tiger 23 (Left)-2013

e) KWR-Khata-ID no-7 Female-2013

f) BNP-46 (Left)-2014

g) KWLS-ID 14-Left (Khata Male)-2012

h) BNP-ID 3-Left-2012

i) KWLS-ID 14-Left (Khata Male)-2012

j) BNP-ID 3-2012-Right

k) KWR-ID18-Left-Ghumni-2012

l) BNP-ID5-Left-2012

The common tigers between Katerniaghat WLS and Khata corridor (Bardia) were captured in the Khata corridor in several community forests such as Shiva CF, Ganeshpur CF, Kushumya CF, Gaurimahila CF and Balakumari CF, all restored and protected by the stewardship of local communities with support from the DFO, NTNC and Terai Arc Landscape conservation program. In Katerniaghat WLS, they were captured along the Nepal-India border in the Transboundary (beats 1 and 2) and Katiyara beats of Kishanpur Range, all of which lie along the Karnali (Girwa) and Kaudiyala Rivers (Figure 13).

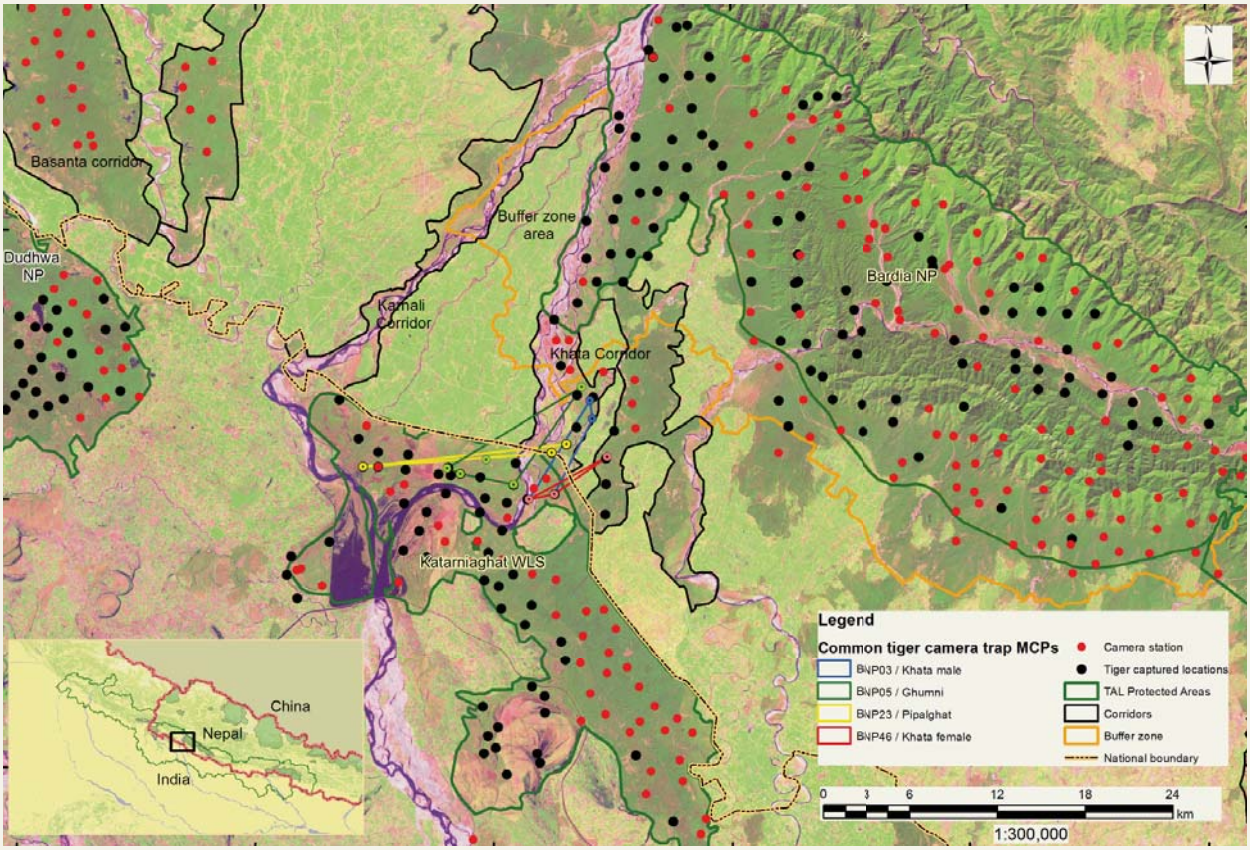


FIGURE 13
Tiger movement in Bardia-Khata-Katerniaghat complex

The Khata male, a transient-aged tiger in Katerniaghat, was found to be the offspring of a tigress who held a territory in the Khata corridor in 2012 (Figure 14). He was photo-captured along with his mother and a female sibling in March, 2012. He was then captured two months later in Katerniaghat WLS. The Khata male's mother continued to hold the same territory in Khata corridor as of yet in 2014. His sibling established a territory close to her mother, extending from Khata to the lower stretch of the Karnali flood plain inside Nepal. Both of them were captured in the Khata corridor in February 2014. However, we have not been able to trace the Khata male during the last one year (June 2013 to June 2014).

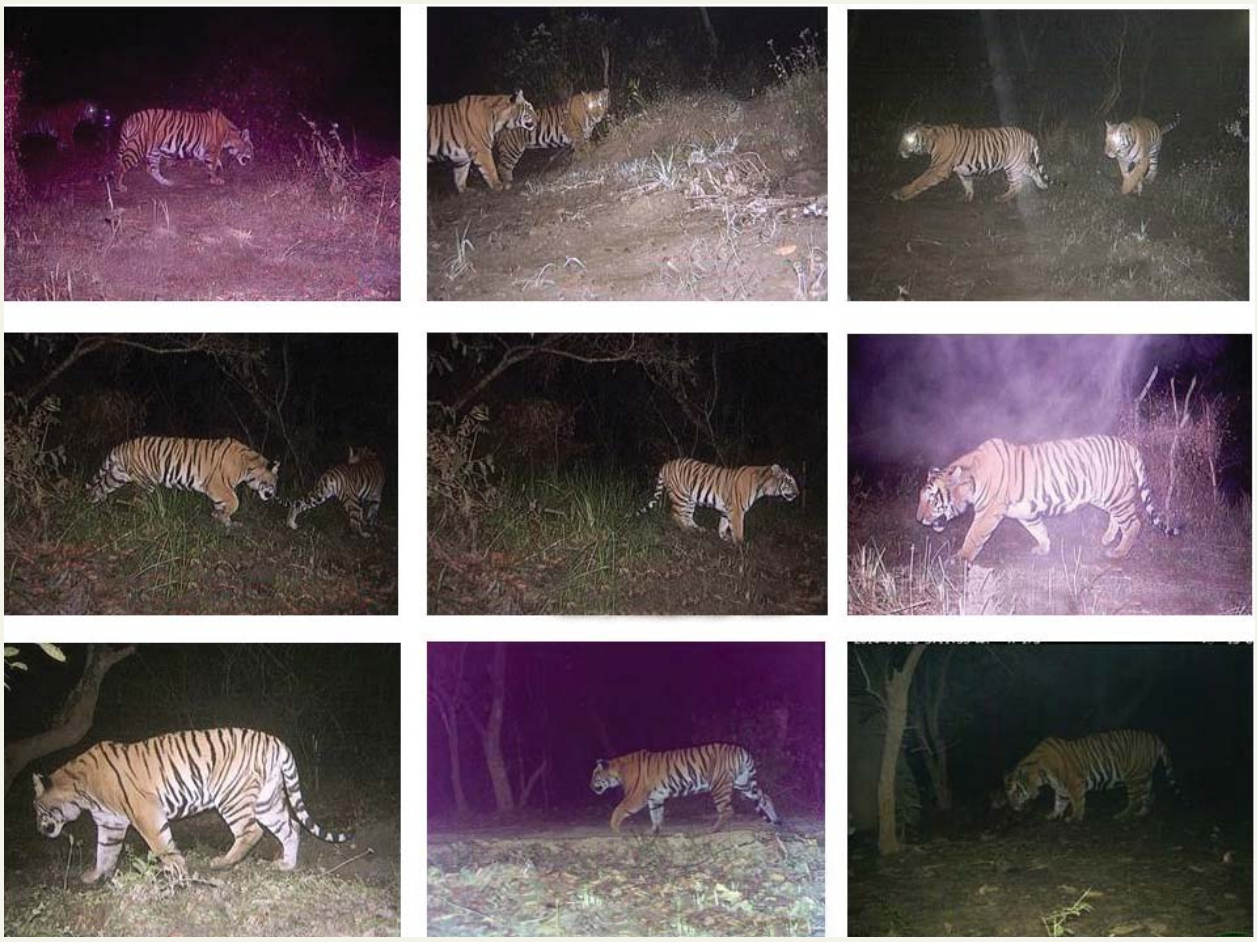


FIGURE 14
Photographic evidence of the Khata male

The Khata male is with his mother and sibling in the first two rows. He is in the Khata corridor (first photo in the third row) and Katerniaghat WLS (mid photo of third row). The last photo in the third row shows Khata male's mother in the Khata corridor.

4.5.3. Shuklaphanta-Laggabagga-Pilibhit Complex

Two male tigers were found to occur both in Shuklaphanta and in Lagga-Bagga and Tatarganj (North Kheri Forest Division). Both of these tigers were the adult males which were captured in larger areas of Shuklaphanta WR (Figure 15).

FIGURE 15
Common tigers between Shuklaphanta WR and Laggabagga

a) Laggabagga -Tiger-01 (Left)

b) SWR-Tiger 01 (Left)

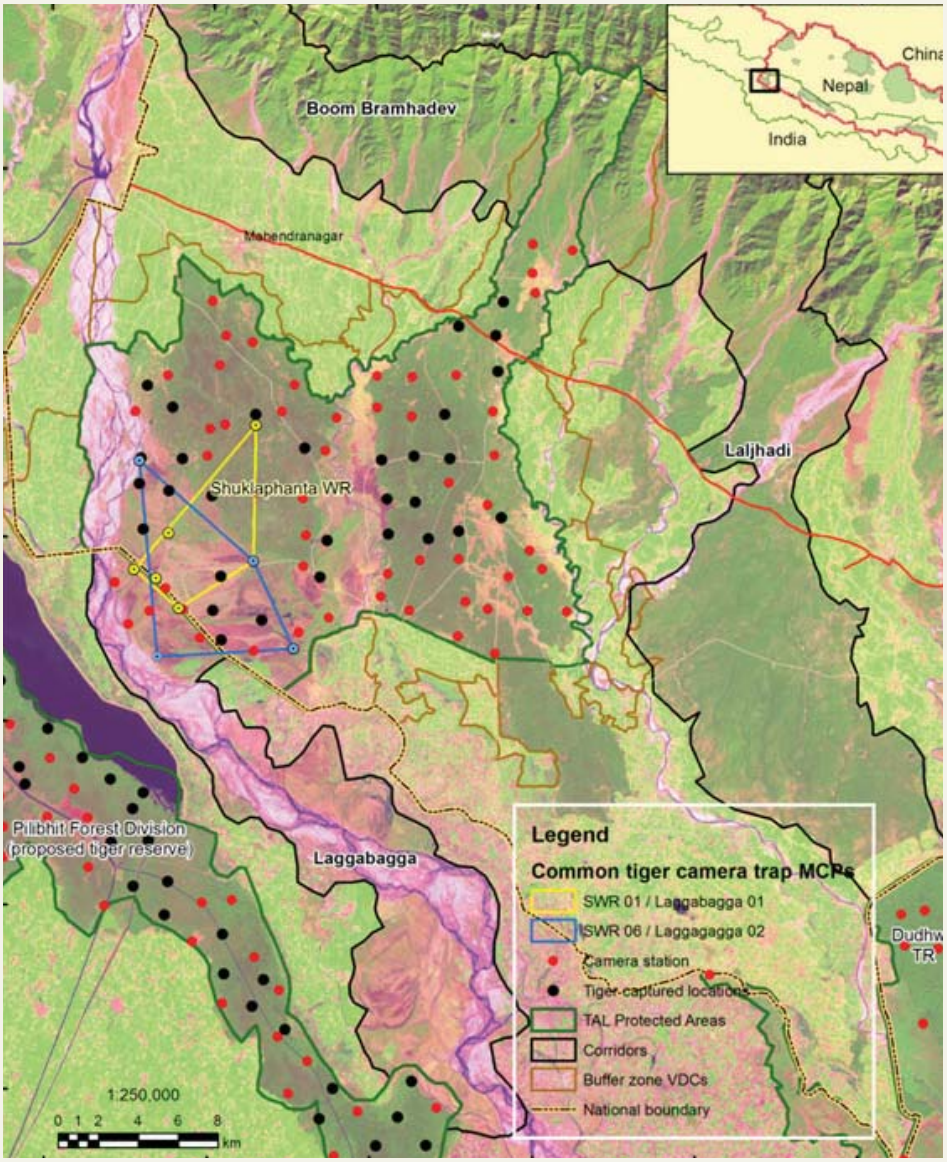
c) Laggabagga -Tiger-01 (Right)

d) SWR-Tiger 01 (Right)

e) Laggabagga -Tiger-02 (Right)

f) SWR-Tiger-06 (Left)

FIGURE 16
Tiger Movement between Shuklaphanta and Laggabagga



4.5.4. Corridors: structural and functional connectivity

Of the nine corridors between Nepal and India shown in Figure 1, we have photographic evidence for tiger movement in two, namely Bardia-Katerniaghat (Khata Corridor) and Shuklaphanta-Pilibhit (Laggabagga-Tatarganj Corridor) from camera trap data collected between 2012 and 2014. In addition, we found sparse tiger signs in three other corridors (Kamdi, Laljhadi and Basanta), suggesting that tigers may occasionally use these corridors. There was no evidence of presence/movement of tigers across the Boom-Brahmadev corridors.

The Chitwan-Valmiki forest complex has a shared boundary of approximately 100 km, and this area is a large forest tract, different portions of which are administered by the two nations. However, we believe that in addition to the protected area complex, the large forest patch of Someshwor hill forest may be serving as a corridor. This forest in

Nepal is currently in the buffer zone of central-south Chitwan NP, which may be linking Chitwan NP with the north-eastern part of Valmiki TR (Figure 11). The size of the Someshwor hill forest (buffer of Chitwan NP) is 145.89 km^2; it links with Valmiki TR to the south and with Chitwan NP along its east and west boundaries. However, this patch is progressively shrinking and forests are gradually being cleared to accommodate new settlements. Of particular concern is the Bandarjhula settlement west of Thori and south-east of Madi valley where approximately 9.84 km^2 of buffer zone forest has been converted to other land uses in the last 10 years. With a growing human population in the Madi valley and increasing pressure on the Someswar hill forest, there is a very real threat that this forest patch between Chitwan NP and Valmiki TR will be eroded away by human settlements unless significant steps are taken to reverse the process.

Our findings on the movement of tigers between Nepal and India suggest that tigers appear to use corridors with intact forest cover (e.g. Khata) and avoid corridors that have been disrupted by land-use change or are disturbed by intense human activity in areas such as Brahmadev, Laljhadi, Basanta and Kamdi (Figure 2).

Camera trapping data also confirmed the use of some corridors by elephant and rhino, in addition to tiger. In particular, the Khata and Laggabagga-Tatarganj corridors appear to provide suitable habitat routes for their movement. There is also evidence for the movement of elephant in the Kamdi, Basanta, Laljhadi and Boom-Brahmadev corridors in recent years. Unlike tigers, elephants seem able to move across human-dominated matrix areas over short distances on occasion, although this movement is often associated with significant human-elephant conflict. We have not documented specific instances of elephant and rhino movement in these corridors in this tiger report.

5. DISCUSSION

The surveys in the transboundary TAL are likely to be among the most extensive camera-trap surveys for tiger at the landscape scale to date. They were undertaken collaboratively and involved government staff, researchers, student volunteers, NGOs and members of local communities from both India and Nepal. The results provide a detailed 'snapshot' of the status of tigers in a 10,000 km² section of the transboundary Terai Arc Landscape, including tiger occurrence, population densities and movement between transboundary habitat complexes.

5.1. TIGER AND PREY SPECIES DISTRIBUTION AND ABUNDANCE

A total of 239 individual tigers were recorded, of which five individuals were photo-captured in both Nepal and India in 2013. Tiger densities ranged between 0.16/100 km² in the newly-declared Banke NP to 4.92 tigers/100 km² in Kishanpur WLS. The study reveals that there is significant spatial heterogeneity in the abundance and density of tigers across the landscape. Tigers in Nepal are mostly concentrated in protected areas and associated buffer zone forests (Figures 7 and 9). Tiger occupancy for grid cells lying inside PAs was 0.75 (SE ± 0.003) while it was only 0.39 (SE ± 0.06) for cells lying outside. However, similar patterns were not observed in the transboundary TAL in India where some PAs had low tiger occupancy and abundance, while nearby Reserve Forests appeared to harbour breeding populations of tigers.

Notable high-density areas are the northern flood-plains of Rapti, Reu and Narayani rivers in Chitwan NP; the Karnali river flood plain; and areas along the Sharada River in Pilibhit FD and Kishanpur WLS. Other areas with relatively high densities lie in the Babai river valley in Bardia NP, the Khata corridor - Trans-Girwa and Katerniaghat Range areas, and riparian habitats along the Suheli River in Dudhwa NP and Mala River in Pilibhit FD. There were also many locations with low levels of tiger use in the study. Unexpectedly, 63 % of our camera traps stations across the transboundary TAL yielded no captures of tigers, indicating strong habitat selection. Variation in tiger density is illustrated in Figure 9; from these results, it is apparent that riparian habitats and flood-plains are the most productive tiger habitats in the TAL.

There is also wide variation in prey density. Prey densities are notably high in the old and well established PAs of Nepal (i.e. Bardia, Shuklaphanta and Chitwan). They are notably lower in the PAs of India, with the exception of Kishanpur WLS. While we have not conducted any formal analysis to on the underlying causes of these differences, we offer a few hypotheses.

First, we posit that prey species may achieve their highest densities in Terai-grassland habitats, especially when the grasslands occur as mosaics of short and tall grass, their growth being regulated by flooding, fires, grazing herbivores and grass cutting by people. Second, it appears that complex habitats (comprising both Terai and Shivalik-Bhabar elements) may provide a variety of micro-habitats and better year-round food availability than habitats that are more homogenous. Further, a number of studies have indicated that homogenous Sal forests are associated with low densities of grazing ungulates (Dinerstein 1979; Bhattarai and Kindlmann, 2012). While habitat differences

may account for these differences, it is also possible that elevated levels of protection provided by the Nepal army and park staff to PAs have allowed the recovery of ungulate populations in recent decades (Wegge et al., 2009). Moreover, sustained and positive engagement between park personnel and communities in buffer zone management in Bardia National Park in recent years appears to have benefited conservation. A clear indication of this comes from villages along the northern boundary of the park who practiced subsistence hunting in the past, but who surrendered more than 200 guns to the park authorities in 2011 and 2012.

5.2. TRANSBOUNDARY CONNECTIVITY STATUS AND TIGER MOVEMENT ACROSS BORDERS

The transboundary TAL spans 600 km of international border, of which approximately 250 km has forested habitat along the border, comprising PAs and surrounding forest. This provides important opportunities for transboundary conservation of wildlife. However, most of the large, intact habitats in the Terai are now concentrated within protected areas and connectivity between these PAs has been compromised by forest degradation and deforestation, large-scale encroachment of human settlements into the forest, urbanization, and linear developments such as roads and highways. In TAL there is therefore a major challenge to sustain healthy tiger populations given their occurrence in small, isolated habitat patches.

Wildlife populations that are isolated or have a probability of exchanging less than one individual per generation are vulnerable to inbreeding depression (Mills and Allendorf, 1996). In a simulation study involving cougar (*Puma concolor*) populations, Beier (1993) showed that the addition of one to four immigrants over a decade into a small population can significantly increase its persistence. Similarly, the persistence of tiger populations in TAL can be enhanced if these populations can be managed as a meta-population, or a set of populations in different sites that are connected with one another. *The transboundary TAL thus presents us with a unique opportunity to conserve tigers at the landscape scale by maintaining and restoring connectivity between smaller habitat patches that support tiger populations.*

An overarching vision for conservation in the TAL has consequently been to maintain or restore connectivity between key habitat blocks to enable the persistence of large mammals and the maintenance of key ecosystem functions and services. The results of our study are encouraging in a number of ways – for instance, they demonstrate that transboundary connectivity is still functioning well in three key places and being used by tigers. Photographs of ten tigers found to use habitats in both Nepal and India (over a two year period) provide evidence for the movement of tigers across the border, and emphasizes the relevance of maintaining transboundary connectivity. Two of these places involve forested corridors outside PAs, and have received protection and restoration efforts with community stewardship (Wikramanayake et al., 2010). However, while tiger movement was documented in some transboundary corridors, others have been severely degraded by anthropogenic pressure. We failed to document the movement of tigers between proximate areas in India and Nepal through corridors such as Brahmadev, Basanta, Laljhadi and Kamdi, even though limited signs were documented from these areas. There are daunting challenges to restore connectivity

between some habitat blocks where corridors have been degraded or where habitat connectivity has been severed by expanding human settlements and road networks.

5.3. FRAGMENTATION, HABITAT LOSS AND DISTURBANCE

Fragmentation can severely impact wildlife populations and result in the local extinction of species in a relatively short period of time (Gibson et al., 2013). Even if it does not result in extinction it may impact species and populations in other ways. For example, the wellbeing of large migratory species may be affected if they cannot access critical resources such as water, food or breeding areas, or opportunities for dispersal. It is well established that loss of connectivity can result in reduced genetic heterozygosity, population persistence, evolutionary potential and individual fitness (Garner et al., 2005), and that such losses can be offset by the presence of functional corridors (Sharma et al., 2013).

In another region of the TAL, the effects of fragmentation on tiger populations are evident in a few sites. For example, in Rajaji National Park, western TAL, the loss of a prominent forest corridor has divided the park in two. Both areas have high ungulate densities. In the eastern part of the park there is a sizable tiger population; this area has good connectivity with the Corbett Tiger Reserve. The western part of the park, however, has witnessed the near extirpation of tigers. The corridor between the two parts of the park has become dysfunctional due to the growth of Haridwar town and other settlements, and a major highway (Harihar and Pandav, 2012).

We believe that fragmentation may have influenced the male-biased sex ratios of tigers that we report from Dudhwa National Park and Katerniaghat WLS (Table 3 and Chanchani et al., 2014(b)). Another example is from Bardia National Park, where 2008 surveys revealed a small population of 18 tigers (Karki et al., 2009). In our recent surveys, we estimated the population size of tigers in Bardia to be 45-55 individuals. The recovery of this population in recent years is likely to have been enabled by connectivity with Katerniaghat WLS through the Khata corridor, and by effective protection and community engagement in northern sector of the park, where previously there was significant pressure on wildlife (WWF Nepal, 2012). Moreover, fragmentation effects are visible in the sporadic distribution of mammalian species across the landscape; rhinos, elephants, gaur and wild buffaloes that are absent from some patches but present in others. Similarly, swamp deer, hog deer, black buck and some other species that were once widely distributed in the TAL now occur patchily, presumably on account of habitat fragmentation.

Recent development in the Laljhadi and Basanta corridors may have severed connectivity between Dudhwa NP and the forests of Nepal. The Basanta corridor has been eroded by the growth of settlements such as Ratnapur, Bhajani, Lalbojhi and Pahalmanpur VDCs, whereas the Laljhadi corridor has been severely impacted by growing settlements on the fringes of Dhangadhi town (Nepal). The loss of these corridors is likely to have greatly reduced tiger movement between Dudhwa NP and the Churia hills in Nepal. These areas are now enveloped by agriculture land and human settlements. We reemphasize the recommendation of Jhala et al. (2011) that areas

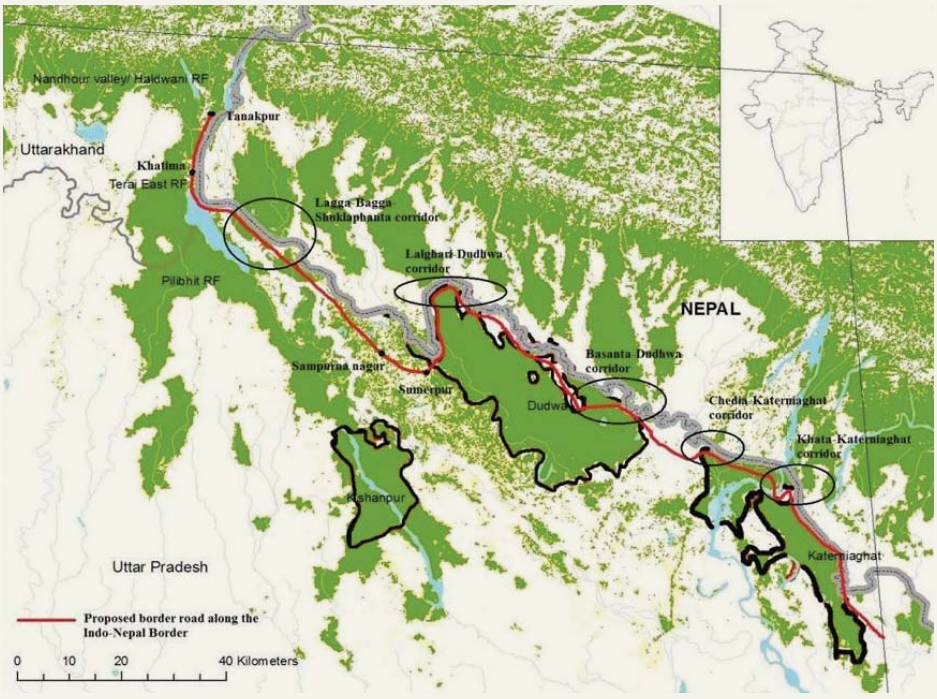
identified as corridors be declared eco-sensitive zones, and that land use change be monitored and regulated in such areas.

5.4. ROAD AND RAILWAY PROJECTS

Previous sections have outlined how tiger conservation in the TAL will only be successful in the long run if we can maintain connectivity between patches of habitat. Thirteen years have elapsed since the establishment of the TAL conservation program. While there have been some successes with corridor restoration (e.g. the Khata corridor - see Wikramanayake et al., 2010 and results of this study), several other corridors are more compromised today than they were a decade ago. As human populations continue to grow, the task of securing corridors has become more daunting. Currently, a most significant threat to wildlife corridors stems from proposals for infrastructure development in TAL – the Hulaki road in Nepal and the border road in India (Figure 16), and a railway line in Nepal. There is overwhelming evidence in the literature of the adverse impacts of roads on large mammals in general, and specifically on tiger survival (Fahrig and Rytwinski, 2009; Kerley et al., 2002).

These planned projects will pass through, dissect and fragment critical wildlife habitats and disrupt transboundary corridors. Not only will there be direct impacts from construction and use of the roads and railway: there is likely to be associated expansion of settlements and new linear development along them. This will cause additional pressure in these narrow, disturbed and ecologically fragile areas, including corridors that have been carefully restored in recent years (e.g. Khata). There may be knock-on effects that also affect animal movement in other corridors. Figure 16 shows the proposed road along the Indo-Nepal border.

FIGURE 17
The proposed road along the Indo-Nepal border in Terai Arc Landscape



Infrastructure is already causing impacts. Indian rhinoceros (also known as one-horned rhinoceros) have often been recorded moving from Chitwan NP towards the Madanpur forest block of Valmiki TR in Bihar, India, and many rhinos have died from collisions with trains on the existing Bagaha-Chhitauni railway line where it passes through Valmiki forest. To minimise these mortalities the Railway Department is constructing walls along the section of railway line passing through the forest (about 6 km). However, these colossal walls will act as a barrier for normal migration of wildlife, including the highly endangered and wide-ranging rhino and tiger.

It is imperative that Government agencies investing in these projects consult with and duly consider the recommendations of conservation agencies and Forest Departments. Infrastructure that is causing conflict should be realigned where possible, and new projects should be aligned and designed in such a manner as to minimize adverse impacts on vulnerable forests and wildlife species in general, and on corridors in particular. Where re-alignment is not deemed feasible, we think it necessary to provide adequate mitigation structures in the form of carefully sited and designed flyovers, underpasses etc. (WWF-India, 2014).

5.5. PROTECTION, POACHING AND TRADE

While habitat connectivity has played an important role in maintaining wildlife populations, there are other factors that influence population size and species recovery. Protection is an important variable. Wegge et al., 2009 have revealed a dramatic increase in the population of prey in Bardia NP as a result of increased protection. On the other hand, in Parsa WR (Nepal) and Suhelwa WLS (India), lack of manpower and effective protection over the years has likely led to population declines. Although both these sites form part of a larger forest complex, they do not appear to sustain viable tiger populations at present. Evidence of poaching was found in camera trap data, and on more than one occasion, survey teams encountered armed poachers in or near these sites. We identify the Thori-Nirmal Basti area in Parsa and the area of Suhelwa-Dang valley near the international border as areas where wildlife is highly susceptible to poaching. We also obtained pictures of poachers in various sites in the Indian Terai, and believe that the northern and western areas of Dudhwa NP near the international border are particularly susceptible. It is imperative that tiger conservation efforts recognize the magnitude of this problem, and measures be taken to enhance field patrolling and improve law enforcement.

It is deeply worrying that a number of forest tracts that were associated with large tiger populations until a few decades ago (e.g. Suhelwa WLS - Dang) now no longer seem to support viable tiger populations. Further, survey results suggest that both tigers and prey are occurring at densities that are lower than the habitat-based carrying capacity at several sites in the TAL, including several PAs in India and in Nepal. The reasons for this can be many fold, but the routine recovery of tiger skins, traps and snares for carnivores and ungulates, and the arrest of poachers operating in this landscape serve as a reminder that wild mammal populations face a persistent threat from poaching. The landscape is particularly challenging to protect, given its long, thin shape and hence high boundary:area ratio; involvement of several law enforcement bodies in two countries; and the very porous international border between Nepal and India.

The multi-billion dollar illegal wildlife trade is a global crisis that not only threatens the conservation of protected species but also has deep implications for peace and security in nations across the world. As wildlife trafficking becomes more organized and illegal trade of wildlife continues to flourish on the ground and in cyberspace, there is an urgent need for a stronger concerted international effort to gather and share wildlife crime information among law enforcement and policymakers, empowering them to stem the tide of wildlife trafficking. There are several good examples of existing efforts, primarily by the Convention on International Trade in Wild Flora and Fauna (CITES); South Asian Wildlife Enforcement Network (SAWEN); and INTERPOL; and the India and Nepal governments to combat poaching and illegal transboundary wildlife trade. Co-ordinated patrolling by Indian and Nepalese agencies and intelligence sharing in the transboundary TAL are important steps towards this goal.

5.6. HABITAT QUALITY, AND IMPACTS OF HYDROPOWER DEVELOPMENT AND CLIMATE CHANGE

As mentioned previously, some habitats are more productive for tigers and their prey than others, such as alluvial grasslands versus Sal-dominated forests (Wikramanayake et al., 2011, Dinerstein 1979). The quality of vegetation in these habitats is also a key variable for wildlife populations. In recent years wetlands in many parts of TAL have been drying up, or becoming engulfed by species such as *Ipomoea cornea, Eichhornia crassipes, Nelumbo nucifera, Nymphaea nouchali, Hydrilla verticillata,* and *Nymphoides hydrophyllum* which are destroying wildlife habitats. These areas require regular management to arrest the growth of these species. In Shuklaphanta WS and other PAs, some grasslands have to be actively managed to prevent encroachment of woody vegetation. The spread of *Tiliocora acuminata* in the understorey of Sal forests in DNP and other PAs in India is a cause of concern. While the causes of some existing changes are poorly understood, major forces are at play both within and beyond the TAL which can have huge effects on these habitats in the future. In Nepal the rapid development of hydropower in the upper catchments of the major rivers flowing through TAL is likely to have big impacts on the floodplains and grasslands that sustain tiger and prey populations: for example, in the Gandaki and Karnali basins. Storage reservoirs in particular are likely to reduce stream flows and extent of flooding, and hence could cause the conversion of wetland to grassland, and grassland to woody vegetation and forest. Extraction of water for irrigation and other purposes may compound falls in water table level. Deforestation higher in the catchments also affects stream flow, including in the fragile Churia. Unfortunately TAL boundaries do not include the headwaters of several major catchments.

As climate change advances it is likely to bring additional impacts for tiger and prey populations, and their habitats. Increasing climate variability is likely to result in more extreme weather events, which could include longer drought periods as well as an increase in flooding. Water availability could become an issue for tiger and prey species in the dry season, possibly bringing wildlife into increasing conflict with people and domestic livestock. Increased contact could increase transfer of zoonotic diseases among wildlife, livestock and people. Impacts of extreme flooding are already being seen on vulnerable people and wildlife, and affected people are increasingly likely to move around and rely on forests as they seek safer locations and more

resilient livelihoods. In the longer term rising temperatures due to climate change will impact vegetation types and species, and may result in major shifts in the wetland-grassland-forest balance as well as changes in forest type (Gokarna et al. 2014). Fire could be a major factor: uncontrolled fires may become more frequent and intense as temperatures rise and relative humidity decreases, and this may be particularly important outside protected areas where there is no fire management regime.

- A recent climate vulnerability assessment for the Nepal TAL (Hariyo Ban Program, in prep.) contains detailed recommendations on building resilience and promoting climate adaptation in TAL. Recommendations relevant to this report include:
- Identify large, climate resilient patches of forest and prioritize them for conservation
- Maintain ecological connectivity of major blocks of wildlife habitat through corridors, and ensure connectivity with climate refugia
- Manage wetlands and waterholes to prevent them from silting and drying up; consider restoring natural ecological communities such as wild water buffalo to help maintain them
- Enhance active management and monitoring of grassland to maintain the desired spatial configuration and extent of grassland communities, especially in PAs and refugia
- Restore degraded watersheds in the Churia hills to reduce impacts of extreme weather events such as droughts, floods and landslides
- Identify areas that are safe from climate related disasters such as floods to which climate affected or vulnerable people can relocate in a planned way; restore flood-vulnerable vacated lands to increase resilience, for example restoring floodplain function to buffer the impacts of floods and river cutting
- Support local communities to build resilience and adapt to climate change, for example through use of climate-adapted crop varieties.

5.7. CATTLE GRAZING

Livestock in tiger habitats is pervasive in the TAL but grazing pressure is particularly severe in certain sites. Large herds of grazing livestock are common in Katerniaghat WLS especially in Seed Farm areas of the Sanctuary and the Trans-Girwa region. It is likely that >40,000 cattle enter the sanctuary each day. Similarly, high grazing pressure exists in Suhelwa WLS, Banke National Park, Shuklaphanta Wildlife Reserve, Mahof and Deoria Ranges of Pilibhit Forest Division, and the southern boundary of DNP. All the corridor forests (Basanta, Laljhadi, Karnali, Kamdi and Laggabagga-Tatarganj) and buffer zones forests in this landscape are also subject to heavy grazing by cattle, buffalo and goats. Cattle grazing pressure is especially severe along river and stream courses.

This is most detrimental to wildlife in areas where water availability is limited. An example is Suhelwa WLS, where the few perennially flowing streams and ponds face relentless pressure from cattle. In several overgrazed sites, grassland patches and forest understorey have been degraded, resulting in loss of ground cover and suppressed

regeneration. In addition, areas with intense grazing pressure are associated with rampant proliferation of invasive species such as *Senna tora*. Studies from other regions in India have shown that cattle may compete for forage resources with wild ungulates, especially those that are true grazers such as chital (Madhusudan, 2004; Harihar et al., 2009).

5.8. ENCROACHMENT

The conversion of forest land to other land-uses is one of the biggest threats to the continued existence of large mammal species in TAL. Encroachment has spread rapidly in Nepal's corridor forests, buffer zone and national forest. In some areas this is due to lack of a clear policy and coordination between governments departments. For example, the Land Survey Department surveys forest land including land that is already vested with local communities and managed as community forest. Following this, land holding cards are distributed to landless *muktakamiyas* (freed bonded labourers), a category of landless people in Nepal. Land allocation by the Survey Department in this manner seems to undermine the authority of the Department of Forests, under which the land is officially vested. Therefore, there is an urgent need for inter-agency coordination to determine where land can be allocated for landless people, people displaced by floods and landslides, and other groups; and which critical areas should be retained for conservation, especially corridors and buffer zone forests. Land granted to these groups should be clearly demarcated so the forests of the Terai do not become encroached and fragmented by haphazard development.

Some corridors have been severely affected by recent episodes of unplanned development. In particular, we stress the need to restore Nepal's Boom-Brahmadev, Laljhadi, Mohana, and Basanta areas in the western block, and the eastern Khata and Kamdi corridors in the central block of transboundary TAL.

A geospatial comparison of forest cover in the Basanta Corridor between 1999 and 2010 reveals that the forest area decreased by 10% (36.4 km^2) with a corresponding increase in agricultural lands by 25% (47.2 km^2). This suggests that agricultural lands are expanding every decade engulfing forest areas (Ratnapur-ward nos. 5, 6, Khailad-ward nos. 2, 3, 7, 9, Pahalmanpur-ward no. 2 and Masuriya-ward no. 2) and other habitats like grassland and shrub land. Kailali district alone has the most encroached lands in Nepal, totalling about 21,000 hectares, causing fragmentation of the Basanta corridor into several smaller forest patches. In the Laljhadi-Mohana corridor, while there has been no significant change in forest cover in the last decade the grassland area has decreased by 44% (10.5 km^2). Encroachment of forest land in Kanchanpur district occupies an area of 109.6 km^2. Here, encroachment has been particularly problematic in Kubgada, Eklegada, Chiurigada, Sundariphanta, Bhetghatshivir, Dokebazar and Naurangaun villages of the Laljhadi-Mohana corridors. Encroachment has also proliferated in the Brahmadev corridor where 2,400 households have settled illegally in hamlets such as Khallamacheti, Tudikhel, Lipna and Bagun, reducing grassland cover by 33% (32.9 km^2). Similarly, the Kamdi corridor has been encroached upon by more than 700 households in 222 ha of previously forested habitat in areas such as Buchapur, Ghopte, Balapur, Perani, Milaniya, Nanapur, Babhanpuruwa, Pashupati and Kalaphanta (WWF Nepal, 2012).

In the transboundary TAL landscape of India, conversion of forest land to agriculture occurred primarily in the pre-independence years. However, encroachment continues to be a problem in some areas. This has led to a loss of east-west connectivity between PAs in India such as Kishanpur, Dudhwa and Katerniaghat. Formerly, a network of drainage features and associated grasslands existed between these forests patches, and these may have served as migration and dispersal routes for species such as swamp deer and tigers. Such swamp areas have now been converted into productive agricultural land. This is most severe in marginal forest patches (or Forest Department land) that lies along important major rivers: for example, the Dudhwa-Katerniaghat corridor that lies along the Mohana River. While patches of grassland and riparian habitat formerly connected these two parks, forest land along these 'corridors' has been encroached by sugarcane farmers. Several areas along the Sharada River in North Kheri Forest Division have also been encroached and similar problems are reported in Terai East Forest Division in Uttarakhand. The expansion of Tanakpur town has affected connectivity in the lower reaches of the Boom-Brahmadev corridor. The presence and expansion of some illegal settlements in forests (such as the village of Bichiya in Katerniaghat WLS) needs to be addressed. Similarly, Valmiki Tiger Reserve is facing encroachment from the state of Uttar Pradesh and from within Bihar. There are some temporary settlements on the western boundary of Madanpur forest block which could flourish if not controlled properly, leading to unplanned and unwanted developments.

5.9. HUMAN-TIGER CONFLICT

Human-tiger conflict is more evident in areas with high density of tigers, especially in Rapti, Reu and Narayani flood plains of Chitwan National Park in Nepal. Annually an average of two to three tigers are reported to be pushed out by dominant males and often end up going to the fringe areas and villages where they may kill livestock and people. This is likely to escalate as the tiger population increases in the Karnali flood plains and other high density tiger areas, as Nepal strives to meet its global commitment to doubling its tiger numbers by 2022. There is a need to systematically document incidences of conflict; develop and implement timely strategic mitigation measures to reduce conflict; address incidences of injury, and loss of human life and property; and rescue and rehabilitate tigers. Ignoring these larger issues will result in much human hardship and suffering, and greatly compromise conservation in long run.

In India, the areas along the Suheli River at the southern boundary of Dudhwa NP and the Trans-Girwa region of Katerniaghat WLS have high human-tiger conflict, particularly for cattle attacks. WWF-India and the State Forest Department offer some compensation for cattle lifting by tigers (particularly when such events occur outside forests). Similarly, the Government of Nepal has endorsed a relief scheme for human death, injury and livestock killing by nine large mammals including tiger; however, the scheme pays much less than the value of the loss and the process is bureaucratic and lengthy, which limits its effectiveness.

6. CONCLUSIONS AND RECOMMENDATIONS

The surveys of tiger and other wildlife species in the TAL have generated fine-scale information on the occurrence and abundance of these species, enabling the following conclusions on the status of tigers in the landscape and their movement across transboundary corridors:

(i) Breeding populations of tigers continue to persist in the larger habitat patches of the landscape, including prominent PAs: Chitwan NP, Bardia NP, Shuklaphanta WR, Parsa WR, eastern Dudhwa NP, Katerniaghat WLS, Valmiki TR, Kishanpur WLS, and Pilibhit Tiger Reserve.

(ii) Tigers sporadically use the highly disturbed and fragmented patches in the landscape (e.g. Basanta, Laljhadi, Brahmadev and Kamdi); their populations have severely declined in some areas (e.g. Suhelwa Wildlife Sanctuary and Parsa Wildlife Reserve), possibly because of the poaching of wild mammals at unsustainable levels.

(iii) By examining tiger data collected over a three-year period and developing individual identities, we were able to document tiger movement between habitat areas in India and Nepal. However, documented movement of this nature was observed only for forests that are contiguous on both sites of the border, or in sites that are well connected by forested corridors (e.g. Khata), or in some cases small patches of sugarcane plantations (Shuklaphanta - North-Kheri). This confirms the importance of maintaining and restoring corridors between sites.

(iv) There are notable differences in the densities of ungulate prey species between sites. Enhanced protection appears to have been beneficial for the recovery of prey populations in Bardia NP and other sites in Nepal. The key to the recovery of depleted tiger populations in the transboundary TAL will be the recovery of prey populations.

(v) This study once again underscores the importance of riparian tracts and other grasslands, and early-succession stage forests as important habitats for tigers and their ungulate prey. Densities of tiger and prey are several-fold higher in such habitats than in Sal-dominated deciduous forests. The protection and management of these habitats in particular should be prioritized.

(vi) Community stewardship in the restoration and protection of habitats and wildlife can play a major role in the conservation of tigers and other species (e.g. Khata corridor, and community managed forests in buffer zones of Chitwan NP such as Bagmara and Kumroj CF). We therefore emphasise the importance of strategic restoration through people's participation to maintain and restore habitat connectivity, and regular monitoring of the intervention sites.

(vii) This study has identified some key tiger and prey recovery sites: Parsa WR and its extended habitat to east; Banke National Park, Kamdi corridor, Dang forest and Suhelwa WLS in central trans-border TAL; and Shuklaphanta WR, Dudhwa National Park and Pilibhit Tiger Reserve in the western transboundary area. The current issues in each of these sites have already been highlighted in the discussion section, and are covered in the recommendation in Appendix I.

We believe that conservation in the Transboundary TAL over the next decade should be strategized and addressed through the following five major areas of interventions:

1. Advocacy and policy interventions
2. Strategic restoration and management of key habitats, corridors and connectivity
3. Strengthening of protection to deter poaching in both core, buffer-zone and corridor areas
4. Community stewardship in conservation;
5. Monitoring and research activities.

6.1. ADVOCACY AND POLICY INTERVENTIONS

Advocacy and policy interventions are required to enable conditions for maintaining corridors and connectivity in transboundary TAL. The following actions are recommended:

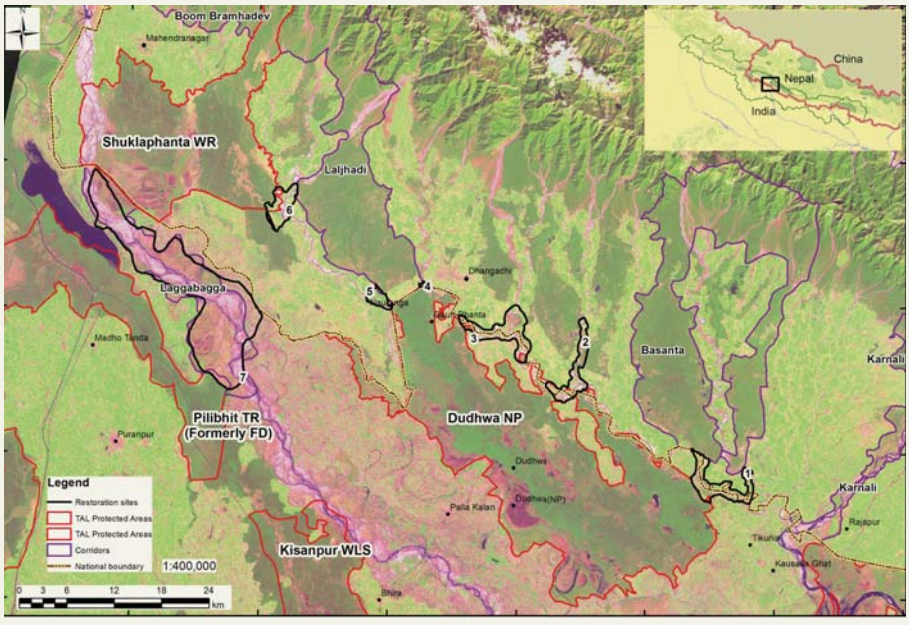
- Recognize corridors as areas of conservation importance and give them the status of no-development zones.
- Provide strong administrative support at all levels to evict illegal settlements from forest lands and prevent further encroachment in areas that forest departments have jurisdiction over. Instant enquiry is recommended for any illegal movements, and action should be taken immediately.
- Lobby to prevent the development of roads and other infrastructure in key wildlife habitats or corridor areas, and to minimize impacts of developments upstream such as hydropower and irrigation that can affect transboundary TAL. Work with responsible agencies to find alternatives and mitigate potential impacts.
- Support expansion and modernization of Protected Areas and wildlife department/ forest department infrastructure to enable effective protection and habitat management.
- Encourage and facilitate science and research to monitor the effectiveness of interventions.
- Build development programs to ensure equity, sustainable livelihoods and good stewardship for groups that are dependent on forests and other wilderness areas.
- In addition to conservation efforts by each country in TAL, continue to promote and commit to transboundary collaboration between India and Nepal in managing the shared resources and ecosystem services of the TAL at local and central levels, sharing information and results, and making use of the comparative advantages of both countries.

6.2. STRATEGIC RESTORATION AND MANAGEMENT OF KEY HABITAT, CORRIDORS AND CONNECTIVITY

Conservation targets in the TAL can only be met if concerted and well-coordinated efforts are made towards these ends, both in India and in Nepal. For example, the recovery of tiger and prey populations in one site, but ineffective conservation and management in another adjacent site can result in a situation where dispersing tigers end up being poached or becoming conflict animals, rather than establishing territories and contributing to population recovery. The sharing of information, knowledge, experience and dedicated efforts to maintain and restore corridors and habitats will go long way in safeguarding the future of tigers in a rapidly changing landscape. We emphasize the following:

- Ensure continuous management of habitats associated with breeding tiger populations and high prey densities so that they remain productive and are not degraded.
- Enhance understanding of climate change vulnerability of tiger and prey populations, including potential impacts on protected areas, corridors and habitats, and local communities, and incorporate resilience building and adaptation measures into the management of transboundary TAL.
- Take proactive measures to restore key wildlife corridors (Figures 17 to 20); acquisition of land and voluntary resettlement of populations need to be considered.
- Restore habitats in PAs, buffer zones and along wildlife corridors where they have been degraded as a result of cattle grazing, encroachment and other disturbance (Figures 17 to 20).
- Strengthen and extend support to the Forest Department in both countries to prevent the encroachment of settlements on forest lands and restore forests that have been encroached. Recommendations for specific areas are outlined below.

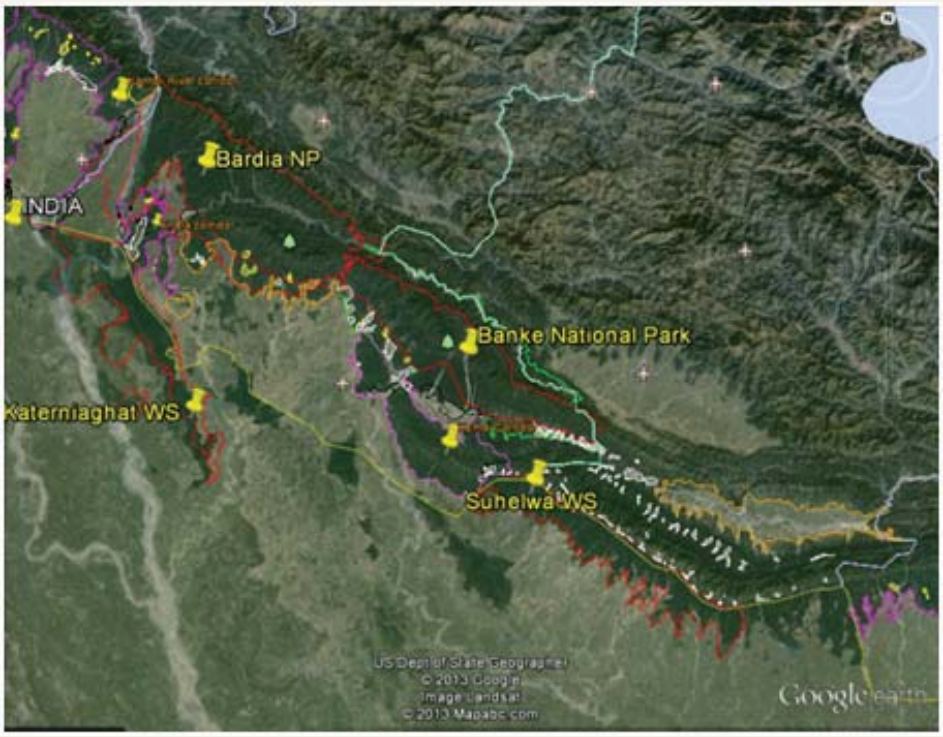
FIGURE 18
Block 1, Western block of Transboundary TAL



PAs are outlined in red; the corridors shown in purple; areas in yellow are settlements (both legal and illegal); recommended restoration sites are shown in black. (Background image source: Google Maps)

The Basanta corridor in Nepal is now divided into three distinct narrow strips of forest and currently has no connectivity with Indian forests. Three sites (restoration sites 1, 2 and 3) have been identified in both Nepal and Indian TAL. Three sites have been identified for connecting Laljhadi (restoration sites 4 and 5) with Dudhwa NP and Shuklaphanta via south-eastern buffer zone (Restoration site 6). Laggabagga-Tatargunj corridor between Pilibhit FD and Shuklaphanta WR is highly disturbed and needs immediate protection. Restoration site 7 has been identified to restore connectivity between Nandhaur WLS and Brahmadev which is currently encroached.

FIGURE 19
Block 2, Central block of Transborder TAL



PAs are outlined in red; the corridors and surrounding forests are shown in purple; areas in white and yellow are settlements (both legal and illegal) inside and adjacent to forests; and areas in black are recommended restoration areas. (Background image source: Google Maps.)

There is a need for community engagement in the settlements indicated in Figure 19, and along the forest border area in TAL. Proposed restoration/village relocation sites are sensitive wildlife zones, flood prone areas where communities are vulnerable, and/or degraded forest or encroached areas. Four sites are identified in Karnali river corridor, nine sites in Khata corridor, one site in Babai river corridor (that links Babai valley with Katerniaghat WS via Khata corridor) and five sites in Kamdi corridor and Banke National Park. Settlements shown in white in Dang forest along the border of Suhelwa WLS and along the river valleys south of Deukhuri valley need further assessment.

FIGURE 20
Block 3, Eastern block of Transborder TAL

PAs are outlined in red; the corridors and the surrounding forests are shown in purple; areas in white and yellow are towns/settlements (both legal and illegal) inside and adjacent to forests; areas in black are the identified restoration sites /degraded forest or encroached areas. (Background image source: Google Maps.)

The forest east and south of Parsa WR faces intensive logging. Community engagement should be focused in these settlements and along the forest border in TAL. Forests north-west of Chitwan NP are rapidly becoming more fragmented and require restoration at several points to repair lost connectivity. Six restoration sites are identified north-west of CNP which will connect the five smaller fragmented forest patches with western CNP and Barandabhar corridor. Two restoration sites are identified along the Parsa-Valmiki border and Chitwan-Valmiki near BhiknaThori area. Someshwor hill forest has high potential to sustain dispersing tigers from both CNP and Valmiki but is gradually being cleared from south of Madi valley and south-eastern side of CNP buffer-zone, and needs immediate protection.

FIGURE 21
Block 4: Large patch of forest in Nepal TAL between eastern and central blocks

PA boundaries are red; corridors and surrounding forests are shown in purple; areas in white and yellow are towns/settlements inside and adjacent to forests.

(Background image source: Google Maps.)

Though there are no protected areas in this block, some patches of forest in Dang, Rupendehi, Kapilvastu and Nawalparasi are large enough to support breeding tiger populations if prey populations could be restored in these areas. The areas also act as extended habitat for dispersing tigers. The areas in yellow and white are settlements and towns; community engagement is recommended around these settlements and along the forest border from Rupendehi to Nawalparasi.

6.3. STRENGTHENING OF PROTECTION TO DETER POACHING IN CORE, BUFFER-ZONE AND CORRIDOR AREAS

We identified those areas where wildlife is highly susceptible to poaching: Thori-Nirmal Basti area in Parsa; international-border area of Suhelwa-Dang valley; northern and western areas of Dudhwa NP; and areas along the Sharda River (near Pilibhit Tiger Reserve, North Kheri Forest Division and Nandhaur WLS-Brahmadev). Protection measures need to be strengthened in these areas. However, poaching can shift over time and space, and therefore we recommend the following:

- Identify areas where animals are most susceptible to hunting and support the development and expansion of law enforcement there.
- Build the capacity of protected area staff. We also recommend enhancing the capacities of forest department personnel to effectively patrol and protect wildlife, through approaches such as MsTRIPES/SMART patrolling.

- Strengthen mechanism of patrolling along the international border to curb illegal trade in wildlife products.
- Develop computer-aided tools to enable strategic data sharing on law enforcement.
- Develop effective patrolling mechanisms for corridors and other critical sites that may serve as corridors, including mobilization and strengthening of community-based antipoaching units in Nepal.
- Improve patrolling in the monsoon months, when access to many areas becomes harder for law enforcement personnel.

6.4. COMMUNITY STEWARDSHIP IN CONSERVATION

Community activities have been implemented in transboundary TAL for over a decade. We recommend carrying out a detailed assessment of the effectiveness and lessons of this community engagement and interventions. This will aid in learning from the past and improving the design of programs that promote community stewardship of biodiversity and natural resources, and support the livelihoods and wellbeing of people without contradicting with the conservation goals of TAL. In addition we recommend the following in transboundary TAL:

- Design and implement specific programs for communities living in key and sensitive areas such as corridors and buffer-zones as a means to reduce pressure on forests and promote community stewardship, and set smart indicators to measure conservation goals (e.g. set up programs to work on intensifying and adding value in agriculture in key areas to ensure cover and protection for wildlife).
- Support and strengthen community linkages in conservation and wildlife tourism to create sustainable livelihoods.
- Identify communities and areas where dependence on forest resources is high, and work with agencies specialized in poverty alleviation, or the development of cost and energy efficient technologies to reduce dependence on fuel-wood, and other forest resources.
- Promote improved governance of local groups and ensure that the most marginalized and vulnerable people and women are empowered to take part in decision-making, benefit from alternative livelihoods, and share forest benefits.
- Design programs that support communities to safeguard crops, livestock and property, and entrust them with responsibility to manage and maintain the prevention or mitigation measures. Set up efficient compensation schemes for loss of life, injury, and damage to crops and property by wildlife, with effective mechanisms to engage with families persecuted by wildlife.
- Develop specialized capacity to address human-wildlife conflict involving injury and loss of human life, and the capture and rehabilitation of problem animals.
- Set up a panel to study and redress conflicts between members of local communities and government personnel working for the forest departments.

6.5. RESEARCH AND MONITORING

While we have gained knowledge of the status of tigers and other mammals in the TAL in recent years, this report also highlights the fact that much remains unknown. Effective conservation must be informed by reliably estimated population trends, and an understanding of the environmental and anthropogenic factors that influence the abundance and distribution of endangered species at local and landscape scales. We also recommend that conservation planning increasingly relies on planning and managing for communities of plants and animals rather than single species, and there is a need to generate information on the ecology and status of other species that share or contribute to the habitats of tigers, as well as the impacts of threats and other land uses. In this context, we recommend the following:

- Conduct long-term ecological monitoring to understand population trends and estimate demographic parameters for tigers and other endangered wildlife in the Terai.
- Undertake intensive research on transboundary movement of tigers and the use of corridors, buffer-zones and human land-use areas through radio telemetry studies.
- Fill knowledge gaps on the status and ecology of endangered species, such as foraging and reproductive ecology.
- Conduct monitoring for each site where restoration, relocation or other notable management interventions have occurred, to track and measure their progress.
- Assess habitat use, movement, dispersal and spatial ecology of transboundary corridors by other large mammals including rhinoceros, elephant, swamp deer and aquatic species like dolphin and crocodiles.
- Conduct studies on the scale, extent and local variations in the intensity of human-wildlife conflict (tiger, elephants, ungulates) to identify and design effective mediation measures.
- Promote studies on impacts of land use change, infrastructure and other development on wildlife populations.
- Undertake a climate vulnerability assessment for the tiger population in the Terai, building on the Nepal TAL and other vulnerability assessments and taking into account human vulnerability.
- Establish long-term monitoring programs to understand vegetation dynamics in TAL in response to specific management practices, altered hydrological regimes, and climate change impacts.
- Undertake detailed studies on ungulate-habitat relationships and the feeding ecology of ungulates.
- Develop studies on the socio-economic and cultural drivers of human-nature interactions in the TAL, and promote synergies between ecological and socio-economic research.

Appendix 1 provides detailed recommendations for key activities and targets in each of the major TAL sites in India and Nepal, drawing on the major recommendations in this

section. It is intended to provide broad guidance for conservation in the sites, and we recommend that agencies and organizations working in transboundary TAL, and in the Terai Arc Landscape Program in particular, set tangible and achievable targets to fulfil these conservation objectives.

The tiger populations, associated wildlife assemblages and habitats of the transboundary TAL represent a tremendous shared resource of regional and global conservation importance. Nepal and India have a joint responsibility to conserve the heritage of TAL for future generations, drawing benefits from the plentiful opportunities that this rich landscape offers. At the same time, emerging threats are combining with old ones to pose a serious test to conservation agencies. New approaches and collaboration across boundaries and disciplines will be needed at many levels to ensure that the tigers of TAL not only survive but thrive.

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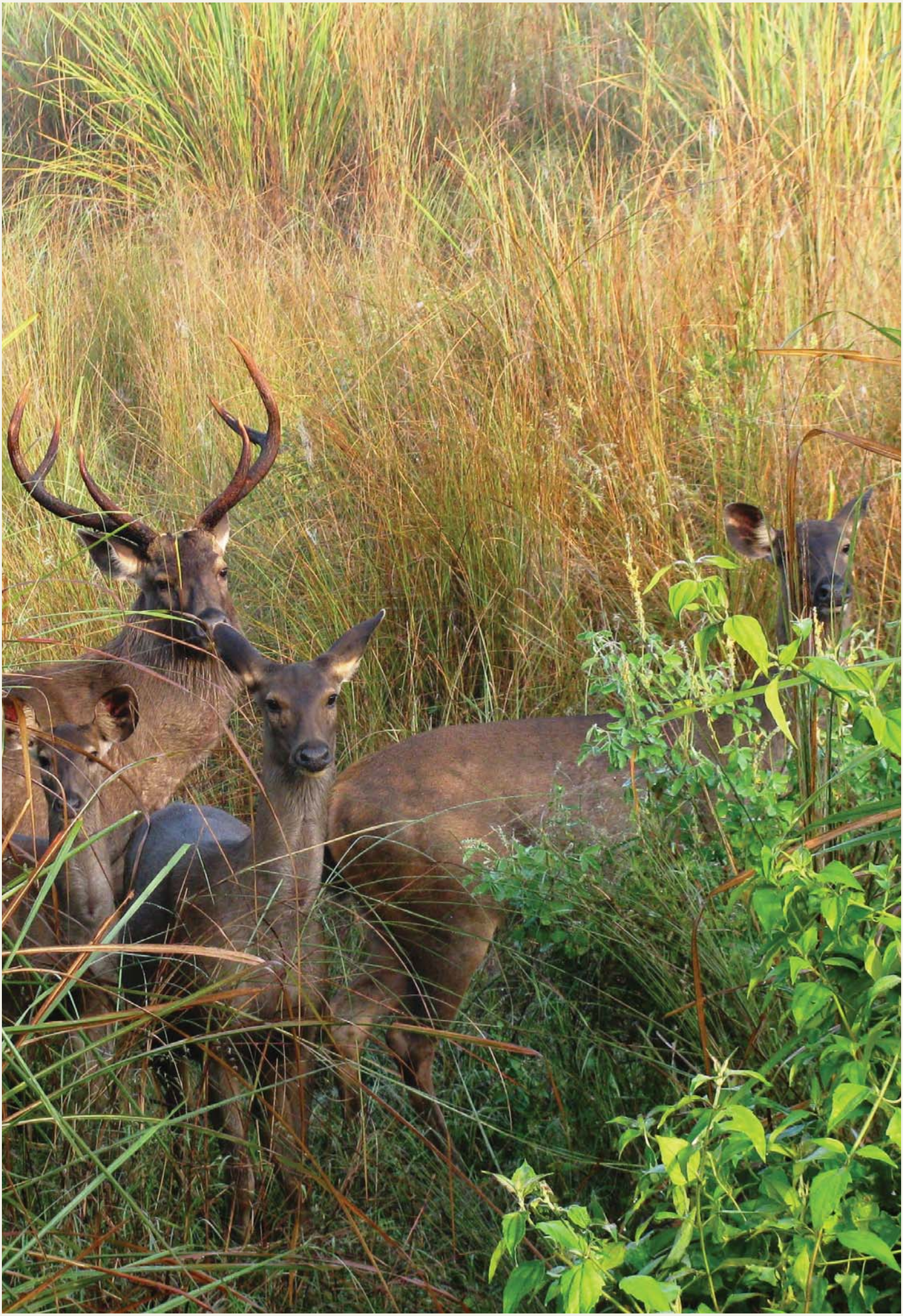

Site specific threats and recommendations for the tiger conservation in transboundary TAL

Key Transboundary sites	Key threats	Recommended protection/habitat restoration actions	Community engagement	Policy and advocacy	Research and monitoring
Nandhaur WLS and Terai East FD	Poaching of tigers and their prey; encroachment of habitats in some areas. Erosion of forest corridors.	Expand protection network and construct new anti-poaching camps. Secure corridors and remove encroachment. Mitigate human impacts in the area	Opportunities of eco-tourism exist. Education programs to raise conservation awareness.	Government intervention needed to secure the upper-Gola, Surai-Kilpura and Boom-Brahmadev corridors	Need for systematic and large-scale surveys, regular monitoring.
Brahmadev corridor	Illegal logging, Livestock grazing, Encroachment in several sites of Bhimdatta and Daijee VDC Human wildlife conflict-mostly reported animals are elephant and common leopard	Capacitate and equip department of forest staff to address illegal logging Remove encroachment particularly in Khallamacheti, Tudikhel, Lipna, Bagun and along Churias(Figure 15)	Engage with communities to restore the connectivity between Nandour and Brahmadev by restoring degraded habitats along Khallamacheti and Tudhikhel Promote integrated livestock management for herder/communities highly dependent on forest for livestock grazing. Effective site specific meditative measures need to be designed to address HWC	Strong lobbying required to free encroachment from two VDCs of Brahmadev -Need for open discussion between the Land survey department and Forest department to address the problem of encroachment and follow up with the decision makers	Regular monitoring of habitat and wildlife Study the spatial use of elephant in the corridor and beyond

Key Transboundary sites	Key threats	Recommended protection/habitat restoration actions	Community engagement	Policy and advocacy	Research and monitoring
Shuklaphanta Wildlife Reserve	Intense cattle grazing and fuel-wood collection pressures in the peripheral sites Encroachment in the south-eastern part of the park Some level of prey and tiger poaching Infestation of wetlands by water hyacinth and other invasive spp.	Need for extensive foot and elephant patrol in park interiors and fringes Reduce cattle grazing: Rotational grazing in some areas to benefit ungulates that prefer short grasslands. Remove encroachment Increase intelligence and surveillance in the surrounding areas Regular management of the wetlands	Identify communities highly dependent of forest for fuel wood and provide alternative energy source (biogas) to the communities Integrated livestock management combined with reward to the informers and punishment system for the offenders Upscale community based anti-poaching programs in the buffer zones	-Enable conditions for removing encroachment and restore the fragmented patch between south-east Shukla buffer zone and Laljhadi corridor - Recognize forest south-east of SWR as its extended habitat and provide similar management interventions	Annual monitoring for the tiger and prey-population -Study on trans-border movement of swamp deer
Pilibhit Forest Division (now TR) (Lagga-Bagga, Barahi Range and Simra, Barahi Range, and Majarajnagar block of Bhira Range)	Intense cattle grazing and fuel-wood collection pressures in both these patches. Risk of retaliatory killing of tigers by poisoning livestock carcasses. Corridors threatened by proposed road development	Reduce cattle grazing. Issue permits and monitor cattle camps (Khattas) along Sharda and Chuka rivers. Enhance surveillance and patrolling.	Initiate compensation schemes for licensed cattle/ camps, where appropriate.	Have the Lagga-Bagga and Simra regions recognized and declared as wildlife corridors. -Plan for mitigation of proposed road projects through corridors.	Annually monitor tiger and prey populations in these corridors, conduct vegetation surveys and quantify cattle grazing pressure.

Key Transboundary sites	Key threats	Recommended protection/habitat restoration actions	Community engagement	Policy and advocacy	Research and monitoring
Kishanpur WLS and SKFD	High human-dependence on forests in some areas. Unregulated cattle grazing along the Sharda needs to be monitored.	Improve patrolling in riparian tracts along the Sharda and Ull rivers. Use of elephants may be necessary.	Build village level institutions and eco-development committees to reduce human impacts on forests in SKFD. Initiate education/ sustainable livelihood programs in Kishanpur, Tanda, Maharajnagar, Dhakka, Chandihazara and Chaltua villages.	Recognition of the Surai-Pilibhit-Kishanpur-south Kheri complex as a single habitat block - to streamline protection measures.	Annual monitoring. Details studies on hog-deer and swamp deer ecology, and effects of 'controlled burning', and timber removal.
Tatarganj (Sampoorna-Nagar Rahge, North Kheri FD)	High human presence in forests, poaching risk. Development activities and forest-land encroachment.	Increased year-round anti-poaching efforts. Need to restore encroached habitats.	Education and livelihood development programs in settlements around Tatarganj.	Recognition of the Tatarganj block as an important corridor areas linking Shuklaphanta with Pilibhit-Kishanpur.	Need for continuous monitoring of tiger use/ movement through this patch.
Laljhadi Corridor	Encroachment exists in Krishnapur (Kubgada, Eklegada, Chiurigada); Shankarpur (Nanda village: Bhetghatsibir); Baisibichawa (Doke bazar, Naurangagaun); and Raikarabichawa VDC Illegal logging is prevalent in all four VDCs and most intense in Baichebichawa VDC Prey poaching very common throughout the corridor. Open grazing is common in Baisechichawa, Raikawarbichawa and Krishnapur Human elephant conflict	Institutional set up in the district forest office to address the threats Capacity building and equipping the staff Strengthen year round anti-poaching efforts to deter poaching and illegal logging Secure all encroached sites and restore them with wildlife preferred species Restore the habitat linkage between Dudhwa NP and Laljhadi corridor from two ends of Laljhadi along the river	Integrated livestock management programs Alternative energy source to the fuelwood dependent communities Mobilize community based anti-poaching patrols throughout the year Plantation of trees that are most preferred by elephants; combination of strategies to address HEC Conservation outreach programs	Strong lobbying for removal of encroachment/ relocation of the villages inside corridor Support for government's master plan to remove encroachment from Laljhadi. Need for concerned government departments to initiate discussions with all stakeholders to address the problem of encroachment	Regular monitoring of wildlife and habitat

Key Transboundary sites	Key threats	Recommended protection/habitat restoration actions	Community engagement	Policy and advocacy	Research and monitoring
Basanta Corridor	Forest degradation Basanta is the most fragmented and encroached corridor especially in areas such as Lalbojhi, Pahalmanpur, Khailad, ratnapur and Masuriya Broken connectivity with Dudhwa National Park alongRatnapur, Bhajani and Lalbojhi Overgrazing is a key factor in arresting the natural regeneration and degrading the forest quality of Basanta Illegal logging exists throughout the corridor	Forest/habitat restoration is required from three major points that link the forest strips of Basanta with Dudhwa NP (Figure 15) Removal of encroachments from the core and all surrounding areas that have disrupted the connectivity Focused and planned interventions to restore and maintain the degraded strips of Basanta forest to facilitate wildlife movement Effective enforcement to deter logging, poaching and livestock grazing	Focused programs to gain the community stewardship in conservation Mobilize CBAPUs year round to deter logging, poaching and encroachment Support for relocation of villages from high flood prone sites.	High level political interventions to remove encroachments Support for government's master plan to remove encroachment; lobbying for Basanta to be given high priority. Punishment for illegal loggers and encroachers; the weightage of punishment be the same as that for poachers.	Assessment of the community programs carried out to date Annual monitoring of the wildlife and habitat in three strips of Basanta Tracking all community interventions that would be carried out in these sites.
Dudhwa NP	Tiger and prey populations appear to be below the habitat-based carrying capacity, possibly because of hunting. High levels of conflict between park administration and Tharu community. Human wildlife conflict along northern and southern boundaries Development of new roads will affect corridors.	Need for enhanced foot and elephant patrolling in forest interiors in all ranges. Grasslands need to be managed effectively by rotational cutting and burning in the winter months, particularly in Duhwa and Bankati ranges. Broken connectivity needs to be restored from both India and Nepal side	Measures to reduce conflict between the Tharu community and Park Management Development of livelihood and eco-tourism schemes in the Tharu belt, and strengthening of village-'level institutions for conservation.	Park is understaffed. The recruitment of new forest-guards and foresters must be treated as a priority. Engagement with the government of Nepal to increase law enforcement around Sathiyana and along the laljhari and Basanta corridors.	Regular monitoring of tiger, ungulate and elephant populations. Monitor grassland communities. Experimental studies on Teliocora removal.

Key Transboundary sites	Key threats	Recommended protection/habitat restoration actions	Community engagement	Policy and advocacy	Research and monitoring
	Spread of Teliocoraacuminata, a weedy climber. Pressure on forest resources and wildlife from villages in Nepal - particularly in Sathiyana and Bankati ranges Broken connectivity with Basanta and Laljhadi corridors of Nepal				
Karnali river corridor	Karnali river corridor is a highly sensitive zone for wildlife, provides vantage points for poachers Forest degradation, Intense cattle grazing, fuel wood collection and illegal logging, sand and stone quarrying and prey poaching are the major issues Loss of connectivity at several sites Human Wildlife Conflict especially HEC and crop raiding by ungulates is a major issue all along the river corridor	Need for regular and systematic patrolling to deter logging and poaching Strengthen enforcement measures to stop illegal sand and stone quarrying Strong vigilance to arrest prey poaching Restoration of sites with loss of connectivity (Figure 15) along Katerniaghat WLS	Conservation outreach programs Integrated livestock management programs coupled with alternative energy source Support for relocation of communities from flood prone areas Engage with communities to design better HWC meditative measures Support for both preventive and meditative measures	Recognition of Karnali river corridor as an important wildlife corridor and declaration for no go zone. Lobby for re-aligning proposed Hulaki highway away from the corridors. Design and facilitate HWC meditative measures	Annual monitoring of wildlife populations

Key Transboundary sites	Key threats	Recommended protection/habitat restoration actions	Community engagement	Policy and advocacy	Research and monitoring
Bardia National Park	Cattle grazing and prey poaching prevalent east of Rambapur to Chispani This sector has fairly homogeneous habitat and lacks sufficient wetlands and grassland to support high density prey. Encroachment of grassland by tree species such as Acacia catechu, Dalbergia sissoo and Bombaxc eiba and wetland by Ipomea spp. Human wildlife conflict (elephant, tigers, common leopard, rhino) and crop raiding by ungulates in all of the VDCs in buffer zones	Strengthen enforcement measures east of Rambapur Creation of wetlands and grasslands in eastern sector Regular management of the short grassland to maintain its productivity Continue the best practices in Karnali flood plain, Babai valley and buffer zones in south and north	Replicate community focused programs of Khata corridor in eastern and northern sector of Bardia Restore degraded forest patches in the buffer zones and areas adjacent to Banke National Park Form and mobilize CBAPUs in the eastern sector Engage with communities to design better HWC meditative measures		Long term ecological monitoring of tiger and prey base to establish population trend, understand population dynamics and response to management regimes
Khata corridor	Construction of 'Hulaki highway' (Nepalgunj-Dhangadhi highway) will bisect Khata corridor and severe the connectivity along patches of Khata forest Human Wildlife Conflict Several sites of Khata corridor are encroached especially in Suryapatuwa and Dodhari VDC	Strategic removal of encroachments and restoration of the vacated sites Khata being a high density tiger area there is the need to strengthen protection measures in the corridor using SMART protocol	Engage with communities to design better HWC meditative measures and Mobilize communities for regular patrolling of the corridor Support for relocation of the communities that are ready to move away due to villages being highly flood prone and human elephant conflicts.	Strong lobbying and advocacy and working with government of India to re-align Hulaki roads away from this corridor. Enabling conditions to secure the corridor from encroachment	Annual monitoring of wildlife Seasonal monitoring to understand the trans-border movement of tigers and other wildlife.

Key Transboundary sites	Key threats	Recommended protection/habitat restoration actions	Community engagement	Policy and advocacy	Research and monitoring
	In Suryapatuwa Ganeshpur Sisaniya CF, Pragatishil Mahila CF, Sukumbasi Tol, Sagun CF (Hikmatphanta), Amar Mahila CF (Amarpur), MahilaLaxmi CF (Ganga Patuwa), fdKhaireniPhanta, Asari CF, Kothiyaghat, Rajuwara CF have been encroached. Dohari VDC has encroachment in border between pillar 81 and 82, Kotahi MahilaCF(Beluwa), Kotahi Mahila CF(Beluwa), Gamakka) and between Pillar no. 85 and 86 Kalika CF, Samjaha CF (Bhagraiya), Balkumari CF (Bipatpur), Dalit mahila CF (Bhangaha), the forest have been encroached by Indians. Wildlife poaching (there is high likelihood of poachers to operate from the adjacent Taratal areas)				

Key Transboundary sites	Key threats	Recommended protection/habitat restoration actions	Community engagement	Policy and advocacy	Research and monitoring
Katerniaghat WLS	Narrow forest, with several existing motor roads and a railway line is threatened by the creation of a new (proposed road) Cattle grazing pressure is phenominally high in the seed-farm area, which is also important for wild ungulates. Poaching appears to be a problem in some areas. Habitat is very homogenous and lacking in water in Dharmapur and Murtiah ranges. Presence of large village enclaves along the Girwa river may affect some key tiger habitats.	Enhanced patrolling and grazing regulations. Stronger enforcement in Kakraha and Motipur Ranges. Need for heightened vigilance in the Katiyara are Trans-Girwa blocks which are connected with the Khata corridor and used by many large mammals.	Community involvement in conservation is particularly important in the Tharu villages along the Girwa River, settlements around the seed farm, and in kakraha and Motipur ranges. Engagement with ghauris(cattle camps) in the seed farm areas is essential.	“Functional” corridors connecting Bardia and Katerniaghat stand to be affected by roads. Need to realign proposed roads away from these corridors.	Annual monitoring of wildlife populations, and of use of the Khata and Karnali (Chhedia) corridors. Intensive studies in the seed farm to facilitate its restoration.
Banke National Park	Currently the park is understaffed Inadequate administrative units and basic resources for park staff Cattle grazing, fire wood collection Lack of grassland and wetlands Habitat fragmentation by canals and roads: Wildlife prone to falling in canals Village inside the park (Gotheri)	Capacity building of park and army staff to conduct SMART patrol in the park Strengthen enforcement in the park to reduce cattle grazing and fire wood collection Creation of grasslands and wetlands in several parts of the park	Conservation outreach programs Alternative energy source for local communities residing in the buffer-zone Identification of all the cattle herders and other forest dependent communities Alternative livelihood options to reduce forest dependency	Recruitment of all staff required for full administration of the park Enable administrative for better functioning of the park Lobby for placing meditative measures for fragmentation by canals (e.g piping water to several places of the park, creating water holes, fencing the canals to lead wildlife safely towards crossings) Facilitation of village relocation with the proper relocation package	Annual monitoring of tigers and prey (Banke NP provides the unique opportunity for long term monitoring since the return of tigers) Research on other wildlife such as four horned antelope, common leopard, hyena and reptiles Monitoring of wildlife along road and canals

Key Transboundary sites	Key threats	Recommended protection/habitat restoration actions	Community engagement	Policy and advocacy	Research and monitoring
Kamdi corridor/Dang Forest	Wildlife Poaching, Illegal logging, fire wood collection and livestock grazing occurs throughout the corridor Several sites of VDCs Kamdi, Kohalpur, Mahadevpuri and Phatepur are encroached Human wildlife conflict especially cattle and livestock depredation by common leopard are reported	Increased patrolling and surveillance especially along the border and forest interiors Train and equip forest staff and local communities for systematic joint patrolling and reporting Removal of encroachment and restoration with native species Restoration of vacated paddy fields in flood prone areas along Rapti river Effective livestock insurance program be initiated	Conservation outreach programs Formation and mobilization of CBAPUs to cover all of the Dang and Kamdi forest and establish the format for reporting Increase support for intelligence network Identification of the forest dependent communities Alternative energy program to reduce fuel wood dependency Support sustainable livelihoods of the forest dependent communities Support for livestock insurance program	Recognize Kamdi and Dang forest as an important wildlife habitat and facilitate its scientific management. Initiate dialect with all concerned government partners to remove encroachments	Annual monitoring of wildlife and habitat
Suhelwa WLS	High human and cattle presence in forest interior. Water limitation. Pressure from growing settlements along northern boundary (Nepal) and southern boundary make very little inviolate space available for wildlife. Proposed border road will further fragment wildlife habitats. Poaching seems to have decimated tiger and prey populations.	Increased patrolling, especially along water-sources and along the international border. Maintance of some disturbance-free areas around water sources. Regulation of cattle grazing and to-and-fro movement between India and Nepal through the forest.	Schemes to reduce dependence on fuel wood, and encourage stall-feeding of cattle. Conservation education. New recruitment of forest department staff, and development of capacity and infrastructure for law enforcement.	Increased financial and administrative support to strengthen law-enforcement and conservation initiatives. Recovery of tiger populations in Suhelwa (and adjacent Nepal forests) must be recognized as an important target.	Regular wildlife monitoring. Identification and protection of key wildlife habitats, particular along streams and reservoirs. Reduction of human pressure and livestock grazing within the sanctuary.

Key Transboundary sites	Key threats	Recommended protection/habitat restoration actions	Community engagement	Policy and advocacy	Research and monitoring
Forest between Dang and Nawalparasi	Very low prey density due to hunting, grazing and other disturbances High pressure of resource extraction	Control illegal hunting by increased law enforcement and community engagement Discourage people for the extensive use of forests	Aware community forest users on biodiversity issues beside the timber	Consider forests outside PAs as potential habitats and provide appropriate protection measures	Baseline survey about the biodiversity status Occupancy survey of the area annually
Sohagi-Barwa	Declining tiger signs Very low prey density due to hunting, grazing and other disturbances High pressure of resource extraction Poaching of wildlife	Increase protection, intelligence and surveillance in the area Expand protection network and construct new anti-poaching camps. Capacitate and equip staffs of forest department Need for extensive patrolling in park interiors and fringes Increased year-round anti-poaching efforts.	Build village level institutions and eco-development committees to reduce human impacts on forests Mobilize community based anti-poaching patrols throughout the year Focused programs to gain the community stewardship in conservation Conservation education to communities	Recovery of tiger populations must be recognized as an important target. Increased financial and administrative support to strengthen law-enforcement and conservation initiatives.	Establish baseline for wildlife and biodiversity through suitably designed surveys. Regular monitoring of wildlife population, and address threats identified in wildlife surveys.

Key Transboundary sites	Key threats	Recommended protection/habitat restoration actions	Community engagement	Policy and advocacy	Research and monitoring
Chitwan National Park	Human wildlife conflict especially with Elephant, tiger, rhino and ungulates Short grasslands shrinking and conversion into tall grassland and bushes Drying up of wetlands Habitat degradation from invasive plants (Mikania, Chromolaena, Lantena etc) Encroachment in buffer zone areas - Bandarjhula, southeast of Madi Valley, Manahari Proposed hulaki road and railway bisecting the park from the very core	Identify key areas of conflict and channelize the conflict mitigation activities such as predator proof corals Efficient and effective relief policy Regular grassland management Introduce more herbivores (wild water buffalo, swamp deer) Regular maintenance of wetland sites Removal of invasive species (physical or biological) - Assessment of the encroachment status and take actions, - prevent further encroachment	Aware locals about the behaviour of wildlife and responsible human behaviour towards wildlife Controlled rotation grazing on partnership with communities Promote alternative livelihood for river dependent communities Inform locals about the invasives Conservation education about need of evacuating the area	Develop human wildlife conflict management strategy Periodically revise the relief scheme - Create greater assemblage of different size herbivores Promote reintroduction of Wild water buffalo and swamp deer Stop any fishing licence, sand/gravel extraction etc. from the river & riverbanks Zero tolerance for encroachment Coordination and Support from all line agencies	Monitoring of tigers with focusing on the resident females and breeding performance over time Radio-telemetry study of the dispersing and problem individuals to better understand the use of degraded habitats and biological corridors as well as prevent poaching and conflict cases HWC extent, distribution as well as effectiveness of the mitigating measures

Key Transboundary sites	Key threats	Recommended protection/habitat restoration actions	Community engagement	Policy and advocacy	Research and monitoring
Barandabahar Corridor Forest	Encroachment for community structures (Stadium, religious and recreational sites etc.) Resource extraction Invasive plants - Mikania and Chromolaena Highway and feeder roads Garbage	Lobby to stop any encroachment Meet the needs from the community forest areas Removal or control of the invasives Flyovers or underpasses for wildlife crossing Implementation of speed limit and/or stop vehicles for certain hours in the night Strict prohibition for throwing garbage in any part of the corridor	Discourage any development works inside the forest (should come nationally) Promote alternative livelihood less dependent on forest Awareness about the corridor and their role as citizen	Implement the management plan of Barandabhar Protection forest Better coordination between two managing bodies i.e. district forest office - Chitwan and Chitwan national Park	- Long term monitoring of wildlife to understand the corridor functionality
Valmiki	Livestock grazing, Settlements in several sites Tiger and prey populations below the habitat-based carrying capacity. Pressure on forest resources and wildlife from villages Human wildlife conflict	Capacitate and equip department of forest staff to address grazing and other illegal activities Find solutions for removing settlements from and within core areas Increase protection, intelligence and surveillance in the area Promote forest independent alternative livelihoods Control any illegal killing/ hunting of the prey species Better prevention and relief schemes	Conservation education about need of wildlife and ecosystem Education about alternative livelihoods to reduce forest dependency Aware locals about the punishments for illegal entry, poaching or hunting	Recognition of the Valmiki-Chitwan complex as a single habitat block - to streamline protection measures. Joint patrolling particularly along the borders Sharing of intelligence information to prevent illegal activities Need for concerned government departments to initiate discussions with all stakeholders to address the problem of setllements	Regular monitoring of tigers and prey population to understand the population trends Immediate exercise on prey population estimation Identifying sites for reintroducing rhinos Working on creating more grassland habitat areas

Key Transboundary sites	Key threats	Recommended protection/habitat restoration actions	Community engagement	Policy and advocacy	Research and monitoring
Someshwor Hill Forest	Encroachment High dependency on forest resources Very low prey density - hunting might still going Human wildlife conflict and retaliatory killing	Evacuate the encroachment settlements of Bandarjhula, south and south east of Madi valley. Control any further encroachment. Promote forest independent alternative livelihoods Control any illegal killing of the prey species Better prevention and relief schemes	Conservation education about need of evacuating the area Education about alternative livelihoods Mobilize CBAPUs		Include this part as an extended habitat of Chitwan and consider for any park level survey. Synchronized survey of the area along with the Indian counterparts
Parsa Wildlife Reserve	Smuggling route (especially for drugs), - poaching, hunting and illegal logging Grazing Scarcity of water Sand/gravel extraction	Tracing out the smuggling trails and ambushing Strategic and long range patrolling Control grazing through intensive patrolling and Creation and maintenance of water holes in appropriate location Controlling sand and gravel extraction	Aware locals (both north and south) about the punishments for illegal entry, poaching or hunting in WR Promote stall feeding and productive livestock in buffer zone area	Parsa should be considered as high priority tiger recovery site Capacity building of the staff and extensive awareness programs around the Parsa WR is required	Camera trapping of tigers and monitoring prey in every two years Quantify types and amount of pressure of illegal human activities inside the WR Water availability & new water hole need

Key Transboundary sites	Key threats	Recommended protection/habitat restoration actions	Community engagement	Policy and advocacy	Research and monitoring
East of Parsa (Bara-Rautahat)	Fragmentation and encroachment Sand/gravel extraction from stream and riverbeds high pressure for resource extraction Low prey density and high people's pressure Nijgadh Kathmandu Fast track (4 lane road) No legal protection	Restore the areas which are already encroached and stop further encroachment Restrict sand/gravel extraction in certain sections Discourage people for the extensive use of forests Fencing, underpass etc. to prevent road accidents and allow movement of animals	Extensive Conservation awareness programs to the people on the fringe of the forests	Protected area status legal as a part of Parsa WR	Baseline survey about the biodiversity status Occupancy survey of the area annually

APPENDIX - II

Tiger abundance and density estimates in the PAs of transboundary TAL

We report parameter estimates for abundance from spatially explicit capture-recapture (SECR) models implemented in the R package SPACECAP (Gopalaswamy et al., 2012a) and from closed capture recapture models implemented in program MARK using the full likelihood/ Huggins parameterizations of closed-population capture recaptures models using heterogeneity effects (Cooch and White, 2010). For analysis in program MARK, given that the data for each site was are derived from multiple sampling blocks, we 'collapsed' data from multiple blocks, into a single block (Karanth and Nichols, 2002, "design IV"). Abundance was estimated by allowing capture probabilities (p) and recapture probabilities (c) to vary by time, behaviour and individual heterogeneity among tigers that encountered camera traps. Results from these analyses can also be found in DNPWC 2014, Chanchani et al. (2014), and Maurya and Borah (2014). Detailed descriptions of these models are available in Royle et al. (2013), and Cooch and White (2010).

In addition to site-specific estimates of population size of tigers (estimated in program MARK), estimates of the "super population"(Nsuper) of tigers from Bayesian capture-recapture analyses associated with each site have also been reported. The super-population refers to the number of tiger activity (home-range) centres distributed within the sampled area (park/PA) and additional outlying areas categorized as habitat and lying within the buffered area for spatially explicit capture-recapture analysis. For more details on Bayesian SECR models please refer Royle et al. (2009 a,b) and Gopalaswamy et al. (2012 a,b).

Tiger abundance and density estimates in PAs of transboundary TAL

Sl. No.	Site	Mt + 1 (no. of unique individuals captured) > 2 years old	Population estimates with N_{super}*(CI) (Bayesian SECR)	Density CI (Bayesian SECR)	Population estimates with closed mark recapture (MARK)	Detection probability from closed CR (MARK) with SE	ESA*
1	Parsa WR	4	7 (4-13)	0.65 (0.38-1.24)	4 (4-5)	0.13	801.7
2	Chitwan NP	78	120 (98-139)	3.84 (3.15-4.46)	87 (81-107)	0.14 (0.02)	2625.9
3	Valmiki TR**	10	21(18-26)	1.05 (0.88-1.28)	11 (10-25)	0.22 (0.02)	900
4	Banke NP	3	4 (3-7)	0.16 (0.1-0.29)	3 (3-3)*too small dataset	0.5 (0.2)	687.4
7	Bardia NP	44	50 (45-55)	3.38 (3.02-.3.7)	44 (44-53)	0.24 (0.08)	1143.08
8	Katerniaghat WS	17	34(22-45)	2.22 (1.50 - 2.69)	17 (17-24)	0.26 (0.02)	734
9	Dudhwa NP	14	26(17-35)	1.89 (1.27 - 2.54)	14 (14-22)	0.4 (0.30)	778
10	Kishanpur WS **	16	32 (22-43)	4.92 (3.37 - 6.58)	16 (16-18)	0.22 (0.01)	330
11	Pilibhit RF (Proposed TR)	23	60(41-80)	3.44 (3.37 - 6.58)	23 (23-28)	0.13 (0.03)	726
12	Shuklaphanta WR	13	17 (13-21)	3.4 (2.67 - 4.32)	14 (13-18)	0.5 (0.11)	385.7

*Effective Sampling Area (ESA) is given by D=n/â, where $a = \int p.(X:\theta)dX$ (Borchers and Efford 2008). This is reported by software DENSITY when using MLSECR models.

** The closed population CR estimate for MARK reflects a population in a subset of the total sampled area for Valmiki and Kishanpur. Total sampling period in Valmiki TR exceeded 60 days because of the limited availability of camera traps. The reported Mt+1 is for the 60 days trapping period, and the estimates for density and abundance are for a 60 day period, for data derived from two sampling blocks. In Valmiki, we sampled beyond the recommended closure period covering the entire tiger reserve in smaller blocks (5 blocks) which gave us a minimum number of 22 unique tigers as reported in Table 3. Similarly, the reported Mt+1 in Kishanpur WS, exclude the south Kheri forest division area adjacent to Kishanpur. Considering these additional data/ figures, the total minimum number of individual tiger's photo captured was 239 as reported in Table 3.

APPENDIX - III

Management regimes, roles and responsibilities in Nepal and India

Management Category	Details	India	Nepal
Protected Areas	Protection (Core)	Forest Department	Nepal Army and Park Game Scouts
	Protection (Buffer zone)	Forest Department	Nepal Army and CBAPUs
	Community Rights	Strictly prohibited in core areas but selective resource use allowable in buffer zones	Limited use rights in core areas (grass/thatch collection allowed during certain period of the year). Resource managed and used based on community forest operational plan
	Tourism	Regulated tourism in selected zones	Regulated tourism
	Habitat Management	Forest Department	Park and Buffer zone community forest
	Research and monitoring	National Tiger Conservation Authority and State Forest Department	Department of National Park and Wildlife Conservation
Corridors/ Protection Forest /RF/NF	Protection	Forest Department	Department of Forest, Communities, CBAPUs
	Community rights	Open access	• **Protection Forest/ Corridors:** Resource managed and used based on protection forest management plans • **National Forest:** Open Access for resource extraction except timber • **Community Forest:** Resource managed and used based on community forest operational plans
	Tourism	Tourism potential not yet explored	Tourism regulated by communities
	Habitat Management	Limited	Limited management
	Research and Monitoring	Forest Department/ WWF-India/Other stakeholders	Department of Forest

APPENDIX - IV

Summary of camera trap efforts in transboundary protected areas

Sl. No.	Site	Camera stations	Trapping effort (nights)	Area sampled (MCP)	Trapping period
1.	Parsa WR	177	5310	801.93	18 April-26 May, 13
2.	Chitwan NP	362	10860	2626	14 Feb-3 May, 13
3.	Valmiki TR	270	6688	-	Feb-June 13
4.	Banke NP	118	3540	687.41	5 Mar-29 April, 13
5.	Sohagibarwa WR	No survey	-	-	-
6.	Suhelwa WR	No survey	-	-	-
7.	Bardia NP	238	7140	1485.54	5 Mar-29 April, 13
8.	Katerniaghat WS	111	3663	782.08	15 Nov - 15 Feb, 13
9.	Dudhwa NP	202	4861	756.31	20 Feb - 20 April, 13
10.	Kishanpur WS	67	2655	219	25 April - 3 May, 13
11.	Pilibhit RF (Proposed TR)	171	2814	1393.58	25 April - 25 June, 13
12.	Shuklaphanta WR	88	2640	485.76	10 Feb-15 Mar, 13

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