Status of Tigers and Prey in Nepal

Government of Nepal

Ministry of Forests and Soil Conservation

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Foreword

Tigers are a masterpiece of nature and stand at the top of the food chain. The Convention on International Trade of Endangered Species of Wild Fauna and Flora (CITES) lists the tiger in Appendix-I, and it is endangered in the International Union for the Conservation of Nature's Red Data Book. In Nepal, it is a protected species under the National Parks and Wildlife Conservation Act 1973. Tiger numbers have been steadily declining across its range, mainly due to anthropogenic pressures. Major threats to wild tigers in Nepal are degradation, fragmentation and loss of habitats; poaching and illegal trade of tiger body parts; loss of prey base; and retaliatory killing due to human-tiger conflicts. In order to address them, the Government of Nepal together with its conservation partners has been implementing a range of integrated interventions to secure viable breeding population in the wild and save Nepal's tigers from extinction.

The Government of Nepal committed to double the tiger number by 2022 at the Tiger Summit in St Petersburg, Russia in 2010. To fulfill its commitment potential tiger recovery sites were identified, and the Government has been working to reduce key threats and improve habitat quality. There is a focus on corridors and connectivities between core tiger areas within Nepal and between Nepal and India to enable tiger dispersal and avoid genetic isolation. There has been a major focus on reducing human-tiger conflict and building local community stewardship in tiger areas where people are dependent on forests for livelihoods. These activities are in line with the Global Tiger Recovery Plan 2010 produced jointly by all the tiger range countries based on their National Tiger Recovery Plans.

In order to monitor the effectiveness of tiger conservation interventions, the Government of Nepal conducted a national tiger and prey base survey across its national tiger range during the dry season of 2012-2013, in partnership with WWF Nepal, the National Trust for Nature Conservation (NTNC), and the United States Agency for International Development (USAID) funded Hariyo Ban Program. This was a rigorous exercise to understand the tiger and prey status using the national tiger research and monitoring protocol in all potential tiger habitats in the Terai Arc Landscape including protected areas, national forests, and corridors. This national census showed 63% increase in tiger number: from 121 in 2008-09 to 198 in 2012-13. This is indeed a major milestone in tiger conservation and a very encouraging result for all government agencies and conservation allies working dedicatedly on tiger conservation.

This report presents the results of the tiger and prey base survey carried out during 2012 and 2013 using state-of-the-art conservation science technology. I would like to express my sincere thanks to all the government and partner organizations' technical experts and frontline field staff for all the long hours of planning, field work, analysis and report preparation. The National Trust for Nature Conservation, WWF Nepal and the USAID funded Hariyo Ban Program deserve special thanks for their financial and technical assistance. Last but not least I would like to appreciate the major contribution of local communities and other stakeholders who are directly or indirectly involved in ensuring the long term survival of this magnificent but highly endangered large predator.

Ganesh R. Joshi

Ganesh Raj Joshi, PhD
Secretary

Government of Nepal
Ministry of Forest & Soil Conservation
Department of National Parks & Wildlife Conservation

Acknowledgement

In line with the commitment made at the Global Tiger Forum 2010 at St. Petersburg, Russia to double the global number of tigers by 2022, Nepal has been able to lead the way towards the goal by increasing its number of tigers by 63% between 2008-09 and 2012-13. Publishing this result of the nationwide tiger survey 2012-13; ***Status of Tigers and Prey in Nepal,*** gives all of us an immense satisfaction, pride and most importantly an encouragement to continue our tireless efforts to save the magnificent but endangered animal. The survey was conducted by the Government of Nepal in collaboration with National Trust for Nature Conservation (NTNC) and WWF Nepal

I would like to extend my sincere thanks to every individual and institution who made the nationwide survey and publication of this report possible. For their untiring work throughout the survey, I extend my particular thanks to the technical committee members; Dr. Maheshwar Dhakal, Ecologist, Department of National Parks and Wildlife Conservation, Ms. Madhuri Karki (Thapa); Undersecretary, Department of Forests, Dr. Shant Raj Jnawali; Coordinator, Hariyo Ban Program (WWF Nepal), Dr. Narendra Man Babu Pradhan, Research Coordinator, WWF Nepal and Dr. Naresh Subedi; Senior Officer, NTNC.

My special thanks go to all Chief Conservation Officers and their staff of Chitwan, Bardia, and Banke National Parks, Parsa and Shuklaphanta Wildlife Reserve; District Forest Officers of Terai Arc Landscape (TAL) and their staff of -tiger bearing forest districts- for their participation and support in the field survey. Dr. Chiran Pokhrel, Hemanta Yadav, Rabin Kadariya and Mr. Babu Ram Lamichhane of NTNC and Ms. Sabita Malla and Mr. Gokarna Jung Thapa of WWF Nepal deserve special thanks for their outstanding contribution in conducting the fieldwork and publishing the report. Besides, Nepal Army, Buffer Zone Councils, ITNC and University students also deserve especial thanks.

The technical and financial support of WWF Nepal (WWF US, WWF UK, WWF Australia, USFWS and Di-Caprio Foundation), NTNC and USAID funded Hariyo Ban Program to carry out the field work have been undeniably instrumental and deserves special acknowledgement. In addition, I would like to thank the Green governance Nepal, particularly Mr. Kiran Timilsina and Nabaraj Chapagain for their support in data collection, compilation and publication process.

I hope that this report will be useful to all protected area managers, policy-makers, academia, and general readers nationally and internationally.

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Director General

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List of Acronyms

AIC	Akaike Information Criterion
BaNP	Banke National Park
BNP	Bardia National Park
CARE	Cooperative for Assistance and Relief Everywhere
CBS	Central Bureau of Statistics
CI	Confidence Interval
CNP	Chitwan National Park
Dg	Group Density
DNPWC	Department of National Parks and Wildlife Conservation
DoF	Department of Forests
DOF-P	Goodness of Fit
ESW	Effective Strip Width
ETA	Effective Trapping Area
FECOFUN	Federation of Community Forest Users Nepal
GPS	Global Positioning System
GS	Group Size
GTRP	Global Tiger Recovery Program
ITNC	International Trust for Nature Conservation
MCP	Minimum Convex Polygon
MMDM	Mean Maximum Distance Moved
NTCC	National Tiger Conservation Committee
NTNC	National Trust for Nature Conservation
NTRP	National Tiger Recovery Program
PA	Protected Area
P-hat	Detection Probability
Psi	Probability of sites occupied
PWR	Parsa Wildlife Reserve
SD	Standard Deviation
SE	Standard Error
SECR	Spatially Explicit Capture Recapture
SMART	Spatial Monitoring and Reporting Tool
SWR	Shuklaphanta Wildlife Reserve
TAL	Terai Arc Landscape
TRC	Tiger Range Countries
VDC	Village Development Committee
WCCB	Wildlife Crime Control Bureau
WWF	World Wildlife Fund

Executive Summary

This report highlights the status of the tiger and its prey population in Nepal. It presents a study carried out in the Nepal part of the Terai Arc Landscape (TAL), spanning 14 districts of the Terai from Rautahat in the east to Kanchanpur in the west and covering a total area of 21,600 km^2. A similar study was undertaken simultaneously in the Indian part of TAL, and is documented separately.

The Nepal study was carried out jointly by the Department of National Parks and Wildlife Conservation (DNPWC), Department of Forests (DoF), World Wildlife Fund (WWF) Nepal, and National Trust for Nature Conservation (NTNC). It was made possible through generous funding support from the United States Fish and Wildlife Service (USFWS), Leonardo DiCaprio Foundation, WWF US, WWF UK, WWF Australia and the United States Agency for International Development (USAID) funded Hariyo Ban Program.

The study involved data collection by 268 trained personnel working with DNPWC, DoF, WWF Nepal, NTNC, International Trust for Nature Conservation (ITNC), Nepal Army, Nature Guides, Buffer Zone User Committees and students from Tribhuwan University, Pokhara University and Kathmandu University, with more than 17,600 person days.

Camera trapping was used to estimate the tiger population by deploying camera traps in 1,039 grids of 2 km X 2 km in all tiger bearing protected areas, namely: Parsa Wildlife Reserve (PWR), Chitwan National Park (CNP), Banke National Park (BaNP), Bardia National Park (BNP) and Shuklaphanta Wildlife Reserve (SWR), together with major forest corridors: Barandabhar, Khata, and Basanta. Approximately 4,000 km^2 was sampled with a total sampling effort of 15,585 trap days. These surveys were designed to maximize spatial coverage, and to sample all potential tiger habitats including parts of the Churia forest that was previously not surveyed. Prey species were monitored using line transect sampling; 784 line transects were surveyed with a total sampling effort of 1,669 km. Similarly, habitat occupancy surveys involved 2,322.6 km of foot surveys intensively looking for animal signs and recording human disturbance.

Data analysis was carried out using contemporary analytical methods including spatially explicit capture recapture (SECR) models for estimating tiger population and density, and site occupancy models for estimating tiger habitat occupancy. Distance analysis was carried out to estimate densities of prey species from line transect sampling.

A total of 142 individual tigers (CNP-78; BNP-44; SWR-13; PWR-4 and BaNP-3) were identified through careful examination of 7,699 tiger photographs obtained from camera traps. The total tiger population in Nepal was estimated at 198 individuals (163-235) including 120 in CNP (98-139); 50 in BNP (45-55); 17 in SWR (13-21); 7 in PWR (4-13); and 4 in BaNP (3-7) with density estimates of 3.84, 3.38, 3.4, 0.65 and 0.16 tigers/100 km^2, respectively. The population occurs in four distinct sub-populations with little movement between them, though it is highly likely that movement occurs between India and Nepal, and may have contributed to the population increase in Nepal.

The highest prey density was found in BNP with 92.6 animals/km^2 followed by SWR (78.62) and CNP (73.63). PWR and BaNP had notably lower prey densities (PWR-25.33 and BaNP-10.27 animals/km^2). Chital (*Axis axis*), sambar (*Cervus unicolor*), hog deer (*Axis porcinus*), wild boar (*Sus scrofa*), barking deer (*Muntiacus muntjak*), swamp deer (*Cervus duvauceli duvauceli*), langur

(*Semnopithecus entellus*) and rhesus monkey (*Macaca mulatta*) were the major tiger prey species.

Tiger signs were detected in 12 of the 14 districts in TAL (Rautahat, Bara, Parsa, Makwanpur, Chitwan, Nawalparasi, Kapilvastu, Dang, Banke, Bardia, Kailali and Kanchanpur). Tiger habitat occupancy (Psi) was estimated to be 0.55 (0.44-0.66) in TAL which is an increase of 50% from 0.37 in 2008-09 to 0.55 in 2013.

These results indicate that the tiger population in Nepal has increased by 63% over the past 5 year period (2008-2013) which corresponds with the 50% increase in tiger habitat occupancy in Nepal TAL. Similarly, the prey base density in most of the protected areas has increased over the same period. The substantial increase in the tiger population and prey base density reflects current conservation efforts in Nepal, including habitat restoration, control of poaching and illegal wildlife trade, and engagement of local communities in conservation.

This survey has been helpful in generating fine-scale information on the occurrence and abundance of tiger and prey species across the landscape in Nepal, and results should be applied in the revision of the TAL ten-year strategy in 2014, and in the production of site-specific tiger recovery plans. In order to help Nepal reach its target of doubling the 2010 tiger numbers by 2022, the study makes several recommendations for maintaining and improving tiger management, including enhancing habitat management for tiger and prey, and restoring habitat connectivity. The study also recommends ways to reduce key threats to tigers including: control of illegal hunting and trade; mitigating the impacts of infrastructure development including upstream hydropower and irrigation; reducing traffic accidents with wildlife; and reducing human disturbance in tiger habitats. It emphasizes the importance of mitigating human-tiger conflict, particularly in light of increasing tiger numbers and enhanced dispersal, and involving local communities in conservation. As climate change advances there will be major impacts on habitats, prey species and hence the tiger population, and ecological resilience building and climate adaptation measures need to be mainstreamed into tiger management. Further applied ecological and socio-economic studies are recommended to better understand the threats to the tiger population and refine management.

Tiger conservation does not take place in a vacuum. It is important to take into account the evolving social, economic, political and climatic conditions in this heavily populated landscape, the new threats that this brings (e.g. from infrastructure development), and also opportunities (e.g. through reducing emissions from deforestation and forest degradation, REDD+). The good news is that despite many challenges, Nepal has made major progress towards its goal of doubling tiger numbers by 2022. The challenge now is to maintain this momentum and find ways to accommodate additional tigers while mitigating human-tiger conflict and reconciling tiger management with other land uses.

1

Introduction

Tigers are a symbol of power and are mystical and majestic creatures. They are an umbrella species and symbolize the plight of wildlife across Asian ecosystems. Tigers are also deeply embedded in the cultural history of Asia (Lumpkin 1991). At the turn of the 19th century the global tiger population was estimated at 100,000 individuals, distributed from the forests of eastern Turkey and Caspian region of western Asia, all the way to the Indian sub-continent, China, Indo-China, south to Indonesia, and north to Korean Peninsula and Russian far-east (Sunquist 1981). Unfortunately, human activities such as habitat destruction, loss of prey, sport hunting, poaching and illegal trade in tiger parts resulted in drastic decline with the global population declining to as low as 3,200 by 2010 (GTRP 2010). Once distributed widely, tigers are now confined to 7% of their historical range in 13 countries of the world. To address this global tiger crisis, the Global Tiger Summit 2010 was held in St. Petersburg, Russia where the heads of Governments of the 13 tiger range countries committed to double wild tiger populations by 2022 and endorsed the Global Tiger Recovery Program (GTRP). The Government of Nepal committed to double Nepal's tiger population by 2022 and has been implementing the National Tiger Recovery Program (NTRP) since 2010.

Information on the status of tiger and its distribution is integral to developing conservation strategies and programs to safeguard tiger populations in the landscape. The first country level assessment of tiger populations in Nepal was conducted in 2008-09 which was successful in identifying core tiger populations in the country and showcasing key anthropogenic pressures affecting them. It estimated the tiger population at 121 individuals (100 -191) in Nepal with 91 (71-147) in CNP, 4 (4-4) in PWR, 18 (17-29) in BNP and 8 (8-14) in SWR (Karki et al. 2009). Tiger habitat occupancy (Psi) in TAL was found to be 0.37 (Barber-Meyer et al. 2012) and prey density was estimated at 5.5 animals/km^2 for PWR, 62.6 animals/km^2 for CNP, 67.8 animals/km^2 for BNP and 86.2 animals/km^2 for SWR.

The information generated through the first assessment was used to leverage major changes in policy as well as field level tiger conservation in Nepal. The major conservation successes since then include the declaration of BaNP, addition of buffer zone in BNP, declaration of major corridors as protection forests, establishment of the National Tiger Conservation Committee (NTCC) under the chairmanship of the Prime Minister, creation of a special tiger conservation fund, and the commitment to double tiger numbers by 2022. Therefore, to build upon these important national endeavors, monitor early progress and better operationalize tiger conservation efforts in Nepal, the second national level survey of tiger and prey base was executed during 2013. It was designed to evaluate the effectiveness of management interventions undertaken in all the protected areas and the wider landscape since the previous tiger survey. It was done concurrently with a survey in the Indian TAL using compatible methodologies, to enable a more complete picture of the TAL tiger population including movement across the border.

The field implementation in Nepal was jointly undertaken by DNPWC, DoF, NTNC and WWF Nepal. The survey was carried out using the latest science and technology, refining the earlier design with wider coverage across all potential tiger habitats.

Funding support for the Nepal survey was made possible by the United States Fish and Wildlife Service (USFWS), WWF US, WWF Australia, WWF UK, the DiCaprio Foundation and the United States Agency for International Development (USAID)-funded Hariyo Ban Program (a consortium of WWF, NTNC, Cooperative for Assistance and Relief Everywhere (CARE), and Federation of Community Forest Users Nepal (FECOFUN)).

Rapti floodplain in Chitwan National Park-©NTNC/Naresh Subedi

2

History of Tiger Conservation in Nepal

The history of tiger conservation in Nepal dates back to as early as the 1930s when the forests in the Nepal Terai were continuous from east to west and were popularly known as *charkose jhadi* (miles of forest). These forests had been maintained as a defensive frontier to deter invasion from British India during the 19th and 20th centuries (Mishra and Jefferies 1991). The Terai forests were famous as hunting grounds of the ruling class and visiting dignitaries; several anecdotal records describe large-scale hunting expeditions in Nepal (Smythies 1942). Historical records of King George V's visit to Nepal describe a hunting expedition when as many as 39 tigers were killed over a week-long period. These records suggest that the Terai forests supported a high tiger density.

In the 1950s, the Government of Nepal undertook a malaria eradication campaign and initiated a massive resettlement program in Terai which resulted in clearing of large tracts of forest, and the destruction of much wildlife and habitat. Realizing the urgency to protect wildlife, the National Park and Wildlife Conservation Act, 1973 was enacted by the Government of Nepal which envisioned the creation of national parks and other protected areas. Chitwan National Park was established as the country's first national park in the same year. The Tiger Ecology Project was initiated in 1973 as a joint venture of the Government of Nepal, Smithsonian Institution and WWF to conduct long-term ecological research on tigers. This was the first study which blended traditional and modern technologies and provided unprecedented insights on tiger ecology and behavior (Sunquist 1981; Smith 1993), and formed the basis for tiger research and monitoring across the globe. The knowledge generated by the Tiger Ecology Project was applied by the Government of Nepal in ecosystem-scale management of the Chitwan tiger population by expanding tiger habitat east of Chitwan as Parsa Wildlife Reserve (Smith 1993). The government of Nepal established the DNPWC in 1980 for effective conservation and management of protected areas in Nepal. Subsequently, Bardia National Park and Shuklaphanta Wildlife Reserve were established in the Terai.

For over three decades, conservation efforts in Nepal were focused on establishing and managing the protected area system in isolation (Heinen and Yonzon 1994); people were not initially considered an integral part of conservation. However, recognizing the importance of community participation in wildlife conservation, the Government of Nepal initiated the Buffer Zone Management Program in 1996 and made provision for 30-50% of the park's revenue to be used for biodiversity conservation and development of the communities in the buffer zones. This helped provide economic incentives to the local communities which in turn promoted development of local stewardship for wildlife conservation.

By the late 1990s it was realized that conserving tigers within protected areas was not an adequate strategy in itself (Wikramanayake et al. 1998). The Terai Arc Landscape Program was therefore initiated in 2001 to mainstream landscape level conservation which aimed to connect protected areas in the Nepal and Indian Terai through habitat corridors so as to facilitate safe tiger dispersal and

manage tiger as a meta-population. In Nepal the Government of Nepal prepared and implemented the Terai Arc Landscape Strategic Plan (2004-2014) and the Tiger Conservation Action Plan for Nepal (2008-2012) which have significantly contributed to the conservation of tigers, co-predators, prey and their habitats in Nepal.

Nepal was a key player in the "St. Petersburg Declaration on Tiger Conservation" signed by the heads of Governments of the thirteen Tiger Range Countries (TRCs) on November 23, 2010 that agreed to double the number of wild tigers across their range by 2022. The Government of Nepal committed to double the country's tiger numbers from 121 to 250 individuals by 2022. Following this, a new protected area, Banke National Park was declared in 2010 to provide additional tiger habitat and contribute to the national effort. Similarly, important corridor forests (Barandabhar, Khata, Basanta and Laljhadi-Mohana) were declared as Protection Forests in 2012. The National Tiger Conservation Committee (NTCC) was formed under the chairmanship of Rt. Honorable Prime Minister of Nepal. Aiming at curbing wildlife trade, a Wildlife Crime Control Bureau (WCCB) with offices in 18 districts have been created. Currently, the Government of Nepal is implementing the National Tiger Recovery Program (NTRP) under the broader framework of the Global Tiger Recovery Program (GTRP) 2010-2022. The Government of Nepal has also allocated additional financial resources to strengthen tiger conservation efforts in Nepal.

Sambar resting in Icharny, Chitwan National Park-©NTNC/Naresh Subedi

3

Tiger Habitats in Nepal

3.1 Terai Arc Landscape (TAL)

The 49,500 km^2 Terai Arc Landscape (TAL) stretches from the Bagmati river in Nepal to the Yamuna river in India, occupying the foothills of the Himalayas and encompassing 16 protected areas of Nepal and India (Map 1). In Nepal the TAL covers 14 Terai districts from Rautahat in the east to Kanchanpur in the west with an area of 23,199 km^2. It includes over 75 percent of the remaining forests of the Terai and foothills of Churia. TAL has special merit as the only place on earth where the ranges of Asiatic elephant (*Elephas maximus*), Greater one-horned rhinoceros (*Rhinoceros unicornis*) and Bengal tiger (*Panthera tigris*) overlap. Since its inception in 2001, TAL has been a model for restoring populations of endangered mega fauna through pioneering innovations and approaches to conservation management in Asia. PWR, CNP, BaNP, BNP and SWR hold the core tiger sub-populations in Nepal.

Historically, tigers were distributed across the lowland Himalayan forests in Nepal but surveys made between 1987 and 1997 documented only three isolated tiger sub populations: Chitwan-Parsa, Bardia, and Shuklaphanta (Smith et al. 1998; Karki et al. 2009). The presence of tigers in several corridor forests suggests that the forests outside protected areas play a vital role in managing tigers as meta-population in TAL. Therefore, a landscape approach is critical to the long-term conservation of tiger populations. TAL in Nepal comprises of the following PAs and important wildlife corridors.

3.2 Protected Areas

Parsa Wildlife Reserve, Chitwan National Park, Banke National Park, Bardia National Park and Shuklaphanta Wildlife Reserve hold the core tiger sub-populations in Nepal (Map 1).

3.2.1 Parsa Wildlife Reserve

Parsa Wildlife Reserve (N: 27.1330 to 27.5498; E: 84.6581 to 85.0245) covers an area of 499 km^2 and is located in the south-central lowland Terai. It is connected to Chitwan National Park to the west and extends to the Birgunj Hetauda highway in the east. Located in the south central lowland of Nepal, it occupies parts of Chitwan, Makwanpur, Parsa and Bara districts of Nepal. Since it is contiguous with Chitwan National Park in the west it potentially provides habitat for dispersing tigers from Chitwan. It is connected to Valmiki Tiger Reserve in India through a narrow strip of forest along Thori-Nirmalbasti.

3.2.2 Chitwan National Park

Chitwan National Park (N: 27.2836 to 27.7038; E: 83.8457 to 84.7472) covers an area of 932 km^2 in south central Nepal in the inner Terai. It was gazetted in 1973 as the first national park of Nepal, and was listed as a World Heritage Site in 1984, recognizing its unique ecosystems of international significance. The park is contiguous with Parsa Wildlife Reserve in the east and Valmiki Tiger Reserve, India, in the south, forming the Chitwan-Parsa-Valmiki Tiger Conservation Landscape which is 1,767 km^2. This landscape forms the level I Tiger Conservation Landscape and supports one of the largest tiger populations

Rapti River floodplain, Chitwan National Park-©WWF Nepal/Sabita Malla)

in South Asia (Wikramanayake et al.1998; Dinerstein et al. 2006).

3.2.3 Banke National Park

Banke National Park (N: 27.9686 to 28.3384; E: 81.6603 to 82.2054) was declared as Nepal's tenth national park on 12th July, 2010 after its recognition as a "Gift to the Earth". It is contiguous with Bardia National Park and provides an opportunity to support more tigers in the Banke-Bardia complex to contribute to the goal of doubling tiger numbers in Nepal. BaNP covers an area of 550 km^2 and is bordered by a buffer zone of 344 Km^2 in the districts of Banke, Salyan and Dang. Together with the neighboring Bardia National Park, the protected area complex covers 1,518 km^2. BaNP has both national and international conservation value as it is connected with the Suhelwa Wildlife Sanctuary in India through the Kamdi forest corridor.

3.2.4 Bardia National Park

Bardia National Park (N: 28.2630 to 28.6711; E: 81.1360 to 81.7645) covers an area of 968 km^2 and is located in the mid-western lowlands of Bardia, Banke and Surkhet districts. The east-west highway divides the Karnali floodplain and Babai valley into two different administrative zones. The Karnali floodplain is situated in the western part of the park and is a biodiversity hotspot with an important mammalian assemblage. The Babai valley extends from Parewaodar to Chepang and covers more than 50 percent of the park. Highly affected by prey poaching in the past, numerous management interventions including anti-poaching activities are focused in the valley to revive the tiger and prey in the area.

3.2.5 Shuklaphanta Wildlife Reserve

Shuklaphanta Wildlife Reserve (N: 28.7193 to 29.0515; E: 80.0609 to 80.4120) covers an area of 305 km^2 and is located in the far-western lowland of Nepal. It is connected to two Indian protected areas: Pilibhit Tiger Reserve through Laggabagga and Tatargunj corridors in the south; and Dudhwa National Park in the southeast through the Laljhadi-Mohana corridor. The tiger sub-population in the reserve is steadily increasing after a sharp decline during the armed conflict in Nepal.

3.3 Forests and Corridors Outside Protected Areas

Forests outside protected areas in Nepal are managed by the Department of Forests under five different categories: Government Managed Forest, Protection Forest, Leasehold Forest, Religious Forest and Community Forest. The important corridors (Map 1) that connect PAs and larger forest patches within Nepal and with India are as follows:

3.3.1 Kamdi-Kapilvastu Corridor

The corridor covers an area of 395 km^2 and is contiguous with BaNP to the north and Suhelwa Wildlife Sanctuary in India to the south. The Rapti river valley and Dang-Kapilvastu corridor are contiguous with it in the east. The corridor is frequented by elephants. The corridor has a human population of 82,419 in over 15,100 households (Central Bureau of Statistics (CBS) 2011).

3.3.2 Khata Corridor

This corridor connects BNP in Nepal with Katarniaghat Wildlife Sanctuary in India. Tiger, rhino and elephant are known to move through this corridor between the protected areas. The Khata corridor covers approximately 92.5 km^2 and its width varies from 0.5 to 4 km. The corridor comprises 5 VDCs: Baganaha, Dhodari, Shivpur, Suryapatuwa and Thakurdwara, with a population of 45,171 people (CBS 2011).

3.3.3 Basanta Corridor

The Basanta Corridor covers an area of 655 km^2 in Kailali district and connects Shuklaphanta Wildlife Reserve and Bardia National Park in Nepal with Dudhwa National Park in India through forests in the Churia foothills. There are 11 VDCs in the Basanta corridor with a human population of 135,831 people (CBS 2011). Forest

encroachment in the corridor has been identified as a major conservation challenge.

3.3.4 Karnali River Corridor

The Karnali river corridor is contiguous with BNP in the east and Katerniaghat WS in the south, and covers an area of 150 km^2. The area is annually flooded and has rich riverine forests and grassland. The corridor is connected to Churia forests in north and plays an important role in the dispersal of flagship terrestrial species and freshwater species.

3.3.5 Laljhadi-Mohana Corridor

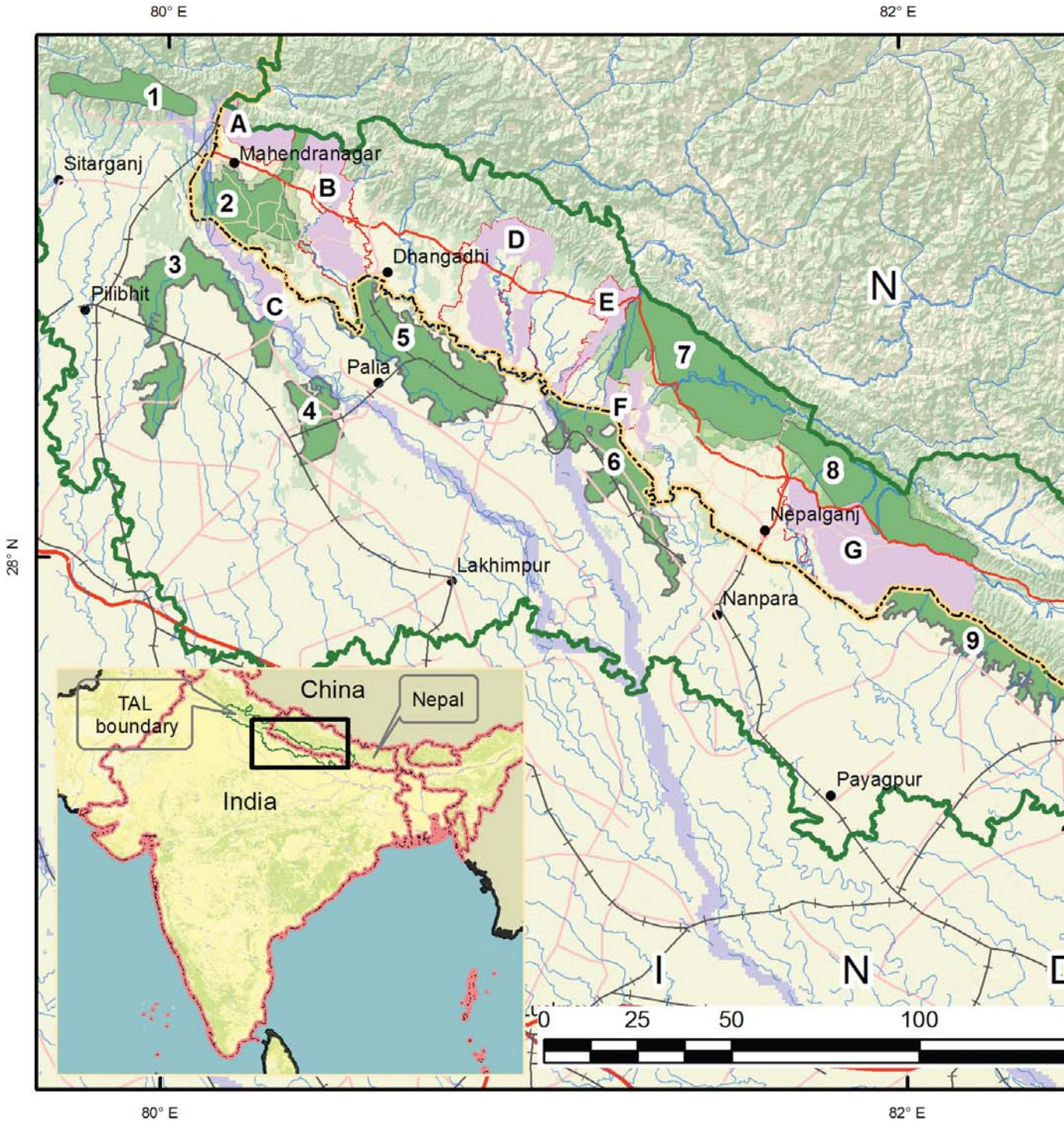
The Laljhadi-Mohana corridor connects Dudhwa National Park in India and SWR in Nepal. It covers an area of 354 km^2. The corridor is frequently used by elephant and tiger. Currently, the corridor is inhabited by 63,060 households with 333,156 people (CBS 2011).

3.3.6 Brahmadev Corridor

Brahmadev corridor is located in the northern part of Kanchanpur district and covers an area of 160 km^2. It connects with SWR in Nepal and Nandhor Wildlife Sanctuary in India through Boom-Brahmadev Churia forests. It is a historic elephant route and a dispersal route for other flagship species. It has a human population of 175,710 with an estimated 33622 households (CBS 2011).

3.3.7 Barandabhar Corridor

The corridor connects Chitwan National Park (CNP) with the Mahabharat range to the north and covers an area of 161 km^2. It is also a very important biological corridor for the Gandaki river basin, connecting the Terai with higher altitude areas and could play a very important function in climate adaptation. It is located between Bharatpur municipality in the west and Ratnanagar municipality in the east. The human population around the corridor is over 50,000 (CBS, 2011), putting high pressure on its fragile natural resources and ecosystems. In addition, the east-west highway which cuts across the corridor has a high volume of traffic, impacting wildlife movement in this corridor.



Symbol	PA name	Symbol	PA name
1	Nandor WLS	8	Banke NP
2	Shuklaphanta WR	9	Suhelwa WLS
3	Pilibhit FD (Proposed TR)	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
A	Boom-Bhramad
B	Laljhadi
C	Laggabag Tatargur
D	Basanta
E	Karnali

dor	Symbol	Corridor
n-madev	F	Khata
adi	G	Kamdi
bagga-gunj	H	Someshwor
nta	I	Parsa Valmiki
li		

Legend

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

Map 1: Terai Arc Landscape in Nepal and India with protected areas and corridors.

4

Tiger Monitoring Methods - 2013

4.1 Institutional setup for tiger survey

As a part of the country's tiger monitoring protocol, the 2013 tiger survey was planned to establish the first four-yearly monitoring standards in Nepal after the baseline assessment of 2008/09. The Fourth National Tiger Coordination Committee (NTCC) meeting chaired by the Prime Minister formally agreed and endorsed the national tiger and prey monitoring in Nepal. Advisory and technical committees were created at central level and field task forces at protected area level. The advisory committee comprised the Director General of DNPWC, the Member Secretary of NTNC and the Country Representative of WWF Nepal who provided strategic direction for the survey (Annex 1). The technical committee comprising the Ecologist, DNPWC; Under Secretary of DoF; and biologists from WWF Nepal and NTNC coordinated and facilitated the entire planning and implementation of field work (Annex 1). WWF Nepal biologists were an integral part of designing the study and NTNC played a crucial role in the field survey. Field task forces were led by the Chief Conservation Officer of each protected area, and biologists from WWF Nepal and NTNC (Annex 1). These teams took on the responsibility of training the field personnel, field mobilization and overall monitoring and supervision of the survey. Outside protected areas, District Forest Officers were assigned as the focal people for coordinating the tiger occupancy survey (Annex 1).

4.2 Orientation Training

Three days of rigorous training and field orientation were provided to all the team members participating in the survey, in SWR (Figure 1), BNP and CNP. The training covered different

Figure 1: Participants of tiger and prey survey in SWR.

aspects of tiger and prey base monitoring such as camera trapping protocol, prey base monitoring techniques, occupancy surveys, the use and handling of equipment, systematic data collection, and record keeping. A total of 268 participants comprising wildlife technicians, rangers, game scouts, community youths and university students undertook the training and the same trained personnel were mobilized for the survey (Annex 4). Training and field survey was facilitated by biologists from WWF Nepal and NTNC.

4.3 Field Methods

4.3.1 Camera Trapping for Tiger Abundance Estimation

4.3.1.1 Tiger Population Estimation

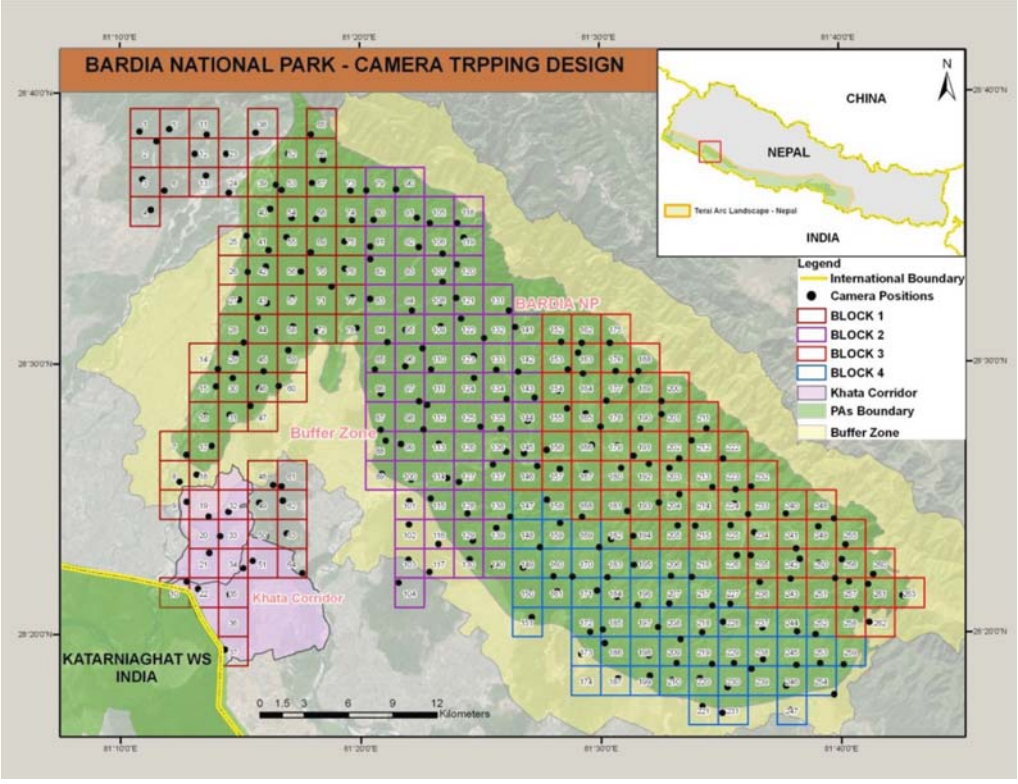
The estimation of population parameters such as abundance (*N*) and density (*D*) forms an integral part of wildlife monitoring programs. Photographic capture-recapture is a reliable method for estimating abundance of tiger in light of the species' elusive nature, making use of the unique identification patterns on each individual. Capture-recapture models provide a statistically robust framework to estimate species abundance, particularly when a population is said to be closed to births, deaths, immigration or emigration during the survey period (Karanth 1995).

4.3.1.2 Sampling Design and Effort

Camera trapping was carried out from 9th February to 4th June, 2013. To maximize spatial coverage and achieve a near-uniform distribution of camera traps, a pair of cameras was placed in each (2 km x 2 km) grid cell of a grid covering each protected area and its surrounding forests (Map 2). There were 1,039 grid cells (PWR - 177; CNP and Barandabhar corridor - 362; BaNP - 118; BNP and Khata corridor - 238; SWR - 88 and Basanta corridor - 56) which were camera trapped with an intensive camera trap effort of 15,585 trap days covering 4,841 Km^2. Churia forests inside PAs and buffer zones which were left out during the 2008-09 survey were systematically covered with camera trapping in this survey. Sampling design was determined by the size of the PA, availability of camera units and field personnel, and other logistic constraints. Camera trapping was conducted in shifting blocks as described by Royle et al. (2009) in each protected area and surrounding forests, which were divided into 3 or 4 blocks. Detailed site-specific information on camera trapping is given in Annex 2A.

Figure 2: Wildlife technician setting up a camera trap

Sites for camera trap stations were selected on the basis of extensive field surveys prior to the placement of cameras. Sites were associated with high tiger use based on signs such as pugmarks, scrapes, scat or the presence of water. 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. In every grid cameras were placed for the standard sampling period of 15 days.



Map 2: Camera trapping design (2013), example from Bardia National Park.

Each camera and memory card was given a unique identification number for data recording and maintenance purposes. Camera traps were checked every second day to ensure they were operating effectively. Five different models of camera (Reconyx 500, Reconyx 550, Bushnell Trophy Cam HD, Moultrie and Stealth) were used in camera trapping.

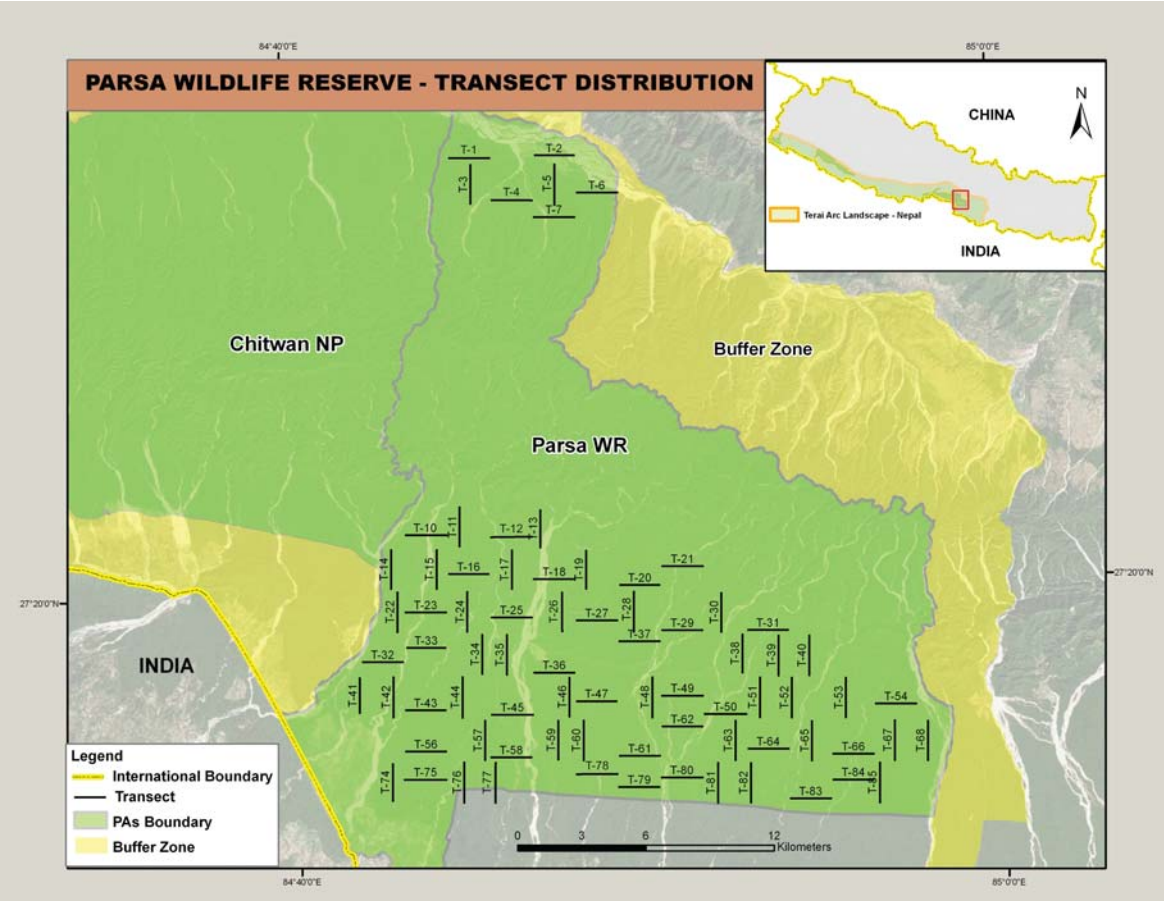
4.3.2 Line Transect Surveys for Prey Density Estimation

Density of prey species in the protected areas was estimated using line transect sampling (Anderson et al. 1979; Buckland et al. 2005). Line transects were placed systematically in all 2 km x 2 km grid cells except in grid cells with undulating and hilly terrain (Map 3) so as to adhere to the straight line assumption of distance sampling. Length of transects varied from 1.5 to 2.0 km. GPS locations of the start and end points of each line 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 field technicians surveyed each transect between 06:30 h and 09:30 h, and each transect was repeated twice. Elephants were mobilized to survey the tall flood plain grasslands.

A total of 784 line transects (PWR 147; CNP 261; BaNP 75; BNP 319; and SWR 82) were surveyed across the PAs with a sampling effort of 1,669 km. Site specific information on the line transect survey is provided in Annex 2, Table 2B.

The following information was recorded on a standard datasheet:

- GPS location of the start point of the transect
- Bearing of the transect
- Species identity from direct observation: chital, sambar, wild boar, barking deer, hog deer, swamp deer



Map 3: Line transect survey design (2013), example from Parsa Wildlife Reserve.

- Group size (cluster size of each detection)
- Age and sex composition (age: adult, sub-adult, yearling, young; and sex: male or female) was recorded when observations were adequate
- GPS location of individual sightings
- Bearing of the animal clusters or individuals using a SUNNTO compass
- Sighting distance from the observer to the animal cluster or individual using a laser range finder (Bushnell Yardage Pro).

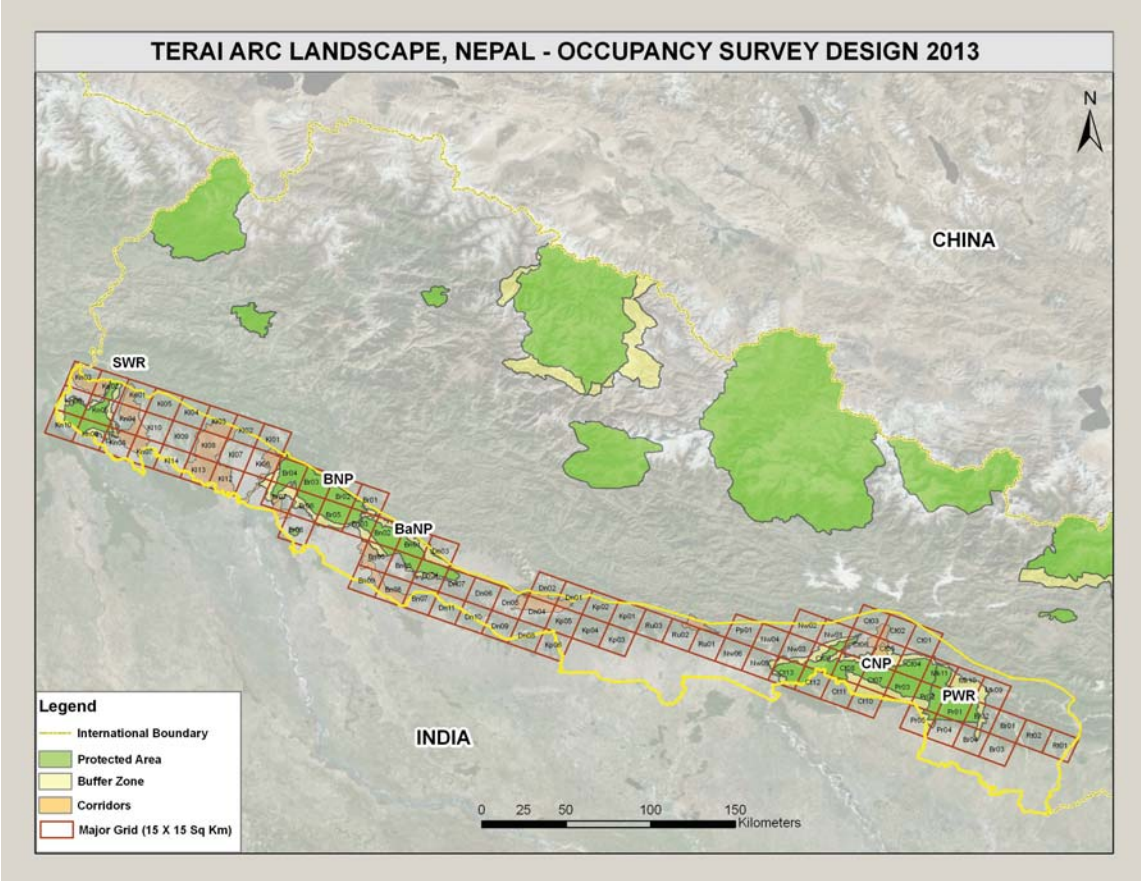
4.3.3 Tiger Habitat Occupancy Surveys

Tiger habitat occupancy surveys were conducted across the Nepal TAL, sampling all potential tiger habitats. A total of 96 grid cells each (15 km x 15 Km) were laid across TAL from Rautahat district in the east to Kanchanpur district in the west (Map 4). Each grid cell was further divided into 16 sub-cells of (3.75 km X 3.75 km). To include an element of randomness in the spatial distribution of survey routes, one sub-cell per grid cell coded as tiger habitat was randomly selected prior to the survey (Karanth et al., 2008). The number of spatial replicates per grid cell (i.e. km walked) was proportional to the percentage of tiger habitat (Karanth et al., 2008). For grid cells with 100% tiger habitat, we sampled 40 km in the cell touching random grid in every sampling route. Each contiguous 1 km segment was considered a 'spatial replicate' (Barber-Meyer et al. 2013; Hines et al. 2010). The field team walked along trails, roads, ridgelines, and river and stream beds in selected sub-cells, searching for tiger signs (scats, scrapes, pugmarks, kills and urination sites), prey signs (dung, footprints, calls and

sightings), and human disturbance (wood cutting, lopping, grazing, poaching etc.) following high probability tiger sign areas (Barber-Meyer et al. 2013). Observations were recorded for every 100 m section of the transect walk, with a total sampling effort of 2,319 km.

There were 43 grid cells inside protected areas and 53 cells outside in the national forest. Occupancy surveys in PA and buffer zone areas were conducted by the same teams that conducted camera trapping surveys and line transect surveys inside the PAs. For the remaining occupancy surveys, a team comprising 20 students from local universities, 14 DoF staff and 54 trained local community members carried out the surveys.

The field work started on 5th February 2013 in Kanchanpur and ended on 5th April, 2013 in Rautahat district.



Map 4: Tiger habitat occupancy survey design (2013), Terai Arc Landscape

5
Data Analysis

5.1 Tiger Population and Density Estimation

Tigers were identified at individual level after rigorous examination of the unique stripe patterns on the flanks, limbs and forequarters in each tiger photograph (McDougal 1977; Karanth 1995; Jhala et al. 2008). We used three different software programs: CAPTURE (Otis et al. 1978; White et al. 1982; Rexstad and Burnham 1991); SPACECAP package Version 1 (Gopalaswamy et al. 2012) and Program DENSITY (Efford 2009) to analyze the data for better comparison.

Tigers were identified by three observers independently, and capture histories were generated. Only animals that were classified to be adults (>2 years old that had dispersed from natal territories) were included in the capture-recapture analysis. No formal test for population closure was carried out because our sampling period was less than or equal to 60 days for each site, which is small relative to the life span of a tiger. Hence we assumed that the sampled population was demographically and geographically closed over the sampling period.

For analysis using the CAPTURE program, we developed a capture history for each individual tiger in X-matrix. Program CAPTURE 2 also provides a statistical test for the assumption of population closure. With the CAPTURE program we evaluated all possible models allowing for the major sources of variation: Models Mt, Mb, Mh and their combinations. Model selection was guided by the discriminant function test that scores all plausible models between 0.0 and 1.0, with a higher score indicating a relatively better fit of the model to the set of observed capture histories.

SPACECAP program version 1.0 (Gopalaswamy et al. 2012) is a user-friendly software package that implements a Bayesian spatially explicit capture recapture (SECR) analysis (Royle et al. 2009). The advantage of SECR models in SPACECAP, unlike the conventional approach in CAPTURE, is that it directly estimates animal density by explicitly using information on capture histories in combination with spatial locations of captures under a Bayesian modeling framework. This makes it possible to substantially deal with problems posed by individual heterogeneity in capture probabilities in conventional capture-recapture analyses. It also offers non-asymptotic inferences which are more appropriate for small samples of capture data typical of individual-capture studies, highly suitable for some of our study sites. The SECR models employed in this study also address the issue of geographic closure (Royle et al. 2009).

With SPACECAP we generated three different types of input files: a. Animal Capture Detail file, b. Trap Deployment Details file and c. Potential Home Range Center file. These files were saved as CSV files (Gopalaswamy et al. 2012). To create a potential home range center (activity center) file for each of the protected areas, we calculated the mean maximum distance moved (MMDM) by tigers by creating a minimum convex polygon (MCP) for each tiger. To define the state space S within which activity centers for animals exposed to camera traps are likely to be located, twice MMDM was used for creating a buffer surrounding the camera trap polygon. Potential tiger activity centers were represented by regularly spaced

points at 580 m intervals representing an area of 0.3364 km^2 (Gopalaswamy et al. 2012). Given that a number of these points were located in non-tiger habitat areas (e.g. settlements or agriculture), the land use map of TAL was overlaid to delineate habitat assigning the value (1) for tiger habitats and value (0) for non-tiger habitats. Files with this information were loaded in SPACECAP version 1.0 under program R environment for analysis of the tiger population and density estimation.

Similarly, the DENSITY program (Efford et al. 2004; Efford 2009) was used to analyze the maximum likelihood-based SECR (Brochers and Efford 2008). Unlike the conventional CAPTURE method, DENSITY estimates both the population and density. Two files (Animal Capture Details and Camera Trap Details) were created and analyzed to estimate population and density.

5.2 Prey Density Estimation

Line transect data were analyzed under the distance sampling framework using DISTANCE program version 6 (Burnham et al. 1980; Buckland et al. 1993; Buckland 2001; Thomas et al. 2010) to estimate the population density of principal prey species. We used two approaches: a. pooling data for all species for fitting a global detection function curve, and b. fitting detection function at species level when there were sufficient detections. In order to model detection functions, appropriate modifications were made so as to ensure a reliable fit of key functions and adjustment terms to the data in order to arrive at density estimates. Akaike Information Criterion (AIC) and Goodness of Fit (GOF-P) tests were used to judge the fit of the model. Using the selected model, estimates of group density (Dg), group size (GS) and individual density (D) were derived.

5.3 Tiger Habitat Occupancy

A detection history matrix was generated in MS-Excel using field information on presence (1) and absence (0) of tigers and this information was imported in PRESENCE program 5.9 (Hines 2013). This program implements the maximum likelihood approach of site occupancy models (MacKenzie et al. 2002; MacKenzie and Kendall 2002) and also permits the inclusion of the influence of site and sampling co-variates. In addition to providing estimates of site occupancy (proportion of sampled area in which tigers occur) and 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 AIC values to determine the most parsimonious model (Hines et al. 2010; Hines 2013; Barber-Meyer et al. 2013).

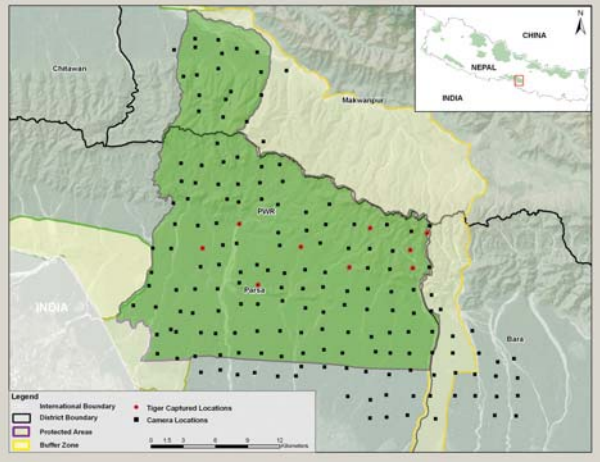
6

Status of the Tiger Population in 2013

6.1 Parsa Wildlife Reserve

6.1.1 Sampling Efforts and Individual Tigers Captured

In Parsa, tigers were captured by 9 out of 177 camera stations (Map 5) with a total sampling effort of 5,310 trap days. A total of 32 analyzable tiger pictures were obtained comprising 12 right flanks, 3 left flanks and 17 frontal and back portions. Four tigers were identified (Annex 3.1) through careful examination of all the photographs, of which one was male and three were females. The camera trap polygon area for PWR was 801.93 km^2 with a total effective trapping area of 1,043.51 km^2.



Map 5: Camera trap locations in PWR (black dots: camera stations with no tiger capture; red dots: tiger capture locations).

6.1.2 Capture and Recapture Pattern

All three females were captured at least twice or more; the male was captured only once (Figure 3). The capture history pattern (Figure 4) shows that no tigers were captured till the 5th sampling occasion and no new tigers were captured after the 13th night.

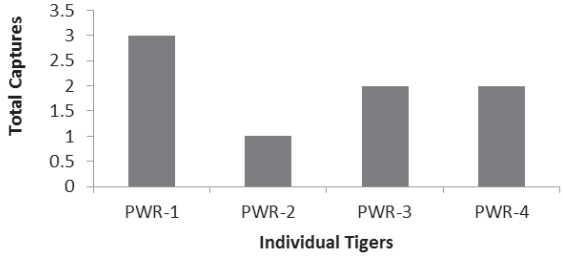


Figure 3: Number of captures of identified tigers in PWR.

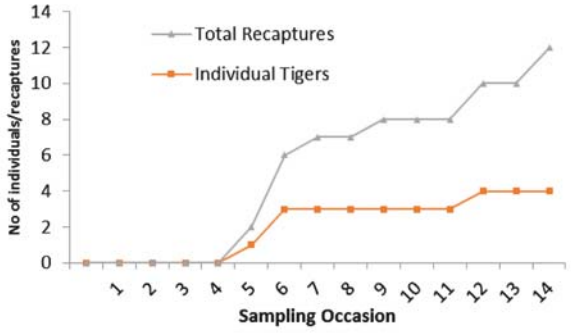
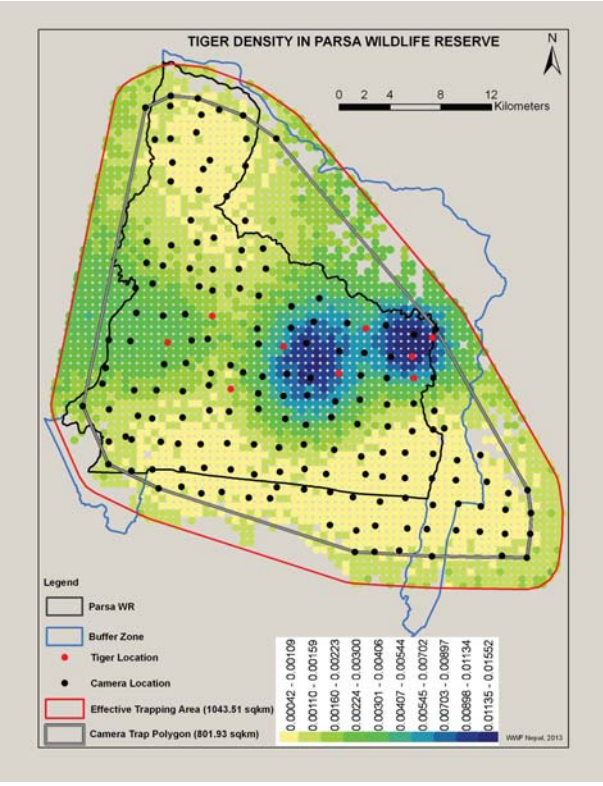


Figure 4: Capture and recapture pattern of tigers in PWR.

6.1.3 Population and Density Estimation Using SPACECAP Program

The tiger population (N_{super}) estimated using the SPACECAP Program is 7 (95% posterior CI 4-7). The estimated tiger density for PWR from Bayesian SECR analysis is 0.65 (95% posterior intervals 0.38-1.24) tigers/100 km^2. The map depicting pixel-wise estimates of tiger density for PWR shows tiger concentration within the central areas of the reserve while the surrounding areas have fairly low tiger density (Map 6).



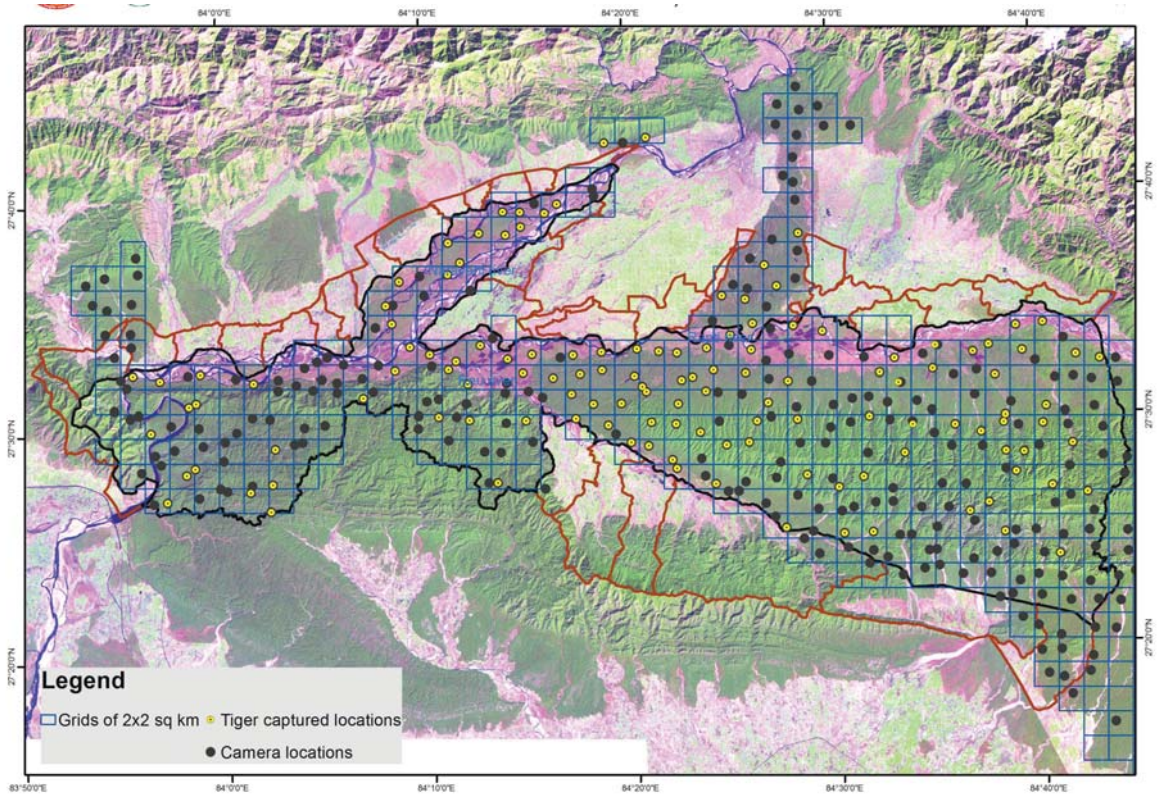
Map 6: Map depicting pixel-wise estimates of tiger density for PWR, 2013.

6.2 Chitwan National Park

6.2.1 Sampling Effort and Individual Tigers Captured

Camera traps were deployed in 365 stations in CNP and the surrounding forests of Nawalparasi and Barandabhar corridor forest. This accounted for an effective trapping area of 3,110.35 km^2 (Map 7). Tigers were captured in 142 stations during a total sampling effort of 10,860 camera trap days.

Of the 2,994 tiger pictures obtained from camera traps in Chitwan, 2,906 pictures were identifiable. Seventy-eight individual tigers were identified from tiger pictures (Annex 3.2) with 1,265 right flanks, 1,199 left flanks and 442 other body parts. Only one tiger was common between PWR and CNP and this was included in the analysis of CNP as it was captured only once in Parsa and occupied a larger territory in Chitwan. Of the 78 individuals identified, 18 were male and 60 were female.



Map 7: Camera trap locations in CNP (Black dots: camera stations with no tiger capture; Yellow dots: tiger capture locations).

Five tigers were captured in Barandabhar forest corridor and 2 were captured north of the Amaltari sector in Nawalparasi outside the buffer zone.

6.2.2 Capture and Recapture Pattern

In Chitwan 65% of the tigers were recaptured at least once or more (Figure 5). The maximum an individual was recaptured was 11 times. The capture history pattern (Figure 6) showed that tigers were captured from the first day of camera deployment and new tigers continued to be captured until the last day of camera trapping. Almost 70% of the tigers were captured for the first time within the first 8 days of the camera trapping period.

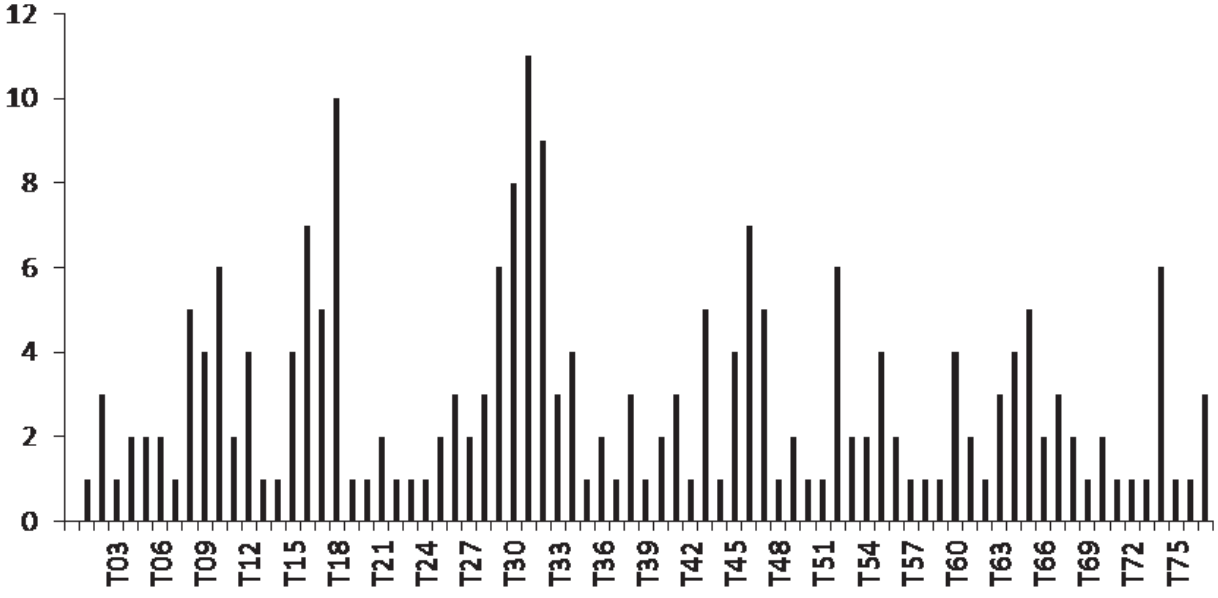


Figure 5: Total number of captures of identified tigers in CNP.

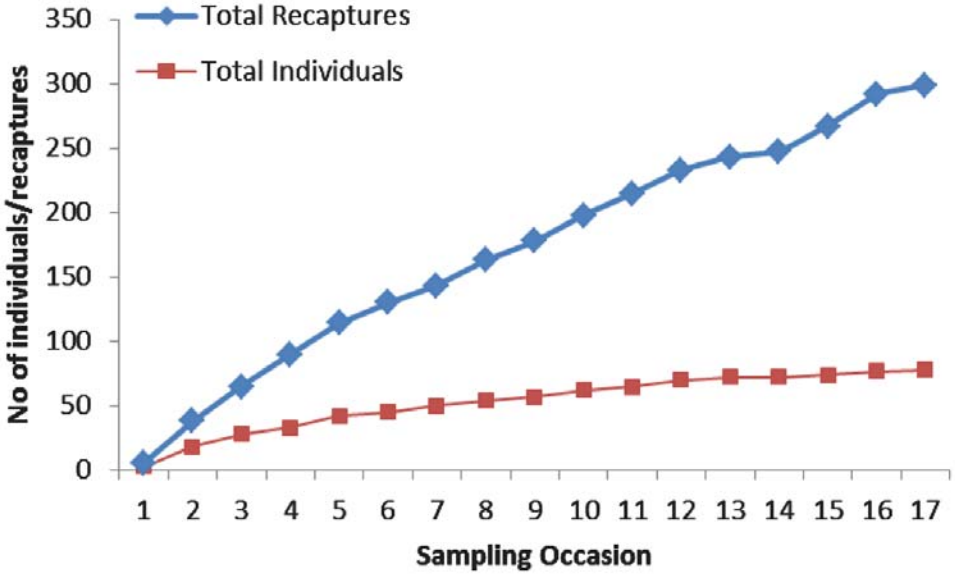
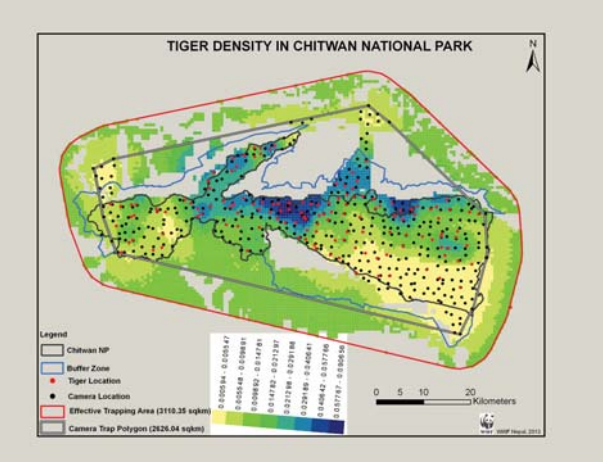


Figure 6: Capture and recapture patterns of tigers in CNP.

6.2.3 Population and Density Estimation Using SPACECAP Program

The CNP tiger population (N_{super}) estimated by SPACECAP Program is 120 (98-139). The estimated tiger density for CNP from Bayesian SECR analysis is 3.84 (95% posterior intervals 3.15-4.46) tigers/100 km^2. The map depicting pixel-wise estimates of tiger density for Chitwan (Map 8) shows high tiger concentration along the Rapti, Reu and Narayani river floodplains. Tiger density is fairly low in the south-eastern part of the Park adjoining Madi, Sikaribas, Thori and Bandarjhulla areas.

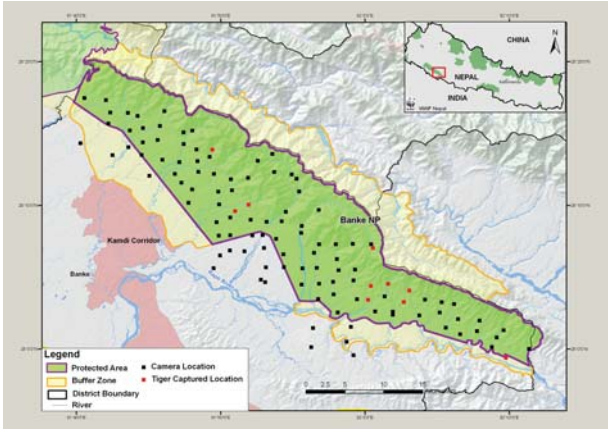


Map 8: Map depicting pixel-wise estimates of tiger density in CNP, 2013.

6.3 Banke National Park

6.3.1 Sampling Effort and Individual Tigers Captured

Camera traps were deployed in 118 stations in BaNP, covering an effective trapping area of 2,367.91 km^2. Tigers were captured in 10 camera stations during a sampling effort of 3,540 trap days (Map 9). Twenty-six identifiable tiger photographs were obtained with 5 right flanks, 8 left flanks and the rest with frontal and back portions. Three individuals were positively identified through analysis of the pictures, two male and one female (Annex-3.3). No tigers were captured from the adjoining buffer zone and corridor forests.



Map 9: Camera trap locations in BaNP (Black dots: camera stations with no capture; Red dots: tiger capture locations).

6.3.2 Capture and Recapture Pattern

One male tiger (# 2) was never recaptured; the other two animals were captured at least 6 times each (Figure 7). The capture history pattern (Figure 8) shows that no new tigers were captured after the 12th sampling occasion but recapture continued to rise until the 15th sampling occasion.

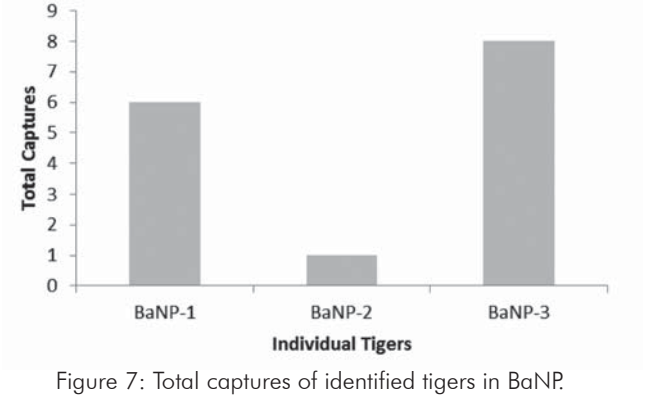


Figure 7: Total captures of identified tigers in BaNP.

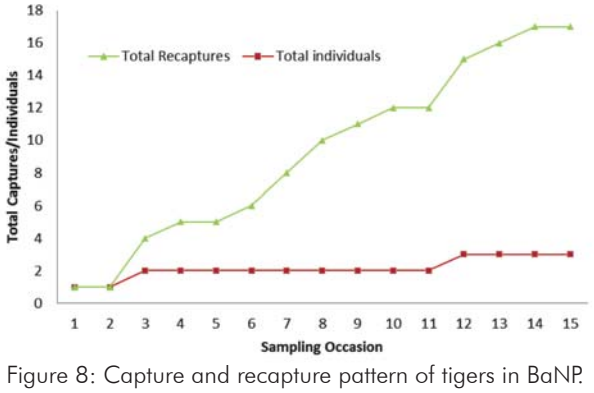
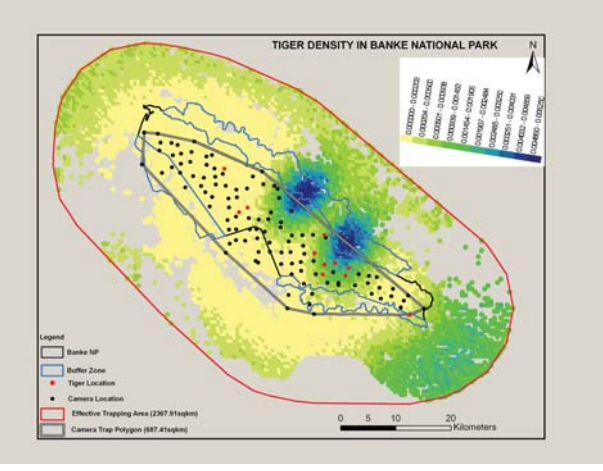


Figure 8: Capture and recapture pattern of tigers in BaNP.

6.3.3 Population and Density Estimation Using SPACECAP Program

The tiger population (N_{super}) estimated by the SPACECAP Program is 4 (3-7). The estimated tiger density for BaNP from Bayesian SECR analysis is 0.16 (95% posterior intervals 0.12-0.29) tigers/100km^2. The map depicting pixel-wise estimates of tiger density for Banke (Map 10) shows tiger concentration in two patches in the northern central part of the park. The tiger density is fairly low in the habitats adjoining BNP.

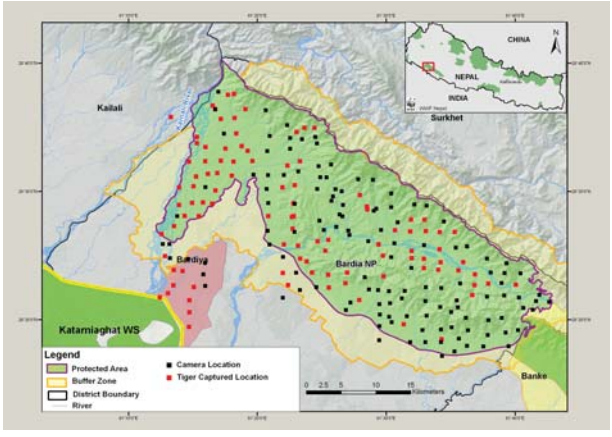


Map 10: Map depicting pixel-wise estimates of tiger density for BaNP, 2013

6.4 Bardia National Park

6.4.1 Sampling Effort and Individual Tigers Captured

In Bardia camera traps were deployed in 238 locations, covering an effective trapping area of 1,485.54 km^2. Tigers were captured in 103 camera stations during a sampling effort of 7,140 trap days (Map 11). A total of 3,098 tiger photographs were obtained and their analysis resulted in identification of 44 individual tigers, 14 male and 30 female (Annex-3.4). This included 5 tigers (2 males and 3 females) captured in Khata corridor and one tiger in Karnali river corridor.



Map 11: Camera trap locations in BNP (Black dots: camera stations with no capture; Red dots: tiger capture locations).

6.4.2 Capture and Recapture Pattern

Capture history of BNP shows that 18% of the tigers were never recaptured whereas 80% were recaptured at least twice or more (Figure 9). The capture history pattern (Figure 10) shows that the capture of new individuals in BNP more or less stopped after the 9th day, whereas recapture of tigers continued right to the end of the sampling period.

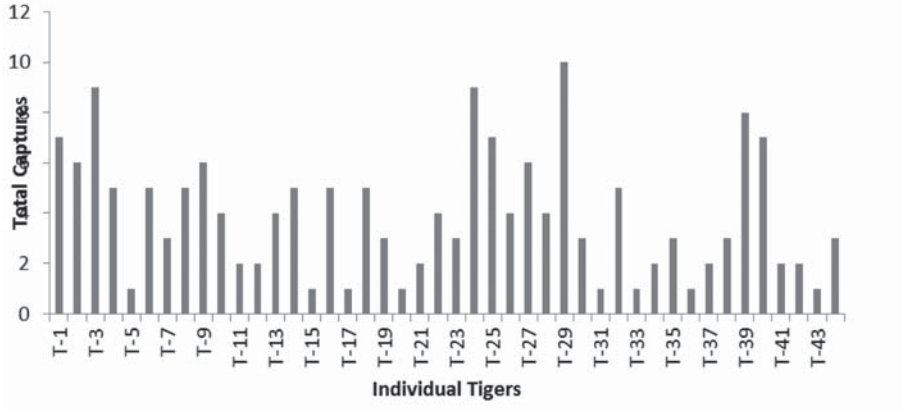


Figure 9: Total captures of identified tigers in BNP

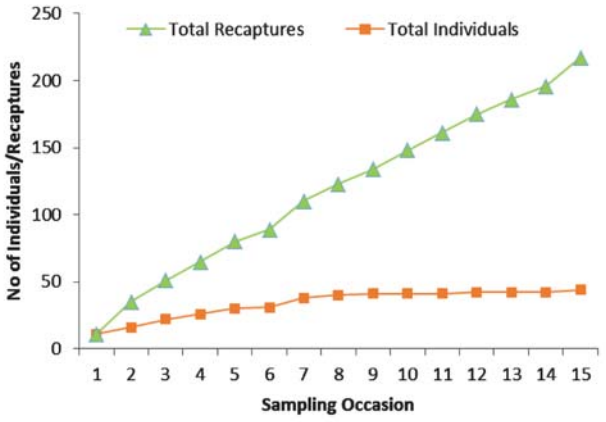
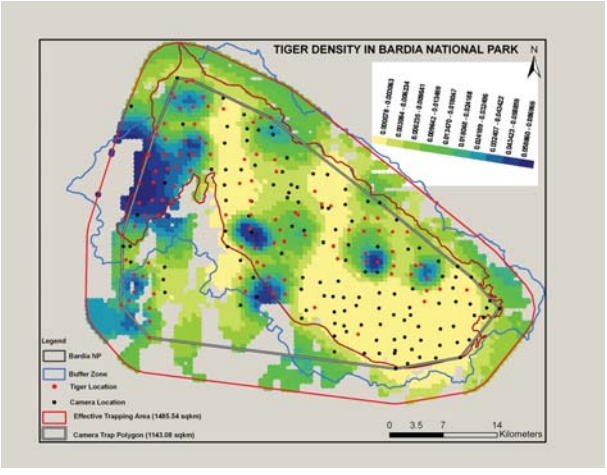


Figure 10: Capture and recapture pattern of tigers in BNP.

6.4.3 Population and Density Estimation Using Program SPACECAP

The tiger population (N_{super}) for BNP estimated with the SPACECAP Program is 50 (45-55). The estimated tiger density for Bardia from Bayesian SECR analysis is 3.33 (95% posterior intervals 3.02-3.7) tigers/100km^2. The map depicting pixel-wise estimates of tiger density for BNP (Map 12) shows the highest tiger density along the Karnali floodplain, followed by Khata corridor forest, and flood plains of the Babai valley, mostly around Shivapur, Guthi and Parewaodar.

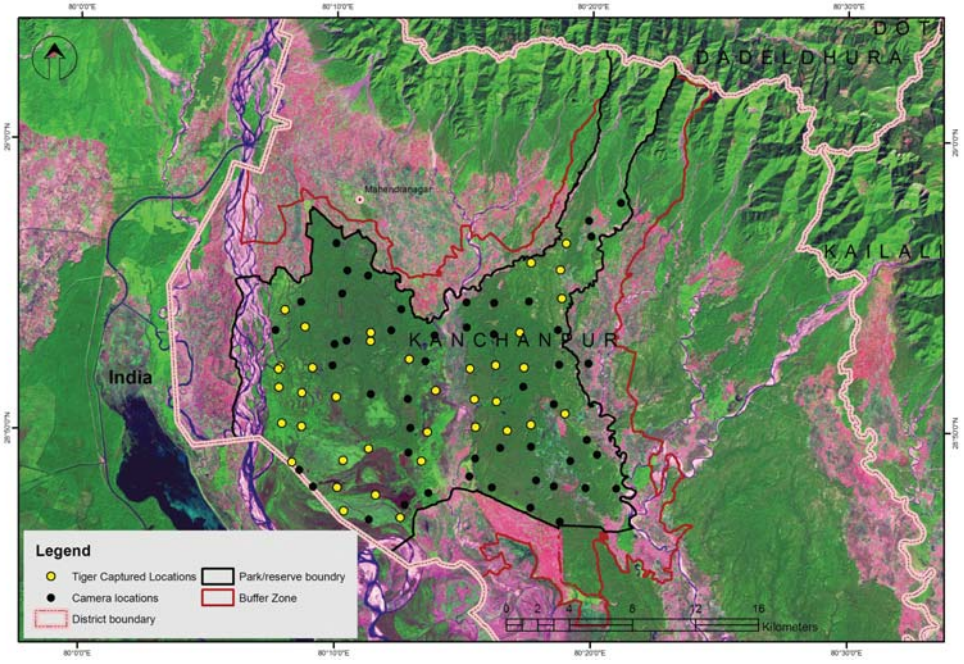


Map 12: Map depicting pixel-wise estimates of tiger density for BNP, 2013

6.5 Shuklaphanta Wildlife Reserve

6.5.1 Sampling Effort and Individual Tigers Captured

Tigers were captured by 32 out of 88 stations in SWR (Map 13). No tigers were captured from surrounding corridor forests (Basanta, Laljhadi and Brahmadev) or buffer-zone forests of SWR. Camera trapping covered an effective area of 485.76 km^2 with an effort of 2,640 trap days.



Map 13: Camera trap locations in SWR (black dots: no tiger capture; red dots: tiger capture locations).

Thirteen individual tigers comprising 5 males and 8 females were identified (Annex-3.5) from a total of 1,549 tiger pictures.

6.5.2 Capture and Recapture Pattern

Over 85% of tigers were recaptured at least twice (Figure 11). Capture history (Figure 12) shows that the capture pattern of tigers in SWR more or less stabilized after 11th sampling occasion and 76% of individuals were captured within first five days of sampling.

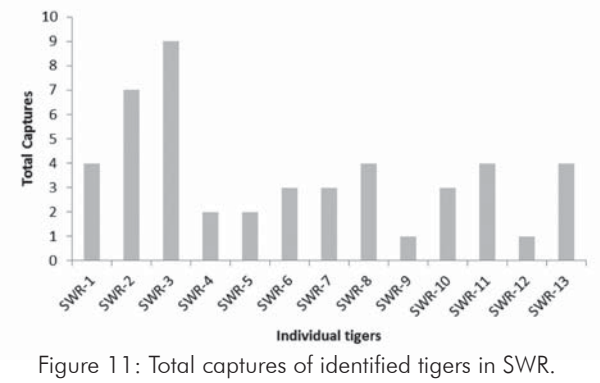


Figure 11: Total captures of identified tigers in SWR.

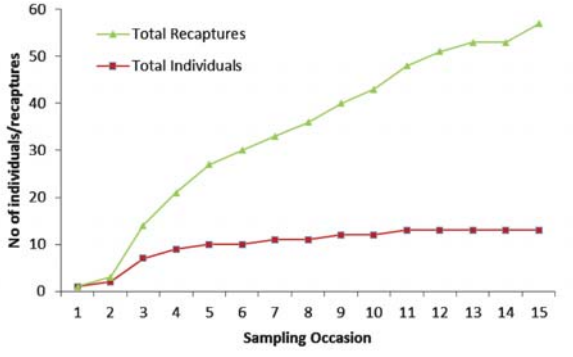
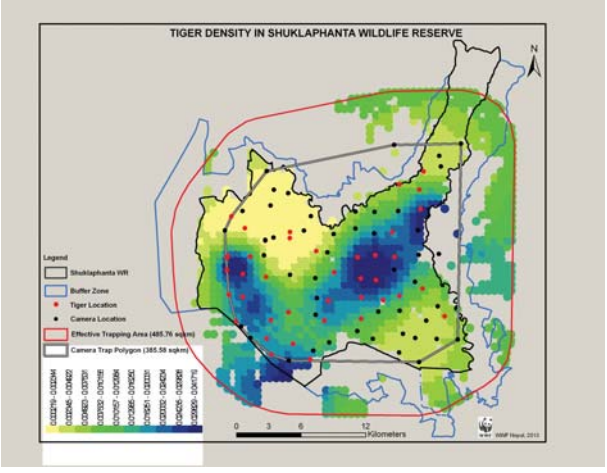


Figure 12: Capture and recapture pattern of tigers in SWR.

6.5.3 Population and Density Estimation Using SPACECAP Program

The SWR tiger population (N_{super}) estimated using the SPACECAP Program is 17 (13-21). The estimated tiger density for SWR from Bayesian SECR analysis is 3.4 (95% posterior intervals 2.67-4.3) tigers/100km^2. The map depicting pixel-wise estimates of tiger density for Shuklaphanta (Map 14) shows that tiger density is high in parts of the SWR core area: Shuklaphanta, Bahuni-Barkaula and the Mahakali floodplain, and low towards the fringes, especially in the north-western and south-eastern parts of the Reserve.



Map 14: Map depicting pixel-wise estimates of tiger density for SWR, 2013.

6.6 Results from CAPTURE and DENSITY Programs

For robust comparison the summary outputs on population and density estimates using CAPTURE and DENSITY programs are presented below for each protected area (Table 1 and Table 2).

Table 1: Tiger population size and density estimates for TAL protected areas using DENSITY program.

Details	Protected area				
	PWR	CNP	BaNP	BNP	SWR
Mt+1	4	78	3	44	13
Trapping occasions	59	73	32	58	32
Number of trap stations	177	365	118	238	88
Total trap nights	2655	5475	1770	3570	1320
Sub-population ±SE	4 ± 1	116 ± 15	4±1	50 ± 4	14 ± 1
95% confidence interval	4-9	97-157	3-11	46-63	13-21
p-hat	0.0319	0.024	0.14	0.0579	0.0915
Model selected	Estimator Mh Chao	Estimator Mh Jackknife	Estimator Mth Chao coverage 1	Estimator Mth Chao coverage 1	Estimator Mh Chao
ETA	801.763 km^2	2625.925 km^2	687.414 km^2	1143.085 km^2	385.575 km^2
Model	Half normal (AIC 141.98)	Half normal (AIC 3393.51)	Half normal (AIC 233.2)	Half normal (AIC 2464.14)	Half normal (AIC 561.14)
ML-Sigma	3399.02	5329.32	8297.58	4233.09	4237.66
ML-DENSITY±SE	1.6± 0.9tigers/100 km^2	6.02±0.12 tigers/100 km^2	1.1±0.7 tigers/100 km^2	5.38±0.8 tigers/100 km^2	6.3±0.18 tigers/100 km^2

M_{t+1} = Minimum individuals captured; p-hat = capture probability, ETA-Effective trapping area, ML- Maximum Liklihood

Table 2: Tiger sub-population estimates for TAL protected areas using CAPTURE program.

Protected area	PWR	CNP	BaNP	BNP	SWR
No. of blocks	3	4	2	4	2
Sampling occasion	59	73	33	68	32
Total identified individuals	4	78	3	44	13
Mean number	5	107	4	48	15
95% Confidence Interval	5-11	92-137	4-10	45-64	14-23
SE	1.4	11.11	1.42	3.99	1.99
Selection criteria (score)	M(h) = 0.91	M(th) = 1.0	M(h) = 0.90	M(h) = 1.0	M(h) = 0.93
Model Selected	M(h)	M(th) Estimator of Chao's M (th)	M(h) Jackknife	M(h) Jackknife	M(h) Jackknife

Herd of Chital in Arjuni-Phanta, Shuklaphanta Wildlife Reserve-©NTNC/Naresh Subedi

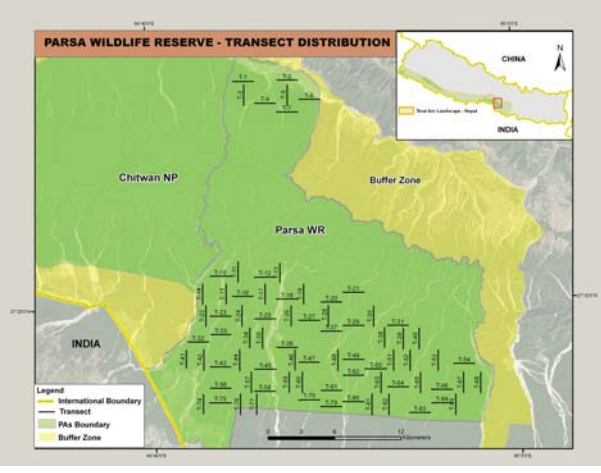
7

Status of Prey-base 2013

7.1 Parsa Wildlife Reserve

7.1.1 Sampling Efforts

A total of 147 line transects were surveyed with a sampling effort of 286.5 km in PWR (Map 15).



Map 15: Transect distribution in PWR.

7.1.2 Prey Species Encountered

Eight different prey species were encountered during the line transect survey (Table 3). However, species specific density estimates were only possible for 4 species (chital, sambar, barking deer and wild boar). Though these species did not meet the recommended 60-80 detections, they did conform to the underlying assumptions of model fitting (Buckland et al. 2005). Estimates were not possible for other species due to the sample size constraints (Buckland et al. 1993).

7.1.3 Prey Density Estimates

The overall prey density estimate for PWR is 25.32 animals/km^2, the species with the highest density being chital (9.6 animals/km^2). Details of prey density in Parsa are provided in Table 4.

Table 3: Summary of prey species detections from all transects in PWR.

Species (common name)	Scientific name	No of detections	Total Number of animals detected
Barking deer	*Muntiacus muntjak*	31	39
Gaur	*Bos gaurus*	3	19
Langur	*Semnopithecus entellus*	7	48
Nilgai	*Boselaphus tragocamelus*	3	4
Rhesus macaque	*Macaca mulatta*	7	73
Sambar	*Cervus unicolor*	29	71
Chital	*Axis axis*	19	168
Wild boar	*Sus scrofa*	37	71
Total		**136**	**493**

Table 4: Prey density estimates for PWR.

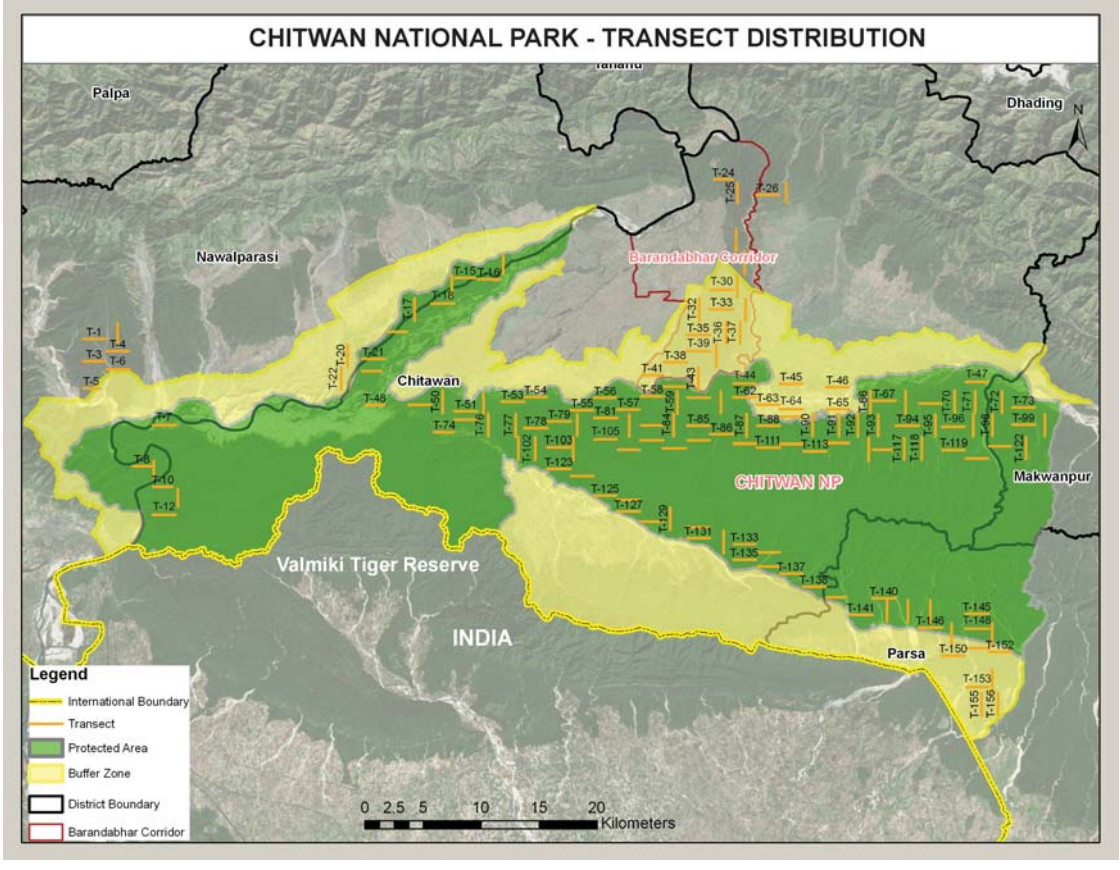
Species	p-hat	ESW	Average Cluster Size	Density	SE(D)	95% CI	DS	SE(DS)	95% CI
All prey species	0.29	28.11	3.59	25.32	3.9	18.71-34.28	8.26	1.02	6.49-10.53
Wild boar	0.29	23.28	1.91	5.07	1.23	3.16-8.15	2.77	0.6	1.81-4.25
Barking deer	0.29	35.26	1.25	2.05	0.48	1.29-3-25	1.53	0.34	0.98-2.39
Sambar	0.33	44.09	1.87	2.15	0.77	1.08-4.27	1.14	0.61	0.61-2.13
Chital	0.39	30.95	8.84	9.6	4.91	3.66-25	1.07	0.39	0.53-2.15

Note: p-hat: detection probability; ESW: effective strip width; D: animal density; DS: group density

7.2 Chitwan National Park

7.2.1 Sampling Effort

In CNP, 261 line transects were surveyed with a sampling effort of 497.7 km (Map 16).



Map 16: Line transect distribution in CNP.

7.2.2 Prey Species Encountered

A total of eight species were encountered during the line transect survey in CNP of which density estimates were derived for all the species except Rhesus macaque and Langur. Chital was the most commonly seen species in the park followed by Sambar, Barking deer and Wild boar (Table 5).

Table 5: Species summary detections from all transects in CNP.

Species (Common name)	Scientific name	No of detection	Total Number
Barking deer	*Muntiacus muntjak*	64	77
Gaur	*Bos gaurus*	8	76
Hog deer	*Axis porcinus*	31	59
Langur	*Semnopithecus entellus*	15	118
Rhesus macaque	*Macaca mulatta*	7	124
Sambar	*Cervus unicolor*	74	138
Chital	*Axis axis*	125	1743
Wild boar	*Sus scrofa*	46	135
Total		370	2470

7.2.3 Prey Density Estimates

The overall prey density estimated for CNP is 73.63 animals/km^2. The highest density was of chital (44.75) followed by wild boar (4.43) and sambar (4.02). The details of the prey density are provided in Table 6.

Table 6: Prey density estimates for CNP.

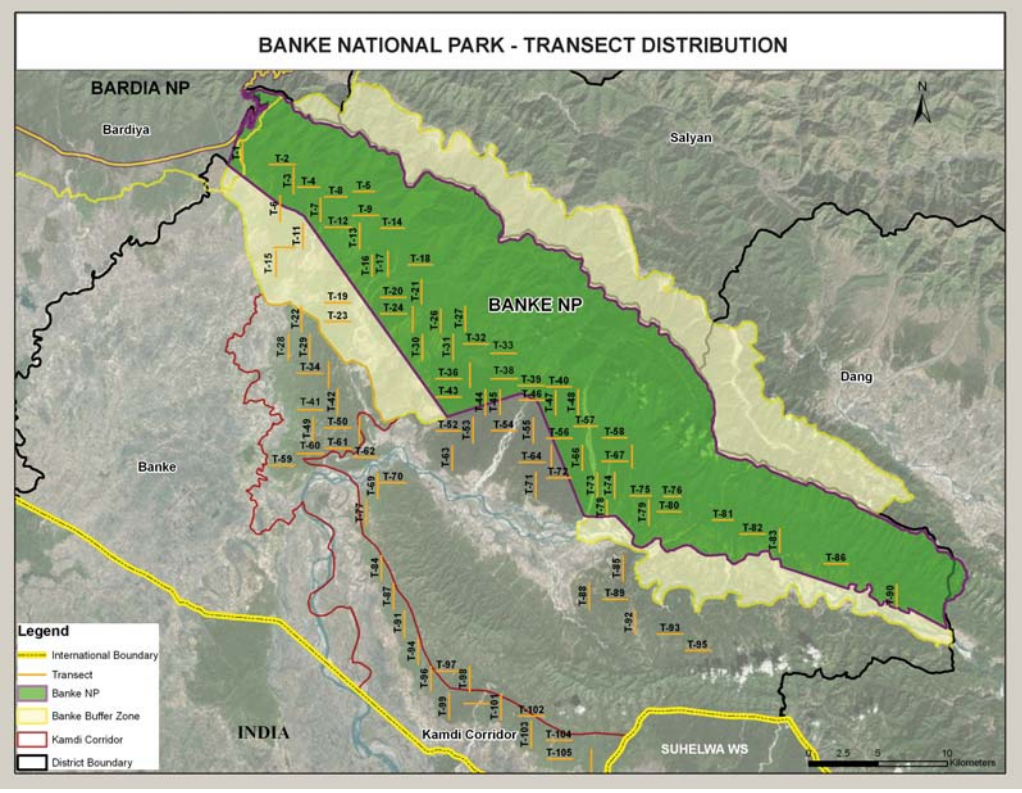
Species	p-hat	ESW	Average Cls-Size	Density (km^2)	SE(D)	95% CI	DS (km^2)	SE(DS)	95% CI3
All Prey	0.4	35	13	73.63	9.08	57.84 - 93.74	11.7	0.76	10.26- 13.26
Chital	0.27	35.8	13.65	44.75	7.9	31.57- 63.42	3.4	0.49	2.5- 4.5
Sambar	0.36	34.2	1.86	4.02	0.59	3.01-5.37	2.2	0.33	1.6-2.9
Wild boar	0.49	24.9	2.18	4.43	0.87	3.01-6.51	2.13	0.37	1.50-3.01
Hog deer	0.53	19.8	1.9	3.28	1	1.8-5.98	1.58	0.45	0.90-2.74
Barking deer	0.39	36.8	1.29	3.65	0.38	2.5-5.32	1.71	0.28	1.25-2.36

Note: p-hat: detection probability; ESW: effective strip width; D: animal density; DS: group density

7.3 Banke National Park

7.3.1 Sampling Effort

In BaNP, the total of 75 transects were surveyed with a sampling effort of 333.7 km (Map 17).



Map 17: Line transect distribution in Banke National Park

7.3.2 Prey Species Encountered

A total of eight species were encountered during the line transect survey in Banke, of which density estimate was possible only for chital due to sample size constraints (Table 7).

Table 7: Species summary detections from all transects in BaNP.

Species (Common name)	Scientific name	No of detections	Total Number
Barking deer	*Muntiacus muntjak*	7	8
Four horned antelope	*Tetracerus quadricornis*	8	13
Chital	*Axis axis*	15	68
Black-naped hare	*Lepus nigricollis*	2	4
Langur	*Semnopithecus entellus*	2	16
Rhesus macaque	*Macaca mulatta*	4	61
Sambar	*Cervus unicolor*	3	6
Wild boar	*Sus scrofa*	13	35
Total		**54**	**211**

7.3.3 Prey Density Estimates

The overall prey density estimated for BaNP is 10.27animals/km^2. The details of the prey density are provided in Table 8.

Table 8: Prey density estimates for BaNP.

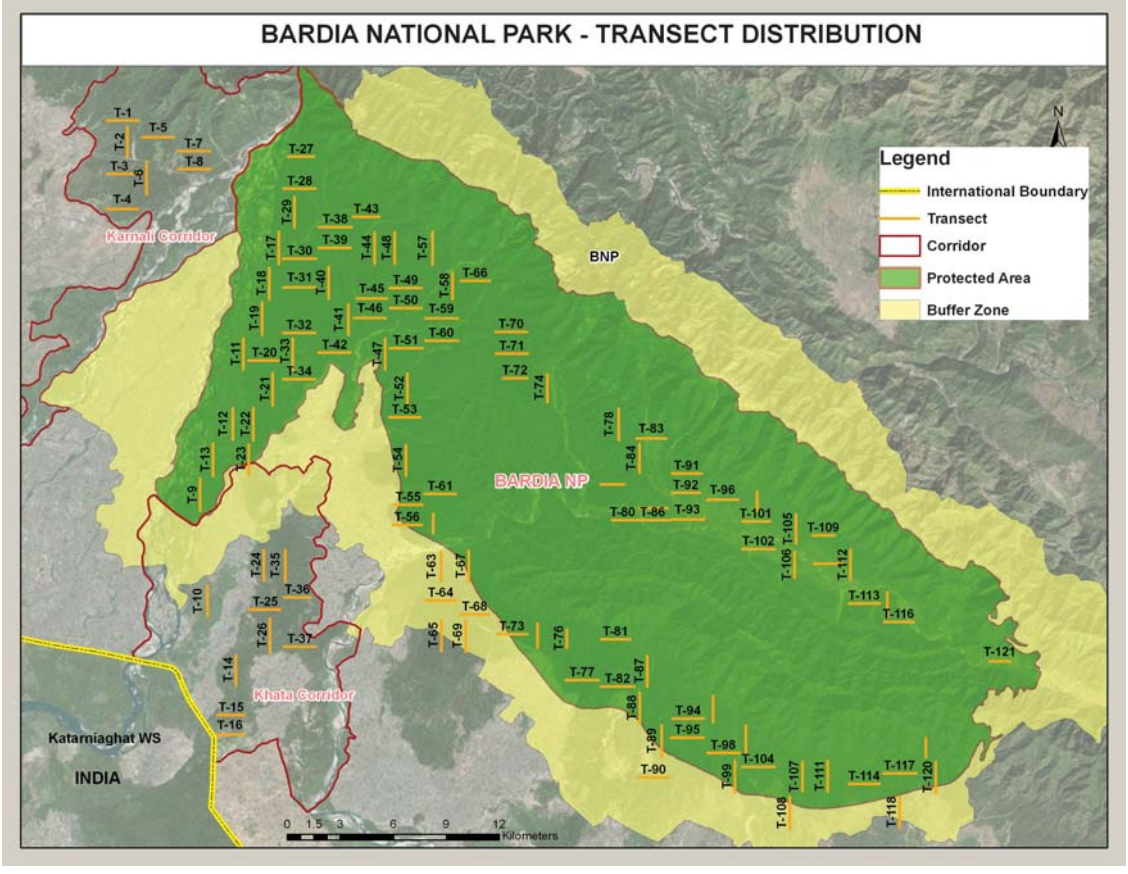
Species	p-hat	ESW	Avg Cls-Size	Density	SE	95% CI	DS	SE (DS)	95% CI (DS)
All Prey	0.4	36.9	3.85	10.27	6.34	3.3-31.8	2.26	1.36	0.74-6.82
Chital	0.3	27.4	4.46	4.7	1.2	1.1- 8.9	0.71	0.50	0.19-2.52

Note: p-hat: detection probability; ESW: effective strip width; D: animal density; DS: group density

7.4 Bardia National Park

7.4.1 Sampling Effort

A total of 219 line transects were surveyed in BNP with a sampling effort of 397.7km (Map 18).



Map 18: Line transect distribution in Bardia National Park.

7.4.2 Prey Species Encountered

A total of 11 prey species were encountered during the line transect survey in BNP with the maximum sighting of chital (332) followed by langur (79), sambar (73), wild boar (38) and barking deer (35) (Table 9). Density estimates were derived for all the above 5 species including rhesus macaque (Table 10).

7.4.3 Prey Density Estimates

The overall prey density estimated for BNP is 92.6 animals/km^2. Chital was the most common species with density of 53.99 animals/km^2. Details of prey density are provided in Table 10.

Table 9: Species summary detections from all transects in BNP.

Species (Common name)	Scientific name	No of detections	Total Number
Barking deer	*Muntiacus muntjak*	35	43
Chital	*Axis axis*	332	2226
Langur	*Semnopithecus entellus*	79	664
Rhesus macaque	*Macaca mulatta*	17	184
Sambar	*Cervus unicolor*	73	161
Wild boar	*Sus scrofa*	38	131
Black-naped hare	*Lepus nigricollis*	1	1
Four-horned antelope	*Tetracerus quadricornis*	1	1
Swamp deer	*Cervus duvauceli*	2	7
Nilgai	*Boselaphus tragocamelus*	3	2
Hog deer	*Axis porcinus*	6	15
Total		578	3412

Table 10: Prey density estimates for BNP.

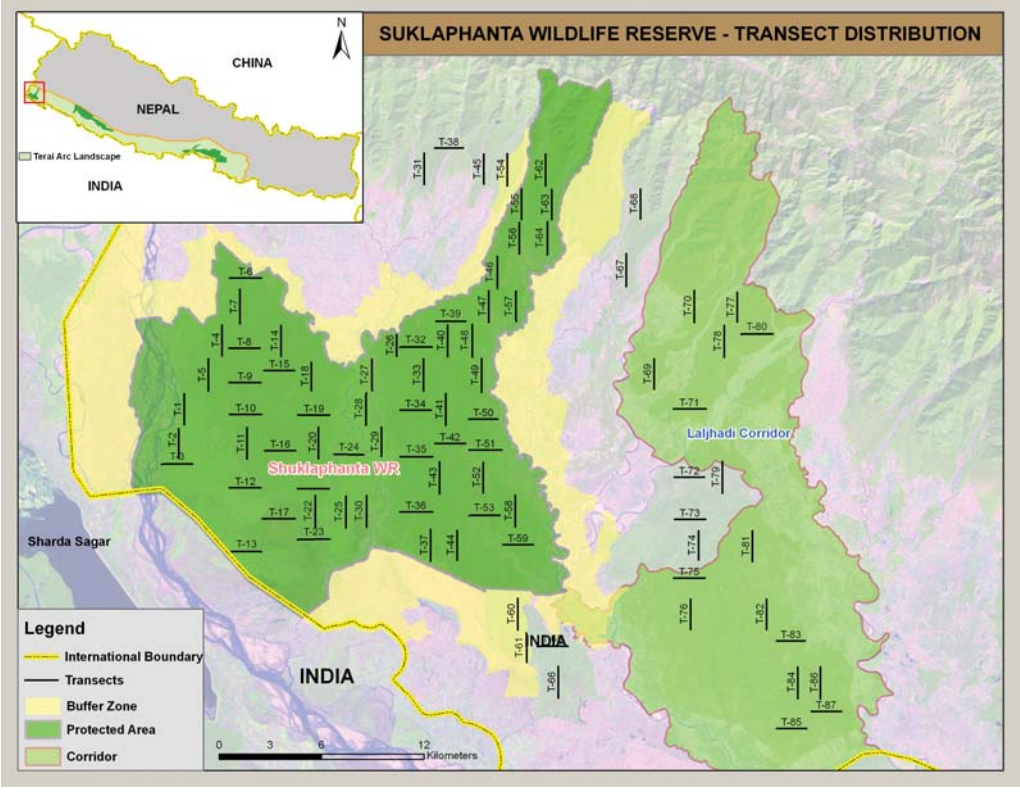
Species	p-hat	ESW	Avg Cls-Size	Density	SE	95% CI	DS	SE(DS)	95% CI (DS)
BNP(All)	0.36	40.52	5.89	92.6	8.8	75.3-111.09	17.71	8.62	14.9-20.9
Chital	0.39	43.3	6.64	53.99	10.29	44.13-66.05	9.46	0.78	8.04-11.13
Sambar	0.39	45.4	2.22	4.45	0.84	3.08-6.45	1.99	0.34	1.41-2.79
Wild boar	0.27	29.7	3.44	4.79	1.32	2.81-8.18	1.6	0.35	1.04-2.46
Barking deer	0.48	29.11	1.22	1.97	0.52	1.17-3.29	1.51	0.39	0.91-2-5
Rhesus macaque	0.47	42.3	10.70	5.47	2.7	2.09-14.28	0.47	0.14	0.25-0.87
Langur	0.4	32	8.33	21.35	3.83	15.03-30.31	2.94	0.43	2.2-3.94

Note: p-hat: detection probability; ESW: effective strip width; D: animal density; DS: group density

7.5 Shuklaphanta Wildlife Reserve

7.5.1 Sampling Effort

A total of 82 line transects were surveyed in SWR with a sampling effort of 154 km (Map 19).



Map 19: Line transect distribution in SWR

7.5.2 Prey Species encountered

A total of 8 prey species were encountered during the line transect survey in SWR with the maximum sighting of chital (56). Density estimates were possible for chital, hog deer and wild boar only (Table 11).

Table 11: Species wise summary detections from all transects in SWR

Species (Common name)	Scientific name	No of detections	Total Number
Chital	*Axis axis*	56	590
Hog deer	*Axis porcinus*	13	40
Langur	*Semnopithecus entellus*	5	35
Nilgai	*Boselaphus tragocamelus*	5	53
Rhesus macaque	*Macaca mulatta*	6	53
Swamp deer	*Cervus duvauceli*	2	4
Black-naped hare	*Lepus nigricollis*	3	4
Wild boar	*Sus scrofa*	24	135
Total		114	914

7.5.3 Prey Density Estimates

The overall prey density estimated for SWR is 78.62 animals/km^2. Chital was the most common species with an estimated density of 41.34 animals/km^2. The details of the prey density are provided in Table 12.

Table 12: Prey density estimates for SWR.

Species	p-hat	ESW	Avg Cls-Size	Den-sity	SE	95% CI	DS	SE2	95% CI3
Shukla (Prey All)	0.28	40.4	8.6053	78.62	16.44	52.28-118.22	9.1366	1.04	7.29-11.449
Chital	0.31	44.16	10.6	41.34	11.76	23.78-71.85	5.33	0.92	3.79-7.49
Wild boar	0.54	38.4	4.11	11.88	4.59	5.6-24.9	2.88	0.89	1.58-5.26
Hog deer	0.44	22.1	3.07	6.76	3.42	2.59-17.64	2.9	1.21	1.35-6.5

Note: p-hat: detection probability; ESW: effective strip width; D: animal density; DS: group density

Babai valley as seen from Chepang, Bardia National Park-©WWF Nepal/Sabita Malla

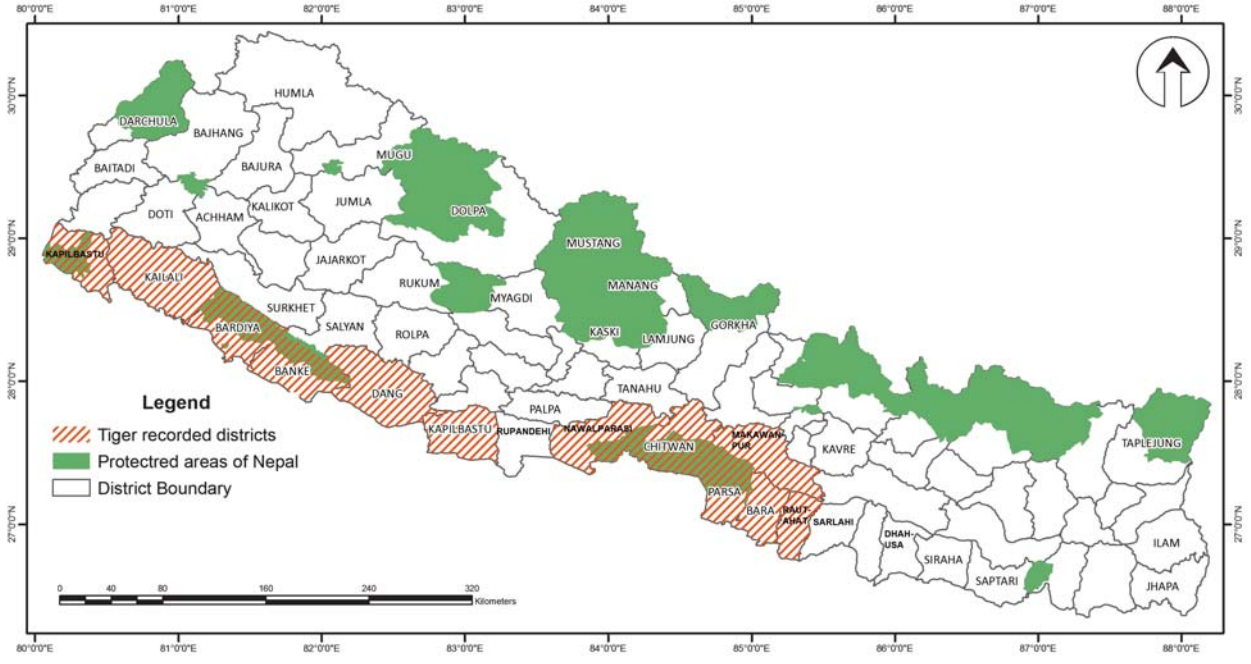
8

Tiger Habitat Occupancy - 2013

A total of 96 grids covering 21,600 km^2 were surveyed with a sampling effort of 2,322.6 km. Tiger signs were detected in 44 grids in 12 districts (Rautahat, Bara, Parsa, Makwanpur, Chitwan, Nawalparasi, Kapilvastu, Dang, Banke, Bardia, Kailali and Kanchanpur) (Map 20). These include three districts (Dang, Kapilvastu and Rautahat) where no tiger signs were detected in the 2008-09 survey.

8.1 Model Selection

We tested different models for detection probability (p) and the model with highest AIC weight was selected to run model occupancy tests (psi). Model no. 9 (psi,θ_o,θ_1,p(H+O)) incorporating human disturbance index (H) and observer experience (O) had the highest AIC weightage of 0.69 (Table 13). Hence, occupancy models were run using this detection model. Two best models viz. 7 and 8 were selected based on AIC comparisons (i.e., <2 Δ AIC suggested by Burnham and Anderson 2002; Table 14). Conditional probabilities were used for estimating habitat occupancy of tigers by taking the average of the best two models (model 7 and 8) and this was used for comparison with 2008 occupancy data (Barber-Meyer *et al* 2013).



Map 20: Districts where tiger presence was detected through tiger habitat occupancy survey.

Table 13: Model selection result for detection probability (p) using Akaike Information Criteria (AIC)

Model name	Model No.	AIC	ΔAIC	AIC weight	Model likelihood	K	-2l
psi,θ_o,θ_1,p(H+O)	9	1003.31	0	0.6866	2.59	7	989.31
psi,θ_o,θ_1,p(P+H+O)	10	1004.92	1.61	0.31	1.15	8	988.92
psi,θ_o,θ_1,p(O)	5	1013.67	10.36	0.003	1.46	6	1001.67
psi,θ_o,θ_1,p(P+O)	7	1014.47	11.16	0.002	9.77	7	1000.47
psi,θ_o,θ_1,p(H)	4	1030.26	26.95	0	3.64	6	1018.26
psi,θ_o,θ_1,p(P+H)	8	1032.2	28.89	0	1.38	7	1018.2
psi,θ_o,θ_1,p(.)	3	1047.69	44.38	0	5.97	5	1037.69
psi,θ_o,θ_1,p(P)	6	1049.62	46.31	0	2.27	6	1037.62
psi(.)p(.)	1	1180.21	176.9	0	1	2	1176.21
1group, constant P	2	1180.21	176.9	0	1	2	1176.21

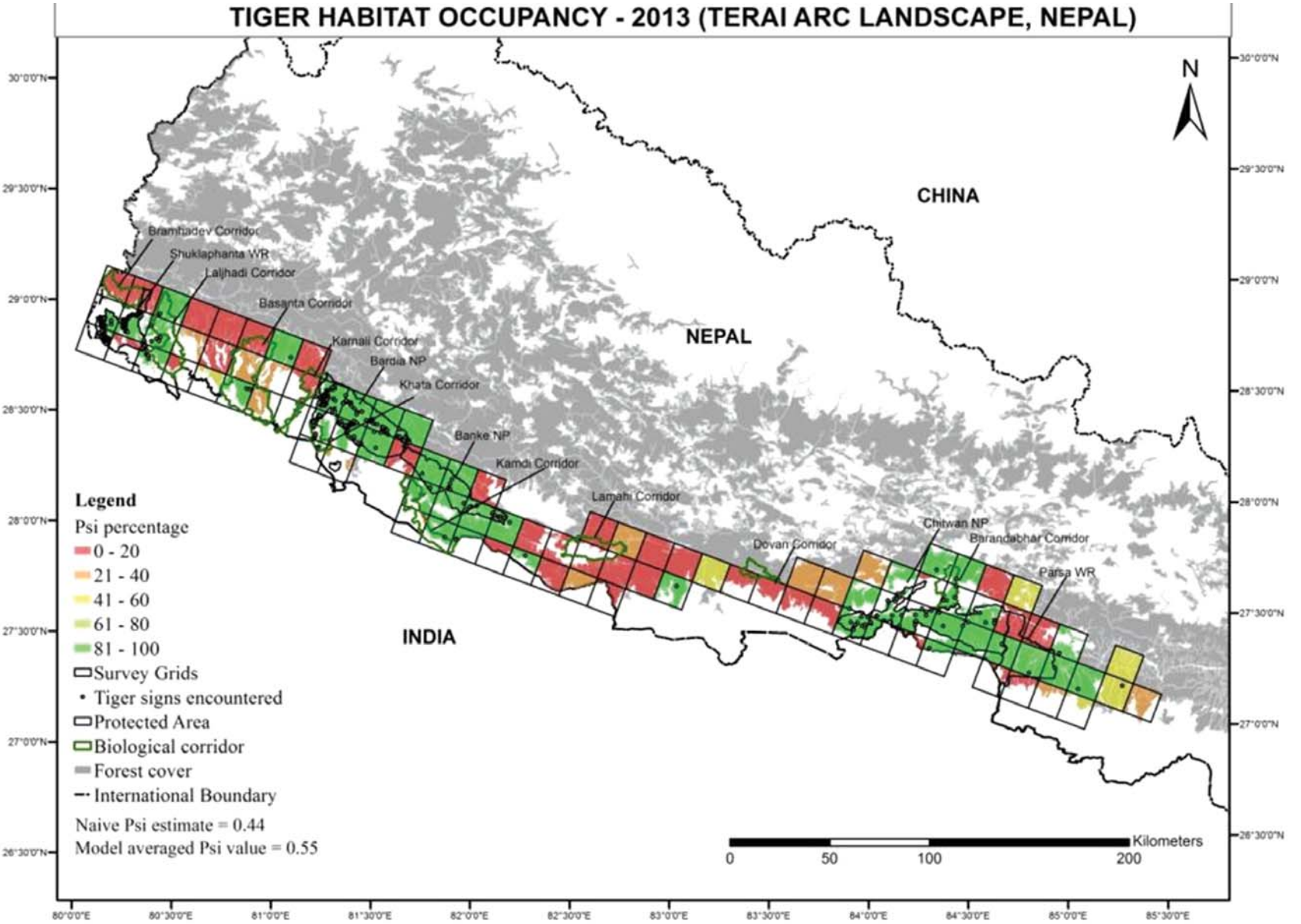
Table 14: Model selection for occupancy (psi) probability using AIC values

Model name	Model No.	AIC	ΔAIC	W	Model likelihood	K	-2l
psi(P),θ_o,θ_1,p(H+O)	7	998.89	0	0.47	1	8	982.89
psi(P+H),θ_o,θ_1,p(H+O)	8	999.58	0.69	0.34	0.7082	9	981.58
psi(H),θ_o,θ_1,p(H+O)	6	1001.32	2.43	0.14	0.30	8	985.32
psi(P+H),θ_o,θ_1,p(O)	3	1004.46	5.57	0.03	0.06	8	988.46
psi(H),θ_o,θ_1,p(O)	5	1005.33	6.44	0.02	0	7	991.33
psi(P),θ_o,θ_1,p(O)	4	1014.57	15.68	0	0	7	1000.57
psi,θ_o,θ_1,p(.)	2	1047.69	48.80	0	0	5	1037.7
psi(.),p(.)	1	1180.21	181.32	0	1	2	1176.21

8.2 Estimation of Probability of Occupancy (Psi) and the Probability of Detection (p)

The estimated naïve occupancy (S_o/S) for TAL Nepal is 0.44 (SE±0.05) where tigers were detected in 44 grid cells with an estimated detection probability of 0.29 (SE±0.05). The estimated overall model-averaged probability of site occupancy (Psi) is 0.55 (0.44-0.66) (Map 21).

In addition, the Psi for grid cells inside the protected areas is 0.75 (SE ± 0.003), and 0.39 (SE ± 0.06) for grid cells outside protected areas. The detection probability (P) inside PAs is 0.29 (SE ± 0.05) and and outside is 0.11 (SE ± 0.04).



Map 21: Overall estimated grid cell occupancy (green color indicates higher probability of occupancy).

9

Key Findings and Discussion

The key findings of this 2013 study are listed below and subsequently discussed in further detail.

- Nepal's Terai Arc Landscape supports 4 resident sub-populations of tigers in 4 complexes: a. Chitwan-Parsa, b. Banke-Kamdi, c. Bardia-Khata-Karnali and d. Shuklaphanta-Laljhadi-Brahmadev.
- The 2013 survey photo-captured 142 individual tigers (40 males and 102 females) in 5 protected areas of Nepal. The estimated population size for Nepal is 198 (163-235), with PWR 7 (4-7), CNP 120 (98-139), BaNP 4 (3-7), BNP 50 (45-55) and SWR 17(13-21). This is a 63% increase in Nepal's tiger population, with a major contribution from the significant increase in the tiger sub-population of BNP.
- There is wide variation in tiger density between PAs and even between different sites within the same PAs. Average tiger density in each PA ranged from 0.16 tigers/100 km^2 in newly declared BaNP to 3.84 tigers/100 km^2 in CNP, a factor of 24.
- There is significant variation in prey density across PAs; high prey densities of 92.6, 78.62 and 73.63 animals/km^2 were estimated in BNP, SWR and CNP respectively. PWR and BaNP were found to have much lower prey densities of 25.33 and 10.27 animals/km^2 respectively.
- There has been an increase in tiger habitat occupancy since the last survey. The naïve occupancy estimate has increased by 30%: i.e. from 0.34 in 2008-09 to 0.45 in 2013; while the model-averaged tiger occupancy increased by 50% during the last five years, from 0.37 in 2008-09 to 0.55 in 2013.

9.1 Tiger Meta-Population Structure

An overarching vision for conservation in TAL has been to maintain or restore connectivity between key habitat blocks to enable the persistence of large mammals through a meta-population management approach, with sub-populations in different sites connected to one another. This is of particular importance because loss of connectivity can result in reduced genetic heterozygosis, population persistence, and evolutionary potential and individual fitness. Connectivity can be restored through restoring habitat in contiguous areas and functional corridors (Sharma et al. 2013). The results of this study are encouraging in a number of ways – for instance, they demonstrate that tigers do occupy habitats outside PAs, in national forests and corridors like Khata and Barandabhar.

The camera-trapping data revealed 4 resident sub-populations of tigers in 4 complexes of Nepal TAL, i.e. Chitwan-Parsa, Banke-Kamdi, Bardia-Khata-Karnali and Shuklaphanta-Laljhadi-Basanta-Brahmadev. Photographic evidence or indirect signs were recorded from these areas, and provided ample evidence for exchange of tigers with the adjoining protected areas in India. However, weak to strong barriers exist for direct movement between the four sub-populations

of Nepal. These are due to the result of habitat fragmentation and degradation.

Tiger sub-populations of Banke-Kamdi and Bardia-Khata-Karnali could become one population if extensive management interventions are carried out in the eastern part of BNP and western part of BaNP. Currently, the Surkhet-Kohalpur highway together with intensively cultivated land, settlement and other anthropogenic activities are posing heavy pressure around Kohalpur, Chyama and Chepang, potentially preventing the dispersal of tigers between the two PAs. Habitat connectivity exists in linking the Chitwan-Parsa sub-population with the Banke-Kamdi sub-population to the west, but it would require intensive management of southern Dang, Kapilvastu and Rupendehi forests to allow tiger dispersal. Similarly, the fragmentation between BNP and SWR is very severe and managing the existing Karnali, Basanta, Laljhadi and Mohana corridors would be extremely important to link these two sub-populations. The tiger populations in TAL India are only connected through the PAs and corridors of Nepal TAL, hence the future of the tiger meta population across TAL lies in managing and maintaining the corridors and connectivity within Nepal TAL.

9.2 Tiger Distribution and Abundance

The tiger population in Nepal has increased substantially compared to the 2008-09 results (Karki et al. 2009). The outcome in BNP is overwhelming: the fast recovery of tiger from 18 (17-29) to 50 (45-55) can be attributed to improved park security, intensive habitat management, intact connectivity through the Khata corridor linking BNP with Katerniaghat Wildlife Sanctuary in India, and effective park-people engagement. The newly declared BaNP has been re-colonized by tigers, though it currently holds only a small number: 4 (3-7) animals. The number of tigers in PWR did not increase to the expected level. This may be due to poaching of tigers and prey species as also evidenced from our camera trap data: pictures of poachers with guns were captured at several locations in PWR. In addition, the field team had direct encounters with poachers on more than one occasion. The Thori-Nirmal Basti areas in Parsa, northern and south-eastern parts of Shuklaphanta, and Kamdi corridor adjacent to Suhelwa Wildlife Sanctuary were identified as areas with high threat of poaching.

The study also revealed significant spatial heterogeneity in the density of tigers across the PAs and within the sites sampled. Tiger density was highest in Chitwan (3.84 tigers/100 km^2) and lowest in BaNP with 0.16 tigers/100 km^2. Within PAs, locations with high estimates of tiger density were mainly floodplains and riparian habitats such as Rapti, Reu and Narayani floodplains in Chitwan, the Karnali floodplain and Babai valley in Bardia, and the Mahakali floodplain and grassland phanta in Shuklaphanta. These variations in tiger densities have been depicted in park specific tiger density maps (6, 8, 10, 12 and 14). From these results, it is apparent that riparian habitats and the flood-plains of rivers, wetlands and grasslands are the most productive tiger habitats in the Nepal TAL. Other habitat types such as the sal forest, mixed sal forest, and parts of the Chure range (comprising of mixed hardwood and hill sal forest) that were unexplored during the 2008-09 survey but included in 2013 have a reasonable distribution of tigers with a low to medium tiger density.

9.3 Prey Abundance

Prey densities have increased significantly in CNP, BNP and PWR since the last estimates in 2008-09. In BNP, the greatest contribution is from the increased prey base in Babai valley which faced severe prey-base poaching in the past. The villages along the northern boundary of the park practiced subsistence hunting in the past (Malla 2009) but surrendered more than 200 guns to the park authorities in 2011 and 2012 following the mainstreaming of these areas in buffer-zone management. In CNP, management has focused on managing and maintaining large grasslands

and wetlands such as the Dumaria phanta, Sukhivar, Lamitaal, Tamortaal and Padampur areas which support a high prey density. The Rambhori and Bhata areas in PWR have also made a major contribution to the ungulate density following the relocation of villages initiated in 2010.

The tiger prey density in Nepal is found to be much higher compared to other PAs in Indian Sub-continent (Karanth and Sunquist 1992; Steinmetz et al. 2010). High prey densities in BNP, SWR and CNP can be attributed to the heterogeneous habitats (riparian flood plains, grasslands and forests) that provide year-round food and water for ungulates, compared to the more homogeneous Bhabar-dominated and water-scarce PWR and BaNP which have notably lower prey densities.

9.4 Tiger Habitat Occupancy

Tiger habitat occupancy has increased significantly compared to the 2008-09 results (Barber-Meyer et al. 2013). In 2008, tigers were detected in 33 grid cells in 10 districts (Bara, Parsa, Makwanpur, Chitwan, Nawalparasi, Rupendehi, Banke, Bardia, Kailali and Kanchanpur) out of the 14 districts in the Nepal Terai Arc Landscape. During 2013, tiger signs were detected in 44 grid cells and an additional three districts (Dang, Kapilvastu and Rautahat). However, no tiger signs were detected in Rupendehi district in the current survey, while they were recorded during 2008-09.

The naïve occupancy estimate increased by 30%, from 0.34 in 2008-09 to 0.45 in 2013, while the model-averaged tiger occupancy increased by 50% from 0.37 in 2008-09 to 0.55 in 2013 (Table 15). This also corresponds with the increase in the tiger population from 121 individuals in 2008-09 to 198 in 2013 as estimated by camera trap survey.

Table 15: Comparison of psi values of tiger occupancy between the 2008-09 and 2013 surveys.

Categories	2008 survey	2013 survey
Total grid cells	96	96
Sampling occasions	40	40
Naïve occupancy (psi)	0.34	0.45
Model averaged psi	0.37 (±0.02)	0.55 (±0.05)
Detection probability (p)	0.65 (±0.08)	0.29 (±0.05)

While prey abundance is a key determinant of tiger occurrence, habitat quality may also have a direct influence on the occurrence and space use by tigers. Our studies indicate high occupancy of tigers in the grid cells lying inside the protected areas: 0.75 (SE ± 0.003), while the Psi for grid cells outside PA is only 0.39 (SE ± 0.06). BaNP was declared in 2010 and since then the occupancy has increased from 0.34 to 0.83, likely linked with improved habitat quality and reduction in anthropogenic pressure. Other notable areas with increased tiger occupancy are the forests of Dang and Banke.

10

Management Implications

The growth and persistence of the tiger meta-population can be fostered by restoring habitat connectivity, protecting the species from poachers, and effectively managing human-tiger conflict. Tiger conservation does not take place in a vacuum. It is important to take into account the evolving social, economic, political and climatic conditions in this heavily populated landscape, the new threats that this brings (e.g. from infrastructure development), and also opportunities (e.g. through reducing emissions from deforestation and forest degradation, REDD+). The good news is that despite many challenges, Nepal has made major progress towards its goal of doubling tiger numbers by 2022. The challenge now is to maintain this momentum and find ways to accommodate additional tigers while mitigating human-tiger conflict and reconciling tiger management with other land uses. It is also well established that tigers thrive in areas with high density of large-bodied wild ungulate prey. Protection therefore needs to be extended not only to the tiger sub-populations but to their prey base and to the habitats they occupy.

We recommend and emphasize the following conservation actions:

1. **Law Enforcement:** Systematic and organized patrolling using the Spatial Monitoring and Reporting Tool (SMART) and intelligence gathering should be continued and ramped up where needed in all PAs, buffer zones and corridor forests, to effectively protect tiger, prey and their habitats. Identified high-risk poaching areas need high-standard security including: Thori-Nirmal Basti in Parsa; northern and south-eastern parts of Shuklaphanta; Kamdi corridor forest adjacent to Suhelwa; and Basanta, Laljhadi and Karnali corridor forest areas.
2. **Habitat Management:** The good management practices of BNP need to be extended to the Chisapani section of the park and replicated in the other PAs in Nepal. Regular habitat management is required to maintain habitat heterogeneity to support high densities of large ungulate assemblages in Terai PAs. Habitat enrichment programs (creation of wetland and grassland) are recommended for BaNP and PWR to increase their prey populations.
3. **Infrastructure Development:** Plans for infrastructure development that may alter hydrological regimes and hence habitats in tiger areas should be very closely monitored and environmental flow analysis conducted to assess possible impacts to tiger and prey habitats. This includes hydropower and irrigation schemes upstream in the Gandaki, West Rapti, Babai, Karnali and Mahakali river basins, as well as road and railway development in the Terai. Impacts on tiger habitat should be incorporated into environmental impact assessments, and cumulative impacts of multiple developments (e.g. a series of dams in the same river basin) should be taken into account. Small changes in water table level, minimum flows and flood regimes can have large impacts on vegetation

types, tipping the balance between wetland, grassland and forest. (See also below for linear infrastructure.)

4. **Habitat Connectivity:** Fast recovery of the tigers in BNP and SWR can be attributed to the proximity to other tiger bearing areas in India. Hence removing barriers and gaps in connectivity along corridors is recommended which will ensure the dispersal of tigers through forested habitats that link important tiger sub-populations in Nepal and India. To restore corridors following strategies are recommended:
   - Restoring forest cover (planting of native species or encouraging natural regeneration) in strategic gaps
   - Reducing human pressure and cattle grazing in corridors
   - Timely advocacy and implementation for smart infrastructure (careful design of infrastructure to avoid corridors where possible; mitigating measures when this is not possible, including overpasses and/or underpasses for wildlife to cross highways, railway and canals safely; avoidance of sensitive areas; etc.)
   - Eviction of encroachers from all wildlife sensitive areas.
5. **Road Accidents:** Collisions between vehicles and wild animals are evident across TAL, resulting in human and wildlife casualties. Speed limits must be set and enforced on roads traversing tiger habitat, and traffic calming measures put in place.
6. **Human Disturbance:** Though human disturbance is not a major issue in core tiger habitats, peripheral areas of CNP, BNP and BaNP suffer from extensive cattle-grazing and wood-cutting. Shuklaphanta including the core area in particular experiences cattle grazing, wood cutting and grass collection. This study also recorded a livestock density of 21 animals/km^2 in SWR and it is therefore recommended that this issue is addressed immediately.
7. **Human-tiger Conflict:** Human-tiger conflict is likely to surge with increasing tiger numbers. It is currently most evident in areas with high tiger density, especially in the Rapti, Reu and Narayani floodplains of CNP. On average 2-3 tigers are reported to be pushed out annually by dominant males (CNP 2013); they often move to fringe areas and villages, where they may attack livestock and people. This is likely to escalate with increasing tiger numbers in the Karnali floodplains and other high density tiger areas. There is a need to systematically document conflict incidence, and develop and implement timely strategic mitigation measures to reduce human fatalities, injuries, and loss of livestock. A rapid disbursing compensation system is essential. In addition, problem tigers need to be rescued and rehabilitated where feasible. Ignoring these important issues results in great human suffering, and can severely compromise conservation in long run, leading to retaliatory killings and loss of local and political support.
8. **Regular Monitoring and Surveillance**: The well-being of source populations is crucial for long term persistence of tigers within the larger landscape which could otherwise deplete very rapidly if targeted by commercial poachers. Therefore, regular monitoring and surveillance is essential for small sub-populations like those of Parsa, Banke and Suklaphanta including important corridors.

9. **Applied Ecological and Socio-economic Studies:** Much still remains unknown in terms of tiger ecology in the face of habitat alteration and anthropogenic pressure. Therefore, long term ecological studies are recommended to understand population trends, population dynamics and tiger behavior for designing better conservation plans and addressing human-tiger conflict. Corresponding socio-economic studies are needed to better understand current trends directly and indirectly affecting the tiger population. Further analysis of the data from the current study can contribute to these studies.

10. **Site-specific Tiger Recovery Plans:** This study has identified PWR and surrounding habitats, BaNP and its surrounding Kamdi corridor, north-western and south-eastern SWR and its surrounding corridor forest as the key tiger and prey recovery sites and therefore recommends the preparation of site specific recovery plans to meet Nepal's TX2 goal, applying results from more detailed analysis of the data from this report.

11. **Climate Change Adaptation:** Climate change is likely to impact tiger, prey base and other associated wildlife and their habitats. Undertaking vulnerability assessments for tiger and PAs; mainstreaming climate change into Nepal's PA network, PA management plans and species action plans; and training PA and forestry staff are recommended in order to build resilience of ecosystems and wildlife, and eventually accept and adapt to change. This includes addressing potential adverse impacts of climate induced hazards such as fire, drying up of water sources, flooding, habitat change, river cutting by flash floods, and landslides particularly in the Churia range.

Swamp deer in Shuklaphanta Wildlife Reserve-©NTNC/Hemanta Yadav

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Annexures

Annex-1

Advisory Committee

Name	Position	Organization	Role in Advisory Committee
Mr. Megh Bahadur Pandey	Director General	Department of National Parks and Wildlife Conservation	Coordinator
Mr. Juddha Bahadur Gurung	Member Secretary	National Trust for Nature Conservation	Member
Mr. Anil Manandhar	Country Representative	WWF Nepal	Member

Technical Committee

Name	Position	Organization	Role in Technical Committee
Dr. Maheshwar Dhakal	Ecologist	Department of National Parks and Wildlife Conservation	Coordinator
Ms. Madhuri Karki (Thapa)	Under Secretary	Department of Forests	Member
Dr. Shant Raj Jnawali	Coordinator	Hariyo Ban Program/ WWF Nepal	Member
Dr. Narendra Man Babu Pradhan	Coordinator	WWF Nepal	Member
Dr. Naresh Subedi	Senior Conservation Officer	National Trust for Nature Conservation	Member
Core Biologists Group (Research Designing, Data analysis and Report Writing)			
Ms. Sabita Malla	Senior Research Officer	WWF Nepal	
Mr. Baburam Lamichhane	Conservation Officer	National Trust for Nature Conservation	
Mr. Hemant Yadav	Conservation Officer	National Trust for Nature Conservation	
Mr. Gokarna Jung Thapa	GIS Manager	WWF Nepal	
Mr. Samundra Subba	Research Associate-TAL	WWF Nepal	
Mr. Pankaj Ratna Bajracharya	GIS-Associate	WWF Nepal	

Field Implementation Committee, Shuklaphanta-Kailali Complex

Name	Position	Organization	Role in Implementation Committee
Mr. Uba Raj Regmi	Chief Conservation Officer	Shuklaphanta Wildlife Reserve	Coordinator
Mr. Lal Narayan Singh	District Forest Officer	District Forest Office, Kanchanpur	Member
Mr. Rajendra Man Singh Bhandari	District Forest Officer	District Forest Office, Kailali	Member
Mr. Hemanta Yadav	In-Charge	Shuklaphanta Conservation Program (NTNC)	Member
Mr. Prakash Lamsal	Manager (Former)	TAL-CBRP	Member
Mr. Sagar Rimal	Manager	TAL-CBRP	Member
Mr. Tilak Dhakal	Co-Manager	TAL-CBRP	Member

Field Implementation Committee, Bardia-Banke Complex

Name	Position	Organization	Role in Implementation Committee
Mr. Tika Ram Adhikari	Chief Conservation Officer	Bardia National Park	Coordinator
Mr. Tulsi Ram Sharma	Chief Conservation Officer	Banke National Park	Member
Mr. Dhananjaya Lamichhane	District Forest Officer	District Forest Office, Bardia	Member
Mr. Tirtha Raj Joshi	District Forest Officer	District Forest Office, Banke	Member
Mr. Arun Sharma Poudyal	District Forest Officer	District Forest Office, Dang	Member
Mr. Rabin Kadariya	In-Charge	Bardia Conservation Program (NTNC)	Member

Field Implementation Committee, Chitwan-Parsa Complex

Name	Position	Organization	Role in Implementation Committee
Mr. Fanindra Raj Kharel	Chief Conservation Officer	Chitwan National Park	Coordinator
Mr. Kamal Jung Kunwar	Chief Conservation Officer	Banke National Park	Member
Dr. Indra Prasad Sapkota	District Forest Officer	District Forest Office, Chitwan	Member
Mr. Soharat Prasad Thakur	District Forest Officer	District Forest Office, Nawalparasi	Member
Ms. Santa Maya Shrestha	District Forest Officer	District Forest Office, Parsa	Member
Mr. Imamuddin Ansari	District Forest Officer	District Forest Office, Makwanpur	Member
Mr. Man Bahadur Khadka	District Forest Officer	District Forest Office, Bara	Member
Mr. Dipak Jnawali	District Forest Officer	District Forest Office, Rupendehi	Member
Mr. Krishna Prasad Pokharel	District Forest Officer	District Forest Office, Kapilbastu	Member

Mr. Nanda Lal Raya Yadav	District Forest Officer	District Forest Office, Rautahat	Member
Dr. Chiranjibi Prasad Pokhrel	In-Charge	Biodiversity Conservation Center (NTNC)	Member
Mr. Shyam Shah	Manager	TAL-PABZ	Member
Mr. Abdul Ansari	Co-Manager	TAL-PABZ	Member

Annex-2

A: Site specific details on camera trapping

S.N	Site	No of Blocks	Camera Stations	Trapping Effort (Nights)	Area sampled (MCP)	Trapping period
1.	Parsa WR and surrounding forests	2	177	2655	801.93	18 April-26 May,13
2.	Chitwan NP and Barandabhar corridor	4	362	5430	2626	14 Feb-3 May,13
4.	Banke NP	2	118	1770	687.41	5 Mar-29 April,13
7.	Bardia NP and Khata corridor	4	238	3570	1485.54	5 Mar-29 April,13
12.	Shuklaphanta WR	2	88	1320	485.76	10 Feb-15 Mar,13
13	Basanta corridor	1	56	840	224	3 April-18 Apr, 13

B: Site specific details on line transect survey

S.N	Sites	No of transects	Sampling Effort	No of detections (Prey)	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
4.	Banke NP	75	333.74	55	10.27 (6.34)	3.3 - 31.8
7.	Bardia NP	219	397.58	571	92.6(8.8)	76.875 - 111.54
12.	Shuklaphanta WR	82	154.15	114	78.62(16.44)	52.98 - 118.22

Annex-3

Annex 3.1: Individual Photographic Profile of Tigers of Parsa Wildlife Reserve


PWR13_MAA-01-


PWR13_FAA-02-Right


PWR13_FAA-02-Left-Back


PWR13_FAA-03-Right


PWR13_FAA-04-Right


CNP 13_MAA-01-Left

Annex 3.2: Individual Photographic Profile of Tigers of Chitwan National Park


CNP 13_MAA-02-Right


CNP 13_MAA-02-Left


CNP13_FAA-03-Right


CNP13_FAA-04-Right


CNP13_FAA-04-Left


CNP13_FAA-05-Right


CNP13_FAA-05-Left


CNP 13_FAA-06-Right


CNP 13_FAA-06-Left


CNP13_FAA-07-Right


CNP13_FAA-07-left


CNP13_MAA-08-Right


CNP13_MAA-08-Left


CNP13_MAA-09-Right


CNP13_MAA-09-Left


CNP 13_FAB_10-Right


CNP 13_FAB_10-Left


CNP13_MBB-11-Right


CNP13_MBB-11-Left


CNP 13_FBB-12-Right


CNP 13_FBB-12-Left


CNP13_FBB-13-Right


CNP13_FBB-13-Left


CNP13_FBB-14-Right


CNP13_FBB-14-Left


CNP13_FBB-15-Right


CNP13_FBB-15-Left


CNP13_FBB-16-Right


CNP13_FBB-16-Left

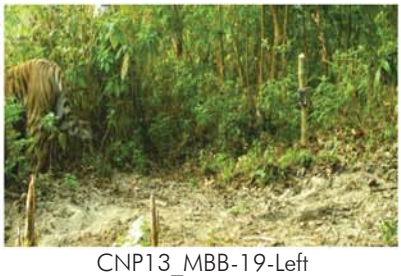

CNP13_FBB-17-Right


CNP13_FBB-17-Left


CNP13_FBB-18-Right


CNP13_FBB-18-Left


CNP13_MBB-19-Right


CNP13_MBB-19-Left


CNP13_MBB-20-Right


CNP13_MBB-11-Left


CNP13_MBB-20-Left


CNP13_FBB-21-Right


CNP13_FBB-21-Left


CNP13_FBB-22-Right


CNP13_FBB-23-Right


CNP13_FBB-14-Left


CNP13_FBB-24-Right


CNP13_FBB-24-Left


CNP13_FBB-16-Right


CNP13_FBB-25-Right


CNP13_FBB-25-Left


CNP13_FBB-26-Right


CNP13_FBB-26-Left


CNP13_FBB-27-Right


CNP13_FBB-27-Left


CNP13_MBB-28-Right


CNP13_MBB-28-Left


CNP13_FBB-29-Right


CNP13_FBB-29-Left


CNP13_MBD-30-Right


CNP13_MBD-30-Left


CNP13_MBB-31-Right


CNP13_MBB-31-Left


CNP13_FBB-32-Right


CNP13_FBB-32-Left


CNP13_FBB-33-Right


CNP13_FBB-33-Left


CNP13_FBB-34-Right


CNP13_FBB-35-Left


CNP13_FBB-36-Right


CNP13_FBB-36-Left


CNP13_FBB-37-Right


CNP13_FBB-37-Left


CNP13_MBB-38-Right Back


CNP13_MBB-38-Left


CNP13_MBB-39-Right


CNP13_FBB-40-Right


CNP13_FBB-40-Left


CNP13_FBB-41-Right


CNP13_FBB-41-Left


CNP13_FBB-42-Right


CNP13_FBB-42-Left


CNP13_MBC-43-Right


CNP13_MBC-43-Left


CNP13_FCC-44- Front


CNP13_FCC-44-Left


CNP13_FBC-45- Right


CNP13_FBC-45-Left


CNP13_FBC-46- Right


CNP13_FBC-46-Left


CNP13_FCC-47- Right-with two cubs


CNP13_FCC-47-Left


CNP13_MBB-48- Right


CNP13_FCC-49- Left


CNP13_FCC-50-Right


CNP13_FCC-51-Right


CNP13_MCC-52-Right


CNP13_MCC-52-Left


CNP 13_FCC-53-Right-with 3 cubs


CNP 13_FCC-53-Left


CNP 13_FCC-54-Right


CNP 13_FCC-54-Left


CNP 13_FCC-55-Right


CNP 13_FCC-55-Left


CNP 13_FCC-56-Right


CNP 13_FCC-56-Left


CNP 13_FCC-57-Right


CNP 13_FCC-57-Left


CNP13_FCC-58-with two cubs


CNP 13_MCC-59-Right


CNP 13_MCC-59-Left


CNP13_MCC-60-Right


CNP 13_MCC-60-Left


CNP13_FCC-61-Right


CNP13_FCC-62-Right


CNP13_FCC-62-Left


CNP13_FCC-63-Right


CNP13_FCC-63-Left


CNP13_MCC-64-Right


CNP13_MCC-64-Left


CNP13_MCC-65-Right


CNP13_MCC-65-Left


CNP13_FCC-66-Left


CNP13_FCC-67-Right


CNP13_FCC-67-Left


CNP13_MDD-68-Right


CNP13_MDD-68-Left


CNP13_FDD-69-Right


CNP13_FDD-69-Left


CNP13_FDD-70-Right


CNP13_FDD-70-Left


CNP13_FDD-71-Right


CNP13_FDD-71-Left


CNP13_FDD-72-Left


CNP13_MDD-73-Left


CNP13_MDD-73-Left


CNP13_FDD-74-Right


CNP13_FDD-74-Left


CNP13_FDD-75-Right


CNP13_FDD-75-Left


CNP13_FDD-76-Right


CNP13_FDD-76-Left


CNP13_MDE-77-Right


CNP13_MDE-77-Left

Annex 3.3 : Individual Photographic Profile of Tigers of Banke National Park


BaNP 13_MAB-01-Right


BaNP 13_MAB-01-Left


BaNP13_MBB-02-Right


BaNP13_MBB-02-Left


BaNP 13_FBB-03-Right


BaNP 13_FBB-03-Left

Annex 3.4: Individual Photographic Profile of Tigers of Bardia National Park


BNP13_MAA_01-Left


BNP13_MAA_01-Right


BNP13_FAB_02-Left


BNP13_FAB_02-Right


BNP13_FAA_03-Left


BNP13_FAA_03-Right


BNP 13_MAA_04-Left


BNP 13_MAA_04-Right


BNP_13_FAA_05-Left


BNP_13_FAA_05-Right


BNP13_MAB_06-Front


BNP13_MAB_06-Right


BNP13_FAA-07-Left


BNP13_FAA-07-Right


BNP13_FAA_08-Left


BNP13_FAA-08-Right


BNP13_FAA-09-Right


BNP13_FAA-09-Left


BNP13_MAA-10-Left


BNP13_MAA-10-Right


BNP13_FAA-11-Left


BNP13_FAA-11-Right


BNP13_FAA-12-Left


BNP13_FAA-12-Right


BNP13_FAA-13-Left


BNP13_FAA-13-Right


BNP13_FAA-14-Left


BNP13_FAA-14-Right


BNP13_FAA-15-Right


BNP13_FAA-15-Left


BNP13_FAA-16-Right


BNP13_FAA-16-Left


BNP13_FAA-17-Right


BNP13_FAA-17-Left


BNP13_FAA-18-Right


BNP13_FAA-18-Left


BNP13_FAA-19-Right


BNP13_FAA-19-Left


BNP13_FAA-20-Right


BNP13_FAA-20-Right


BNP13_MAA-21-Right


BNP13_MAA-21-Left


BNP13_MAA-22-Right


BNP13_MAA-22-Left


BNP13_MAA-23-Right


BNP13_MAA-23-Left


BNP13_FAA-24-Right


BNP13_FAA-24-Left


BNP13_MBB-25-Right


BNP13_MBB-25-Left


BNP13_MBD-26-Right


BNP13_MBD-26-Left


BNP13_FBB-27-Right


BNP13_FBB-27-Left


BNP13_FBB-28-Right


BNP13_FBB-28-Left


BNP13_FBB-29-Right


BNP13_FBB-29-Left


BNP13_MBC-30-Right


BNP13_MBC-30-Left


BNP13_FBB-31-Right


BNP13_FBB-31-Left


BNP13_MBB-32-Right


BNP13_MBB-32-Left


BNP13_FBB-33-Right

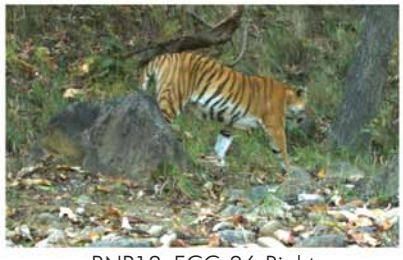

BNP13_FBB-33-Left


BNP13_FBB-34-Right


BNP13_FBB-34-Left


BNP13_FBB-35-Right


BNP13_FBB-35-Left


BNP13_FCC-36-Right


BNP13_FCC-36-Left


BNP13_FCC-37-Right


BNP13_FCC-37-Left

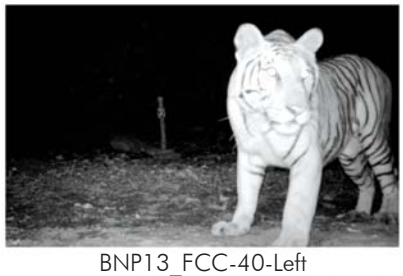

BNP13_MCC-38-Right


BNP13_MCC-38-Left


BNP13_FCC-39-Right


BNP13_FCC-39-Left

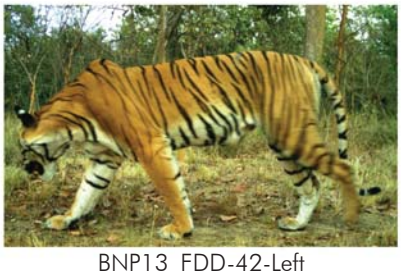

BNP13_FCC-40-Right


BNP13_FCC-40-Left


BNP13_FDD-41-Right


BNP13_FDD-41-Left


BNP13_FDD-42-Right


BNP13_FDD-42-Left


BNP13_FCC-43-Right


BNP13_FCC-43-Left


BNP13_MCC-44-Right


BNP13_MCC-44-Left

Annex 3.5: Individual Photographic Profile of Tigers of Shuklaphanta Wildlife Reserve


SWR 2013_FAA-01-Right


SWR 2013_FAA-01-Left


SWR_2013-FAA-02-Right


SWR_2013-FAA-02-Left


SWR_MAA-03-Right


SWR_MAA-03-Left


SWR_FAA_04-Right


SWR_FAA-05-Right


SWR_FAA-05-Left


SWR_MAA-06-Right


SWR_MAA-06-Left


SWR_FAA_07-Right


SWR_FAA_07-Left


SWR_MAA-08-Right


SWR_MAA-08-Left


SWR_FAA-09-Right


SWR_FAA-09-Left


SWR_MBB-10-Right


SWR_MBB-10-Left


SWR_MBB-11-Right


SWR_MBB-11-Left


SWR_FBB-12-Right


SWR_FBB-12-Left


SWR_FBB_13-Right


SWR_FBB_13-Left

Annex 4: List of participants involved in the tiger and prey-base survey-2013

A: Participants of Tiger and Prey-base Survey in Chitwan-Parsa Complex

S.N	Name	Affiliation
1	Abinash Thapa Magar	Chitwan National Park
2	Anil Prasai	NTNC- Biodiversity Conservation Center
3	Ashish Tripathi	Kathmandu Forestry College
4	Babu Ram Mahato	International Trust for Nature Conservation
5	Bal Kishnan Mahato	International Trust for Nature Conservation
6	Balkrishna Mahato	International Trust for Nature Conservation
7	Basanta Lamichhane	Chitwan National Park
8	Bhola Prasad Subedi	Parsa Wildlife Reserve
9	Bhumi Raj Sedhai	Chitwan National Park
10	Bijaya Chapagain	Kathmandu University
11	Bir Bahadur Kumal	International Trust for Nature Conservation
12	Birendra Prasad Yadav	Chitwan National Park
13	Birendra Roka Gautam	Chitwan National Park
14	Binod Darai	Chitwan National Park
15	Bishal K.C	Kathmandu University
16	Bishnu Lama	NTNC- Biodiversity Conservation Center
17	Bishnu Pradad Neupane	District Forest Office Nawalparasi
18	ChijKumar Shrestha	Chitwan National Park
19	Chiranjivi Khanal	Institute of Foresty, Pokhara
20	Deepak Kumal	Chitwan National Park
21	Devi Prasad Bhandari	Tribhuvan University
22	Dibendra Rai	Nepal Army
23	Dilli Shedai	Tribhuvan University
24	Dipesh Mijor	Kathmandu Forestry College
25	Ganesh Tripathi	Kathmandu Forestry College
26	Ganesh Ghimire	Parsa Buffer Zone
27	Hari P Sapkota	District Forest Office, Chitwan
28	Hari Prasad Bartaula	Parsa Wildlife Reserve
29	Harka Man Lama	NTNC- Biodiversity Conservation Center
30	Hem Lal Subedi	Parsa Wildlife Reserve
31	Hom Bahadur Gurung	International Trust for Nature Conservation
32	Indra Raj Upreti	Chitwan National Park
33	Ishuk Narayan Shreshtha	Nepal Army
34	Josh Raj Rai	Nepal Army
35	Kabindra Regmi	Chitwan National Park
36	Kalu Prasad Gaule	District Forest Office Chitwan
37	Karmath Subedi	Tribhuvan University

38	Karmatha Subedi	Tribhuvan University
39	Khima Nath Belbase	Nature Guide Association
40	Krishna Bahadur Pariyar	Chitwan National Park
41	Krishna Darai	Chitwan National Park Buffer zone
42	Kapil Pokhrel	NTNC-Biodiversity Conservation Center
43	Lalit malla	Chitwan National Park
44	Laptan Tharu	Chitwan National Park
45	Laxman Kumar Mahato	Chitwan National Park
46	Laxman Thapa	Nepal Army
47	Laxmi Mahato	Chitwan National Park Buffer zone
48	Lok Raj Neupane	Chitwan National Park
49	Man Bahadur Lama	NTNC- Biodiversity Conservation Center
50	Manoj Chaudhary	Institute of Foresty, Pokhara
51	Man Puran Chaudhary	Parsa Wildlife Reserve
52	Megh Nath Lamichanne	Parsa Wildlife Reserve
53	Nandu Ram Acharya	NTNC- Biodiversity Conservation Center
54	Nar Bahadur Magar	Nepal Army
55	Narayan K Baniya	Parsa Wildlife Reserve
56	Narayan Prasad Neupane	District Forest Office, Chitwan
57	Om Prasad Chaudhary	NTNC- Biodiversity Conservation Center
58	Padam Bahadur Pakhrin	Nature Guide Association
59	Pawari Yadav	Chitwan National Park
60	Prakhyat Jung Thapa	Tribhuvan University
61	Pramod Kumar Yadav	Parsa Wildlife Reserve
62	Prem Bahadur Bamjan	Nature Guide Association
63	Prem Lama	Nature Guide Association
64	Purna Lama	NTNC- Biodiversity Conservation Center
65	Pushpa Raj Shrestha	District Forest Office, Kapilbastu
66	Rajmani Mahato	Chitwan National Park
67	Ramjee Chaudhary	Chitwan National Park Buffer zone
68	Raju Kumal	International Trust for Nature Conservation
69	Ram Chandra Raila	Chitwan National Park
70	Ram Nath yadav	Chitwan National Park
71	Ram Krishna Bhattarai	Institute of Foresty, Pokhara
72	Ramesh Darai	NTNC- Biodiversity Conservation Center
73	Rishi Ram Bhurtel	Chitwan National Park
74	Rishiram Bhurtel	Chitwan National Park
75	Rishiram Dhakal	Chitwan National Park
76	Roshan Kumar Thakur	Tribhuvan University
77	Rup Narayan Chaudhary	Parsa Wildlife Reserve
78	Sanjaya Mahato	Chitwan National Park Buffer zone
79	Santosh Dotel	Parsa Wildlife Reserve

80	Sujan Khanal	Institute of Foresty, Pokhara
81	Sukram Darai	Chitwan National Park
82	Sukram Mahato	Chitwan National Park
83	Sun Bahadur Mahato	Chitwan National Park
84	Suresh Kumar Yadav	Chitwan National Park
85	Sushil Jha	Chitwan National Park
86	Swagat Nepal	Institute of Agriculture and Animal Science, Rampur
87	Swatantra Dangi	Institute of Agriculture and Animal Science, Rampur
88	Tika Ram Tamang	Chitwan National Park Buffer zone
89	Tika Ram Tharu	NTNC- Biodiversity Conservation Center
90	Tirtha Lama	NTNC- Biodiversity Conservation Center
91	Top Lal Shrestha	Chitwan National Park
92	Tulsi Dahal	Nepal Army
93	Udit Aryal	Institute of Foresty, Pokhara
94	Upendra Kachhadiya	Chitwan National Park Buffer zone
95	Yadav Shahi	Parsa Wildlife Reserve
96	Yagya Prasad Kafle	Chitwan National Park

B: Participants of Tiger and Prey-base Survey in Banke-Bardia Complex

S.N.	Name	Affiliation
1	Bintiram Tharu	NTNC-Bardia Conservation Program
2	Parsuram Tharu	Bardia National Park
3	Tanka Bahadur chaudhari	Bardia National Park
4	Ratiram Chaudhari	BNP-Bufferzone
5	Yugal Chaudhari	BNP-Bufferzone
6	Bipan Chaudhari	BNP-Bufferzone
7	Lahuram Tharu	BNP-Bufferzone
8	Akram Husen Sekh	BNP-Bufferzone
9	Sanet Kumar Chaudhari	BNP-Bufferzone
10	Aakash Chaudhari	BNP-Bufferzone
11	Krimlal Chaudhari	Bardia National Park
12	Baliram Chaudhari	Bardia National Park
13	Chandra Bahadur Oli	Bardia National Park
14	Khusiram chaudhari	NTNC-Bardia Conservation Program
15	Hariram Chaudhari	BNP-Bufferzone
16	Rajesh Thapa	BNP-Bufferzone
17	Shukra Bhadur Chaudhari	BNP-Bufferzone
18	Shankar Tharu	BNP-Bufferzone
19	Anuram Chaudhari	BNP-Bufferzone
20	Dipak Thapa	BNP-Bufferzone

21	Raj Man Chaudhari	BNP-Bufferzone
22	Dip Bahadur Shahi	BNP-Bufferzone
23	Raghupati Chaudhari	Bardia National Park
24	Nirmal Chaudhari	Bardia National Park
25	Praksh Chaudhari	BNP-Bufferzone
26	Binaya Chaudhari	BNP-Bufferzone
27	Udaya Raj Chaudhari	BNP-Bufferzone
28	Dinesh Chaudhari	BNP-Bufferzone
29	Jagat Prasad Rijal	BNP-Bufferzone
30	Phirulal Tharu	NTNC-Bardia Conservation Program
31	Indra Prasad Jaisi	BNP-Bufferzone
32	Hinguwa Tharu	Bardia National Park
33	Rajan Prasad Acharaya	Bardia National Park
34	Ramesh Tharu	BNP-Bufferzone
35	Khushiram Chaudhari	BNP-Bufferzone
36	Lakhan Chaudhari	BNP-Bufferzone
37	Ram Krishana Yogi	BNP-Bufferzone
38	Hariram Chaudhari	BNP-Bufferzone
39	Sohan Chaudhari	BNP-Bufferzone
40	Tilak Prasad Upadhay	BNP-Bufferzone
41	Birendra Kandel	Banke National Park
42	Puroshottam Wagley	Banke National Park
43	Hari Giri	Banke National Park
44	Janga Bahadur Rawol	Banke National Park
45	Prithivi Bahadur Dangi	Banke National Park
46	Bal Krishna Hulala	Banke National Park
47	Shiva oli	Banke National Park
48	Ramraj Chaudhari	NTNC-Bardia Conservation Program

C: Participants of Tiger and Prey-base Survey in Shuklaphanta WR and Basanta Corridor

S. N	Name	Affiliation
1	Karna Bd. Bom	Shuklaphanta WR
2	Kasi Ram Negi	Shuklaphanta WR
3	Ram Bilas Tharu	Shuklaphanta WR
4	Narendra Sunah	Shuklaphanta WR
5	Anand Sunah	Shuklaphanta WR
6	Harendra Sunah	Shuklaphanta WR

7	Umesh Sunah	Shuklaphanta WR
8	Ramesh Rana	Shuklaphanta WR
9	Suman Malla	NTNC-Shuklaphanta Conservation Program
10	Bhubaneshwor Chaudhary	Shuklaphanta WR
11	Dev Raj Joshi	NTNC-Shuklaphanta Conservation Program
12	Shankar Lal Chaudhary	Shuklaphanta WR
13	Ganesh Rana	NTNC-Shuklaphanta Conservation Program
14	Amar Singh Thakur	Shuklaphanta WR
15	Jiteendra Rana	Shuklaphanta WR
16	Ram Singh Sunah	Shuklaphanta WR
17	Indra Chaudhary	Shuklaphanta WR
18	Thaggu Chaudhary	Shuklaphanta WR
19	Thaggu Rana	Shuklaphanta WR
20	Gyanu Kaji Maharjan	Shuklaphanta WR
21	Jograj Rana	NTNC-Shuklaphanta Conservation Program
22	Barun Pandey	Shuklaphanta WR
23	Hansha Rokaya	Shuklaphanta WR
24	Ram Bd. Magar	Shuklaphanta WR
25	Bir. Bd. Chaudhary	Shuklaphanta WR
26	Tula Dutta Badu	Shuklaphanta WR
27	Lilam Singh Thakur	Shuklaphanta WR
28	Satya Narayan Silwal	Shuklaphanta WR

Students involved in Habitat Occupancy Survey-2013

S. N	Name	Affiliation/Institution
1	Pallab Regmi	SchEMS, Pokhara University
2	Ajit Tumbahanphe	SchEMS, Pokhara University
3	Yubraj Khadka	Khwopa College, Pokhara University
4	Supreme Prajapati	Khwopa College, Pokhara University
5	Shohan Shrestha	KNIT, Korea
6	Kalpana Jha	Khwopa College, Pokhara University
7	Sandhya Manandhar	Khwopa College, Pokhara University
8	Akrosh Shrestha	CDES, Tribhuvan University
9	Nitesh Shing	CDES, Tribhuvan University
10	Bijay Maharjan	Khwopa College
11	Rama Karki	CDES, Tribhuvan University
12	Suryaman Shreshta	Khwopa College, Pokhara University
13	Renu Napit	Khwopa College, Pokhara University

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