Conservation Status of Tiger and Associated Species in the Terai Arc Landscape, India

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

RR-04/001, March 2004

Conservation Status of Tiger and Associated Species in the Terai Arc Landscape, India

Project Team

A.J.T. Johnsingh, *Principal Investigator*
Qamar Qureshi, *Co-Investigator*
S.P. Goyal, *Co-Investigator*
G.S. Rawat, *Co-Investigator*

K. Ramesh, *Senior Research Fellow*
Ashish David, *Project Fellow*
K. Rajapandian, *Technical Assistant*
Soumya Prasad, *Technical Assistant*

Technical Support

Remote Sensing & GIS : *Pannalal & Manoj Agarwal*
Desktop Publishing: *Virendra Sharma*

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

RR-04/001, March 2004

Citation:

Johnsingh A.J.T., Ramesh K., Qureshi Q., David A., Goyal S.P., Rawat G.S., Rajapandian K. and Prasad S., 2004. Conservation status of tiger and associated species in the Terai Arc Landscape, India. RR-04/001, Wildlife Institute of India, Dehradun, Pp. viii + 110.

CONTENTS

Acknowledgements		**vi**
Executive summary		**vii-viii**
1.	**INTRODUCTION**	**1 - 2**
2.	**STUDY AREA**	**3 - 7**
2.1	Location	3
2.2	Physical characteristics	3
2.3	Biological attributes	6
2.4	Socio-economic attributes	6
3.	**STUDY DESIGN AND METHODS**	**8 - 11**
3.1	Distribution and status of tiger and prey species	8
3.1.1	Tiger distribution and status	8
3.1.2	Prey (wild ungulates) distribution and status	10
3.1.3	Disturbance index	10
3.2	Vegetation and landscape characteristics	10
3.2.1	Communities and structural components	10
3.2.2	Spatial database and landscape status	11
3.3	Demography and socio-economic profile of people	11
4.	**VEGETATION AND LANDSCAPE CHARACTERISTICS**	**12 – 21**
4.1	Vegetation communities	12
4.1.1	Sal forests	13
4.1.2	Sal mixed forests	16
4.1.3	Riverine forests	16
4.1.4	Mixed or miscellaneous forests	16
4.1.5	Plantations	16
4.1.6	Grasslands	17
4.1.7	Open scrubs	17
4.1.8.	Grassland – Sugarcane patches	17
4.2	Structural components	17
4.3	Landscape characteristics and configuration	20
5.	**UNGULATE DISTRIBUTION AND STATUS**	**22 – 26**
5.1	Species association	22
5.2	Distribution and relative abundance	23
5.3	Influence of ungulates on tiger occurrence	25
6.	**DEMOGRAPHY AND SOCIO-ECONOMIC PROFILE**	**27 – 33**
6.1	Ethnic groups of the TAL	27
6.2	Demography of the people	28
6.3	Dependency on natural resources and access to services	28

7. CONSERVATION STATUS OF TIGER **34 – 53**
7.1 THB I (Simbalbara WLS to west bank of Ganges) 38
7.2 THB II (East bank of Ganges to west bank of Gola river) 41
7.3 THB III (East bank of Gola river to Tanakpur-Khatima Highway) 43
7.4 THB IV (Surai Range of Terai East FD to South Kheri FD) 45
7.5 THB V (Dudhwa National Park) 47
7.6 THB VI (Katerniaghat Wildlife Division) 48
7.7 THB VII (Suhelwa Wildlife Sanctuary) 49
7.8 THB VIII (Western portion of Sohagibarwa WLS) 50
7.9 THB IX (Eastern portion of Sohagibarwa WLS to Valmiki TR) 51
7.10 Bahraich and Shrawasti FDs (no tiger areas) 52

8. SUMMARY AND RECOMMENDATIONS **54 – 63**
8.1 Terrain, status of forests and tiger 54
8.2 Prey availability, disturbance and tiger 55
8.3 Leopards shun terai and high tiger density areas 56
8.4 Where should the conservation efforts be focused in TAL? 57
8.5 Recommendations 58
8.6 Strategies evolved in TAL workshop 62

REFERENCES **64 - 71**

Appendix I: States, districts and tehsils that cover the study area 72
Appendix II: Management units and Tiger Habitat Blocks within Indian portion of TAL 73
Appendix III: Data sheet for recording tiger, prey species and disturbance status 74
Appendix IV: Data sheet for vegetation sampling and monitoring 75
Appendix V: Data sheet for vegetation sampling (Relevé plot) 76
Appendix VI: Champion and Seth (1968) forest types, corresponding to TAL vegetation 77
Appendix VII: Habitat characteristics in Forest Divisions and Protected Areas within TAL 80
Appendix VIII: Transect details, evidence of tiger and other wildlife species in TAL 82
Appendix IX: Status of corridors identified in TAL 92
Appendix X: Poaching in TAL 104
Appendix XI: Encroachments in TAL 106
Appendix XII: Sand and boulder mining in TAL 108
Appendix XIII: List of TAL Workshop (6-7 November, 2003) participants 110

LIST OF TABLES

Table 4.1:	Vegetation structure of landscape and management units	18
Table 4.2:	Vegetation structure of Tiger Habitat Blocks	19
Table 4.3:	Landscape metrics (fragmentation and shape indices) derived for TAL	21
Table 5.1:	Frequency of occurrence of wild ungulates in landscape and management units	24
Table 5.2:	Pellet group densities of wild ungulates (number of pellet groups/plot) in landscape and management units	24
Table 5.3:	Frequency of occurrence of wild ungulates in Tiger Habitat Blocks	25
Table 6.1:	Human population and density for TAL	28
Table 7.1:	Mean (± SD) pug mark encounter rates (no. /km) and frequency of occurrence (%) of tiger and associated species across sampling units	36
Table 7.2:	Frequency of occurrence of tiger, leopard, wild prey species and disturbance indicator (domestic dog) in management units	37

LIST OF FIGURES

Figure 2.1:	The study area - Indian portion of Terai Arc Landscape (TAL), showing Protected Areas and Forest Divisions	4
Figure 2.2:	Tiger Habitat Blocks – THBs (Indian portion of TAL) and Tiger Units – TUs (entire TAL)	5
Figure 3.1:	False Colour Composite of TAL with sampled transects and vegetation plots	9
Figure 4.1:	Vegetation communities in TAL (Ward's method)	13
Figure 4.2:	Forest cover of TAL	14
Figure 4.3:	Broad vegetation and landcover classification of TAL	15
Figure 4.4:	Dendrogram of Forest Divisions and PAs based on vegetation attributes	18
Figure 4.5:	Dendrogram of Tiger Habitat Blocks based on vegetation attributes	20
Figure 5.1:	Dendrogram depicting ungulates association in TAL (Ward's method)	23
Figure 5.2:	Distribution of tiger, ungulates and disturbance indicators in two dimensional space (NMDS) in TAL	26
Figure 5.3:	Results of logistic regression depicting relationship of ungulates and disturbance indicators with tiger in TAL	26
Figure 6.1:	Human population density (2001) for tehsils of TAL	30
Figure 6.2:	Natural resource (NR) based occupations in TAL (Census 1991)	31
Figure 6.3:	Hierarchical Clustering of TAL tehsils based on socio-economic variables	32
Figure 7.1:	Spatial distribution of tiger and prey (chital, sambar and wild pig) in TAL	35
Figure 7.2a:	Location of corridors in TAL	39
Figure 7.2b:	Corridors identified in TAL	40
Figure 8.1:	Frequency of occurrence of tiger and leopard across THBs	57

ACKNOWLEDGEMENTS

This study was made possible by National Fish and Wildlife Foundation (NFWS), Washington D.C., USA through the **Save the Tiger Fund (STF).** Specifically, Dr. John Seidensticker (Chairman, STF), Ms. Tracy Frish (NFWS), Dr. Mingma Sherpa (WWF), Dr. Sybille Klenzendorf (WWF) and Dr. Judy Mills (WWF) were greatly supportive of this work. We sincerely express our gratitude to these people and NFWS. We gratefully acknowledge the unstinting support and encouragement from our Directors Mr. V. B. Sawarkar and Mr. S. Singsit towards successful completion of the project. Dr. Anil Berry, CWLW of Uttar Pradesh, Mr. A.K. Gulati, Additional PCCF and CWLW of Himachal Pradesh, Mr. R.D.Jakarty, CWLW of Haryana and Mr. A.S.Negi, CWLW of Uttaranchal granted permission to undertake the field work and provided useful inputs. The field component of the project greatly benefited from the support and hard work of numerous forest staff from the level of Beat Watchers to Conservator of Forest. In many places where the field condition was challenging, field work was possible only because of these people, who arranged logistics even at the shortest notice and also participated in the field work. Mr. D.V.S.Khati, Director of Corbett TR, Mr. Samir Sinha, Director of Rajaji NP, Mr. Kapil Lal, DFO of Terai West, Ms. Neena Grewal, DFO of Ramnagar, Mr. G.S. Pande, DFO of Terai East, Mr. Ramesh Chandra, DFO of Lansdowne, Mr. P. K. Singh, Dy. Director of Dudhwa TR, Mr. Vivek Pandey, Dy. Director of Corbett TR, Mr. Deepak Kumar, DFO of Shivalik, Mr. H.K. Singh, DFO of Haridwar, Mr. Kuruvilla Thomas and Mr. Ramesh Pandey, DFOs of Pilibhit, the Director and Dy. Directors of Valmiki TR, and Mr. Dhananjai Mohan, IGNFA were particularly helpful during the field work, we thank them all.

We were truly encouraged by the diverse representation from various Government and Non-Governmental Agencies in the workshop held at WII. Mr. Nav Prabhat, Minister of Forests and Environment, Government of Uttaranchal showed keen interest in conservation issues articulated in the workshop and expressed commitment for tiger conservation. We are grateful to Dr. Dave Ferguson of USFWS, who took time to participate in the workshop and provided valuable input for developing Indo-Nepal cooperation. We appreciate Dr. Barry Noon, Colorado State University (USA) for his time and provided critical inputs for monitoring protocols for the future. Mr. Rupak De, CF - Mirzapur, Mr. Sunil Pandey, CF - Moradabad, Mr. P.K.Sen, WWF-India, Mr. Ashok Kumar and Mr. Vivek Menon of Wildlife Trust of India, Dr. Eric Wikramanayake, WWF-US, Dr. Sarala Khaling, WWF Nepal, Mr. G.D. Sarin, The Corbett Foundation were among the key participants in the workshop. Dr. David Smith, Dr. Anup Joshi and other colleagues in Nepal have always been supportive, shared data and other information required by us. We sincerely thank them all. We appreciate the help rendered by Dr. Christy Williams (WWF- AREAS programme) during the initial stage of the project.

Messers Md. Yasin, Ram Saran, Satinder and Rajiv were active part of the survey team and it was due to their hard work and technical skills, the field work could be achieved as planned. We express our gratitude to the entire staff of the Library and Computer Sections for their cooperation and help. Specifically, Mr. Pannalal, Dr. Manoj Agrawal and Mr. Rajesh Thapa provided immense support in DIP & GIS Unit to develop the spatial data base, and Mr.Virendra Sharma in desktop editing. Mr. Babu (Herbarium Section) was ever helpful in plant identification. We acknowledge the help rendered by Messers M.P. Aggarwal, Vinay Sharma and H.C. Pathak in administration and accounts. Dr. Nima Manjrekar provided useful comments on the earlier draft of the report. We remain indebted to the people of TAL who were enthusiastically helpful during the field survey.

EXECUTIVE SUMMARY

"*All along the edge of the Himalayas, from Saharanpur and the Jumna River in the north-west, to Gorakpur and the Gandak River to the south east, is a belt of forest varying in width from twenty to fifty miles, which is home to many species of animals*" wrote Col. R.W. Burton in his diary in January 1924 (Toovey 1987).

The Indian portion of Terai Arc Landscape (TAL), stretching from Yamuna river in the west to Valmiki Tiger Reserve, Bihar in the east, spreads across five states along the Shivaliks and Gangetic plains. This unique Landscape consists of two distinct zones: (i) *bhabar,* characterized by a hilly terrain with course alluvium and boulders, and sal mixed & miscellaneous vegetation communities and (ii) *terai,* characterized by fine alluvium and clay rich swamps dominated by a mosaic of tall grasslands and sal forests. The *terai*, in particular, is listed among the globally important 200 ecoregions for its unique large mammal assemblage. Over the decades as a result of conquest of malaria, establishment of numerous settlements and consequent increase in human population, this Landscape has become highly fragmented and degraded. This has led to the local extinction of species such as one-horned rhinoceros (*Rhinoceros unicornis*), swamp deer (*Cervus duvauceli*) and hog deer (*Axis porcinus*), for example, west of Sharda river. Despite its ecological richness and faster rate of degradation and species extinction, conservation initiatives are far from desired in this Landscape, perhaps due to inadequate information and lack of coordinated efforts.

Given this circumstance, the Wildlife Institute of India (WII) submitted a proposal to **Save the Tiger Fund** (**National Fish and Wildlife Foundation, USA)** to carry out a survey of TAL on the Indian side, which is ca. 42,700km^2 with a forest area of ca. 15,000 km^2. Save the Tiger Fund allotted US $53,500 and an 18-month project was initiated in July 2002. The project objectives were to (i) develop spatial data base on the TAL, (ii) assess tiger (*Panthera tigris*) and large ungulate distribution and status, (iii) describe the status of the Landscape and its vegetation characteristics and (iv) document the socio-economic conditions of the local people and major disturbance factors. Indian Remote Sensing (1C/1D) satellite images with the spatial resolution of 188m (WiFS) and 23.5m (LISS III) pixel sizes, and Survey of India topographic maps were used for habitat mapping and other spatial database. The study team surveyed the entire Landscape twice between October 2002 and June 2003 for assessing the status of tiger and other associated large mammal species, and habitat conditions. Extensive sampling of 246 foot transects covering 1001.2km and 1530 circular plots, with nested design, were carried out across the TAL. Demographic and socioeconomic profiles of people were derived primarily from the raw data of 1991 Census. Owing to the applied nature of the project, it was decided to hold a two-day workshop to share the findings and to attain synergy among Forest Officials, NGOs and other conservation agencies for implementation in the field.

The study revealed that the TAL contains homogenous vegetation communities of eight broad types, but the structural components vary highly across the Landscape. The tiger habitats on the Indian side are in nine blocks (referred as Tiger Habitat Blocks, THB) and the largest block (ca. 4,000 km^2) is around Corbett TR. The forests in Kalsi, Dehradun and Haridwar Forest Divisions in Uttaranchal and Bijnor Plantation Division, Bahraich and Shrawasti Forest Divisions in Uttar Pradesh were devoid of tiger. Thirteen corridors that potentially connect these nine blocks have been identified. When connectivity with the Nepal side is taken into account, the nine THBs can be pooled into five larger units (referred as Tiger Units, TU). Among these, TU II, which is in the *bhabar* tract and includes Corbett TR, is the most intact one. TU IV (Pilibhit FD-Suklaphanta Reserve-Kishanpur WLS-Dudhwa NP- Bardia NP-Katernighat WLS) is the most extensive *terai* habitat. Each piece of habitat and connectivity in these Units are crucial and at the same time, are threatened by anthropogenic pressures. Ungulate distribution

and relative abundance in TAL corresponds to the high variation or heterogeneity in habitat features. However, the overall status of prey (ungulate) availability is reasonably better in this Landscape, largely owing to the interspersion of Protected Areas between Reserve Forests. The evidence is clear that tiger distribution and its abundance are linearly related to wild ungulate prey such as chital (*Axis axis*) that has wider spatial distribution. Sambar (*Cervus unicolor*) and wild pig (*Sus scrofa*) also contribute substantially in deciding the occurrence of tiger in *bhabar* and *terai* regions respectively. The domestic dog was identified as a reliable indicator of disturbance that impedes tiger occurrence.

Undisturbed hilly (*bhabar*) areas such as Corbett TR, which usually have many deep *nallahs*, providing hideouts and abundant prey (sambar, chital and wild pig) support substantial population of tiger. The *terai* tall grass habitats, which provide adequate cover, as in Kishanpur WLS and Dudhwa NP, with prey such as chital, pig and swamp deer, is the second best. It appears that in a few years time, tigers may cease to exist in habitats like Sohagibarwa-west (THB VIII), an isolated habitat patch in Uttar Pradesh, which is under enormous anthropogenic pressures. Leopards tend to avoid *terai* habitats and high-density tiger areas, but are still common in areas extirpated of tiger. Data from the Census of India 1991, for 33 tehsils (units of District) within the study area, indicated that the *bhabar*, largely west of Sharda river, had significantly lower human density (334/km^2) and higher percentage of forest cover (36%). The corresponding figures for *terai* (east of Sharda river) are 436/km^2 and 17% respectively. It appears that the *bhabar* areas, at present, are in a better position to buffer firewood dependency of the people.

Human population increase, ever growing habitat encroachments, poaching, firewood extraction and *bhabar* grass *(Eulaliopsis binata*) collection for rope making, stealing of tiger and leopard kills, and boulder mining causing enormous disturbances and fragmentation are the major problems identified. The extensive empirical information (distribution and abundance) collected on vegetation parameters, ungulates and tiger can be used as baseline data to initiate monitoring programmes. In addition, the monitoring should include establishment of adequate number of one-hectare plots and line transects for periodic evaluation of habitat conditions and prey abundance respectively.

The study recommends that Chilla-Motichur and Gola river corridors should be established on priority basis and the conservation status of THB IV containing Suklaphanta Wildlife Reserve-Pilibhit FD-Kishanpur WLS should be strengthened. If done, the former will constitute the largest (ca. 8000km^2) tiger and elephant habitat anywhere along the foothills of the Himalaya and the latter will ensure the future of one of the finest *terai* habitats (ca. 1200km^2). Initiation of a conservation programme like establishing Rajaji-Shivalik Tiger Reserve is urgently needed to eliminate boulder mining in Yamuna river to ensure the ranging and occurrence of tigers between Shivalik FD and the Kalesar-Simbalbara forests, the western most limit of tiger distribution range. Raising of fuel wood plantations with community participation, use of fuel-efficient *chulas*, resettling of *gujjars* (migratory pastoralists) and eight key villages, shifting of one factory and weaning people from *bhabar* grass collection and conservation education programmes are also recommended. There was a consensus in the two-day workshop held on 6-7 November 2003 in WII that the Nepal model, with a strong scientific foundation and involvement of local people, needs to be adapted for the Indian side of TAL. Cross border cooperation between India and Nepal is a must to ensure the long-term conservation of tiger and its habitat in this Landscape.

1. INTRODUCTION

It is well established that the tiger (*Panthera tigris*), with its special habitat needs such as large home range, abundant large wild ungulate prey and undisturbed habitats, cannot be saved in small forest fragments (Johnsingh and Negi 1998, Karanth and Stith 1999, Karanth *et al.* 1999, Seidensticker *et al.* 1999 and Sunquist *et al.* 1999). This realization led tiger biologists and conservationists in the late 1990s to design a framework for identifying key areas for the conservation of free-ranging tigers (Dinerstein *et al.* 1997). The Indian subcontinent, with almost half the world's wild tiger population (Jackson 1997, Thapar 1999), stood out as the prime bioregion for the long-term conservation of wild tigers. This bioregion has 11 of the 25 Level I Tiger Conservation Units (TCUs), 7 of the 21 Level II TCUs and 37 of 97 Level III TCUs (Dinerstein *et al.* 1997).

During a meeting held in Java in September 1999, WWF- International identified three areas in the Indian subcontinent – Terai Arc Landscape (TAL), Sundarbans and Satpura-Maikal Range (Central India) – for immediate conservation attention to save wild tigers (WWF 2000). Several valuable studies have been carried out in the Nepal part of the TAL, through years of excellent collaboration with renowned Institutions, especially foreign Institutions. Some of the key studies are on tigers (Seidensticker 1976b, Sunquist 1981, Sunquist and Sunquist 1988, Smith *et al.* 1987, Smith 1993, Smith *et al.* 1998, Stoen and Wegge 1996 and Bhatta *et al.* 2002). Studies on leopard (*Panthera pardus*) are fewer (Sunquist 1977, 1983 and Seidensticker *et al.* 1990). Publications on sloth bear (*Melursus ursinus*) are by Laurie and Seidensticker 1977 and Joshi *et al.* 1995, 1997 and 1999. Ungulates have been studied by Seidensticker 1976a, Schaaf 1978a, b, Dinerstein 1979a, b, 1980, 2003, Dinerstein and Wemmer 1988, Dinerstein and Gyawali 1993, Mishra and Wemmer 1987, Dhungel and O'Gara 1991, Moe and Wegge 1994 and 1997.

Research in the Indian part of TAL has focused on several aspects scattered across different parts of this Landscape. However, only published literature is cited in this review. Research on vegetation is largely on grasses and grasslands (Singh 1982, Chaturvedi and Mishra 1985, Rodgers *et al.*1990 and Rawat *et al.* 1997) and woody vegetation (Joshi *et al.* 1986, Singh *et al.* 1995 and Agni *et al.* 2000). Pant and Chavan (2000) mapped the vegetation types and land use patterns in Corbett NP using satellite data. Despite the area being highly rich in avifauna, only Bengal florican, *Hubaropsis bengalensis* (Rahmani *et al.* 1989), swamp francolin, *Francolinus gularis* (Javed *et al.* 1999) and raptors (Naoroji 1997a, b and 1999) have received some research attention. Pandey *et al.* (1994) published a very useful bird list for Rajaji NP, based on combined efforts of biologists from Wildlife Institute of India (WII).

Although this tract is home to nine species of ungulates (including rhino), studies are available for only five species. Pendharkar and Goyal (1995), and Johnsingh (2001) described the group size and composition, and its general ecology and behaviour of goral (*Nemorhaedus goral*) respectively. Hog deer

(*Axis porcinus*) has been studied only briefly (Tak and Lamba 1981). Chital (*Axis axis*) was studied in Corbett NP (De and Spillet 1966) and Rajaji NP (Bhat and Rawat 1995 and 1999). All the research on swamp deer, *Cervus duvauceli duvauceli* (Holloway 1973, Schaaf and Singh 1976, Singh 1978 and Sankaran 1990) has focused only on its conservation status. Sale (1986), Sale and Singh (1987) and Mishra (1989) have highlighted the reintroduction of rhinos (*Rhinoceros unicornis*) into Dudhwa NP. Sighting of rhino near Kotdwara on 20th April 1789 (Rookmaaker 1999) indicates its much wider range even in the recent past. Research on primates (Lindburg 1977, Makwana 1979, Pirta *et al.* 1980, Laws and Laws 1984 and Gupta and Kumar 1994) is very limited.

The most intensive studies are on elephants (*Elephas maximus*). Singh (1969 a, 1978 and 1989) assessed the status of elephants in Uttar Pradesh. Johnsingh *et al.* (1990) and Johnsingh (2002) recommended establishment of Chilla-Motichur corridor favouring elephant conservation. Johnsingh and Joshua (1994) suggested the possibility of conserving Rajaji-Corbett National Parks using elephant as a flagship species. Joshua and Johnsingh (1995) have explained the ranging patterns of elephants and highlighted its implications for reserve design. Sunderraj *et al.* (1995) evaluated the use of Rajaji-Corbett corridor by elephants. Javed (1996) has published a note on elephants in Dudhwa NP. Williams *et al.* (2001) made a detailed quantification on human-elephant conflict in Rajaji NP.

Singh (1969b) documented the status of tiger in Uttar Pradesh and more recently, Johnsingh and Negi (2003) evaluated the conservation status of tiger in the area between Yamuna and Sharda rivers. Other relevant works on tiger are by Singh (1971, 1973, 1981, 1982, 1984 and 1993), Bhadauria and Singh (1994) and Johnsingh *et al* (2003). Although this area is riddled with numerous conservation problems, published information on conservation issues is limited to Panwar (1985) and Tilak and Sinha (1987). Even research on people is only scanty (Khati 1993, Sharma 1995 and Badola 1998).

The present study is a part of larger initiatives to conserve wild tigers and associated elements in the TAL, and was carried out by WII, from July 2002 to December 2003, with financial assistance from Save the Tiger Fund and National Fish and Wildlife Foundation, USA. The study had the following major objectives:

1. **Prepare tiger distribution and habitat maps for the Indian side of the TAL, focusing on forest conditions, habitat gaps and priority corridors that require immediate conservation attention.**
2. **Establish a comprehensive spatial database using Geographical Information System (GIS) to help all agencies working in this area for tiger conservation.**
3. **Quantify the status of tiger, associated large mammal species and anthropogenic pressures across this Landscape using field-tested and user-friendly methods.**
4. **Establish permanent plots across the Landscape for monitoring vegetation change, and the status of tiger and prey base over time.**
5. **Train and motivate forest and wildlife staff in field survey methods and conservation.**
6. **Present the information collected in a two-day workshop to officials from Forest/Wildlife Departments and NGOs working in the Landscape, to stimulate further conservation action.**

2. STUDY AREA

2.1 Location

The study area (Indian portion of TAL) lies between the Yamuna river in the west (77 30' E & 30 30' N) and Valmiki Tiger Reserve (Bihar) in the east (84 45' E & 27 15' N). Kalesar Wildlife Sanctuary (Haryana) and Simbalbara Wildlife Sanctuary (Himachal Pradesh) on the west bank of Yamuna were added to the study area on observing that tigers ranged into these regions as well (Figure 2.1). The entire stretch is ca. 900km long and 50-60km wide, covering ca. 42,700km^2 with a forest area of ca. 15,000km^2. Administratively, it is spread across five states of India (Himachal Pradesh, Haryana, Uttaranchal, Uttar Pradesh and Bihar), and twenty-one districts (one each in Himachal Pradesh, Haryana and Bihar, seven in Uttaranchal and eleven in Uttar Pradesh) (Appendix I). The forests are managed under twenty Forest Divisions (FDs), eight Wildlife Sanctuaries (WLSs) and three National Parks (NPs). Three of India's twenty-seven Tiger Reserves are located in this Landscape, namely Corbett Tiger Reserve (Corbett NP and Sonanadi WLS) in Uttaranchal, Dudhwa Tiger Reserve (Dudhwa NP, Kishanpur WLS and Katerniaghat Wildlife Division) in Uttar Pradesh and Valmiki Tiger Reserve (Valmiki NP and Valmiki WLS) in Bihar (Figure 2.1). With reference to distribution of tiger, the Indian portion of TAL is in nine disjunct units (here after, referred to as Tiger Habitat Blocks, THBs, Appendix II), which in turn form five larger units (here after, referred to as Tiger Units, TUs) when considering the connectivity with Nepal side of the forests (Figure 2.2).

2.2 Physical characteristics

This Landscape consists of the Shivalik hills, the adjoining *bhabar* areas and *terai* plains. These three strata are in the form of narrow strips running parallel to the main Himalaya and there is a continuum of forests and wildlife populations across these zones. The Shivaliks, which run along the base of the Himalaya, are an uplifted ridge system formed from the debris brought down from the main Himalaya. The coarse material brought down by the Himalayan rivers is deposited immediately along the foothills to form a pebbly-bouldery layer referred to as the *bhabar*, while the finer sediments or clay is carried further to form the *terai*. The *bhabar* is characterized by low water table as the deposits are bouldery and porous and all but the major rivers and streams disappear into the ground on emerging from the hills. The streams reappear along the *terai*, which has fine alluvial soil resulting in high water table. Beyond the Teesta River, in north Bengal, these three layers are not continuous and the parallelism disappears. East of Sharda river, the *bhabar* lies in Nepal, while there is an extensive *terai* tract in India (Atkinson 1882, Tiwari and Joshi 1997). West of Sharda river, the *bhabar* tract is in the process of fragmentation and degradation due to emergence of numerous large towns. Altitude within the Shivaliks ranges from 750 to 1400 m. The *bhabar* zone exhibits an undulating topography with an altitude ranging

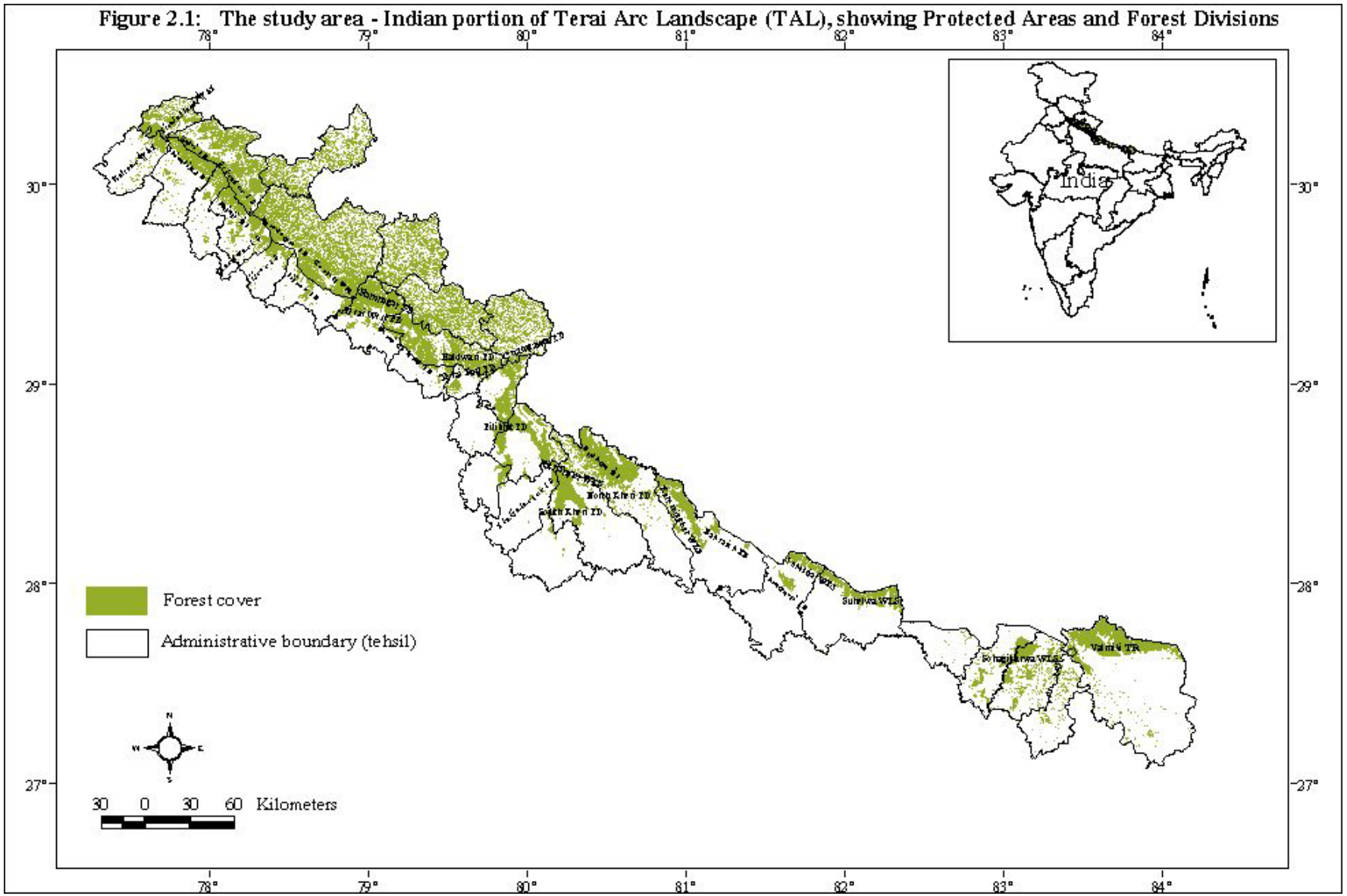
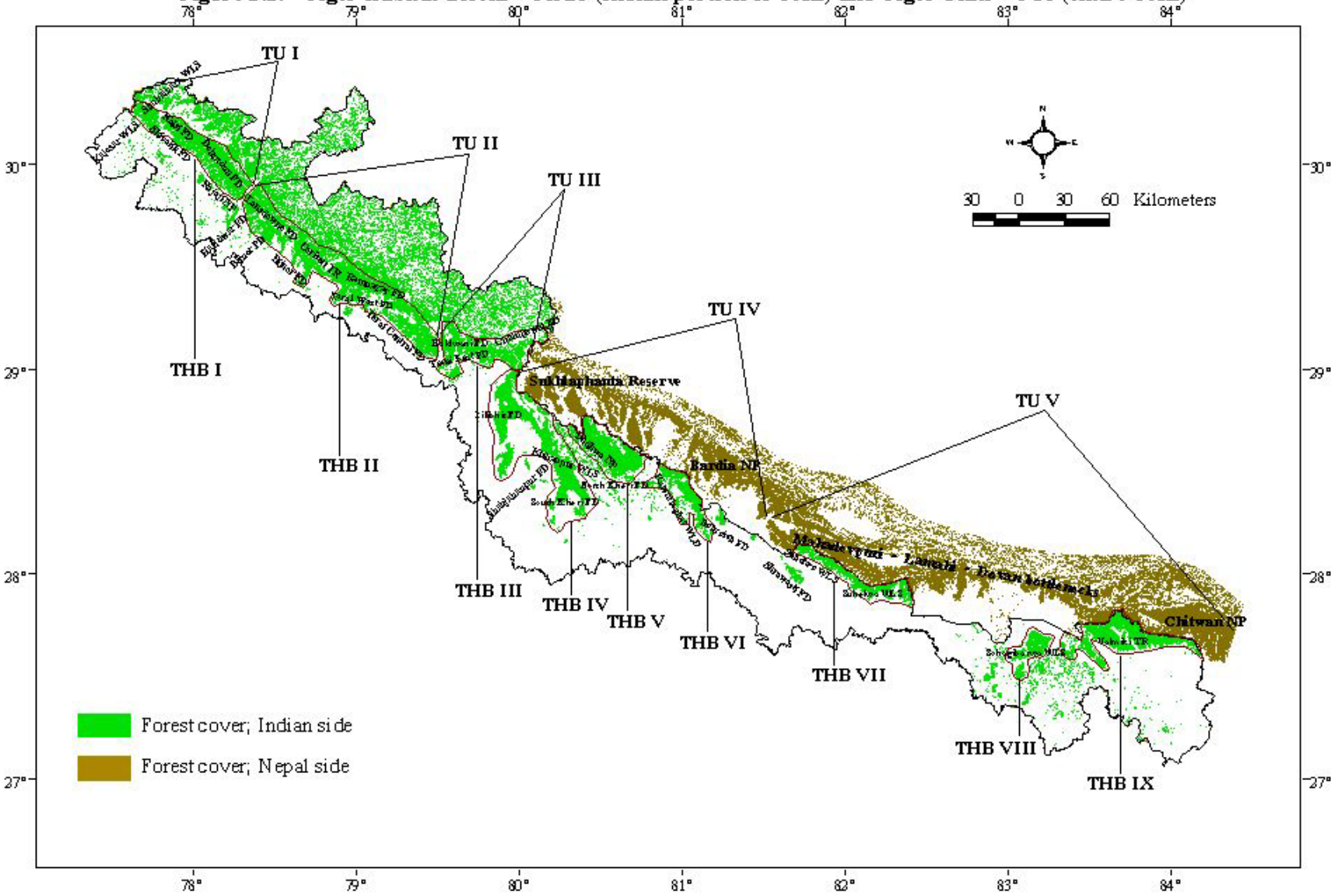


Figure 2.1: The study area - Indian portion of Terai Arc Landscape (TAL), showing Protected Areas and Forest Divisions

Figure 2.2: Tiger Habitat Blocks - THBs (Indian portion of TAL) and Tiger Units - TUs (entire TAL)



between 300 and 400 m. *Terai* is relatively flat with a surface gradient, which is slightly higher near Shivaliks.

According to the biogeographic classification by Rodgers and Panwar (1988), the study area represents two distinct zones – Himalayan and Gangetic Plain and includes three provinces: (i) Western Himalaya (areas in Himachal Pradesh, Haryana and Uttaranchal), (ii) Upper Gangetic Plain (southeastern part of Uttaranchal and the entire area in Uttar Pradesh) and (iii) Lower Gangetic Plain (area in Bihar). According to the recent classification proposed by Wikramanayake *et al.* (2001) that takes into consideration both biogeography and conservation values, the study area corresponds to three ecoregions – (i) Upper Gangetic Plains moist deciduous forest, (ii) *Terai-Duar* savanna and grasslands and (iii) Himalayan sub-tropical broadleaf forest. Of these, the *Terai-Duar* savanna is listed among the 200 globally important areas, due to its intact large mammal assemblage, even though it scores low on plant species richness and endemism. This Landscape also contains a large proportion of the Level I and Level II Tiger Conservation Units, which underscore global and regional priorities for the preservation of wild tiger (Wikramanayake *et al.* 1998).

2.3 Biological attributes

The vegetation in TAL comprises a mosaic of dry and moist deciduous forests, scrub savannah and productive alluvial grasslands that harbour diverse and rich fauna including several endemic and globally endangered species. Prominent among them are the tiger, Asian elephant, one-horned rhinoceros and swamp deer. Other endemic and obligate species found in this Landscape are hog deer, hispid hare (*Caprolagus hispidus*), Bengal florican and swamp francolin. Many of these species, surviving in small populations, have their last home in this Landscape.

2.4 Socio-economic attributes

This Landscape is also among the most populous regions in the country and as per the 2001 census, the total population of the study area is 2, 38, 94,443 persons, which is 2.32% of the country's total population. There has been rapid growth in human population ever since people began to occupy the fertile land after independence, resulting in heavy loss of forest and habitat fragmentation. The Landscape is again among the highest human density regions, with an average of 543 individuals/km^2 (range: 137 in Champawat tehsil to 1872 in Haldwani tehsil), much above the national average of 324 individuals/km^2. The proportion of rural population ranges from 23.5% in Dehradun tehsil to 97.2% in Shrawasti tehsil, with an average of 82%. About 23% of the population belong to Scheduled Castes and Tribes, among the major tribal groups residing within the study area are the *tharus* and *gujjars*; *kanjars* being classified under Other Backward Classes. Further, settlers especially refugees from erstwhile East

Pakistan, retired soldiers from the hills and other settlers from Punjab comprise part of the population influx observed over the last four decades. Human populations are dependent on several forest-based resources for their subsistence. Firewood and fodder, being the most significant resources extracted out of the forested areas, are regarded as the principle causes of disturbance and degradation within forests, besides forest loss to agricultural expansion. Further, non-timber forest products contribute significantly into the household economy, leading to conflicts with wild animals throughout the area. Crop raiding and injury or loss of livestock leads to added conflict, typical of the forest-human habitation interface.

3. STUDY DESIGN AND METHODS

The study was designed to describe quantitatively three major components: (i) distribution and status of tiger and its prey, (ii) landscape characteristics along with connectivities and vegetation attributes and (iii) demography and socio-economic attributes of people within the TAL. The sampling was done at hierarchical scales, in decreasing order represented by: 15x15 minute grids (equivalent to ca. 725 km^2), Forest Divisions and Forest Ranges. Field sampling was restricted to the regions left with *terai-bhabar* vegetation, which had the potential to support tiger populations. Data collection was carried out in two phases. The first phase involved sampling for tiger presence, prey availability and disturbance factors. This was carried out during winter (October 2002 - February 2003), the ideal time to locate pugmarks as riverbeds (*raus*) and unpaved roads are still moist. In the second phase (April - June 2003), vegetation sampling and ground-truthing for preparing land cover map were carried out. Census data and other secondary sources were used to describe demography and socio-economic status of the people residing in the TAL. The following specific approaches and methods were adopted for data acquisition.

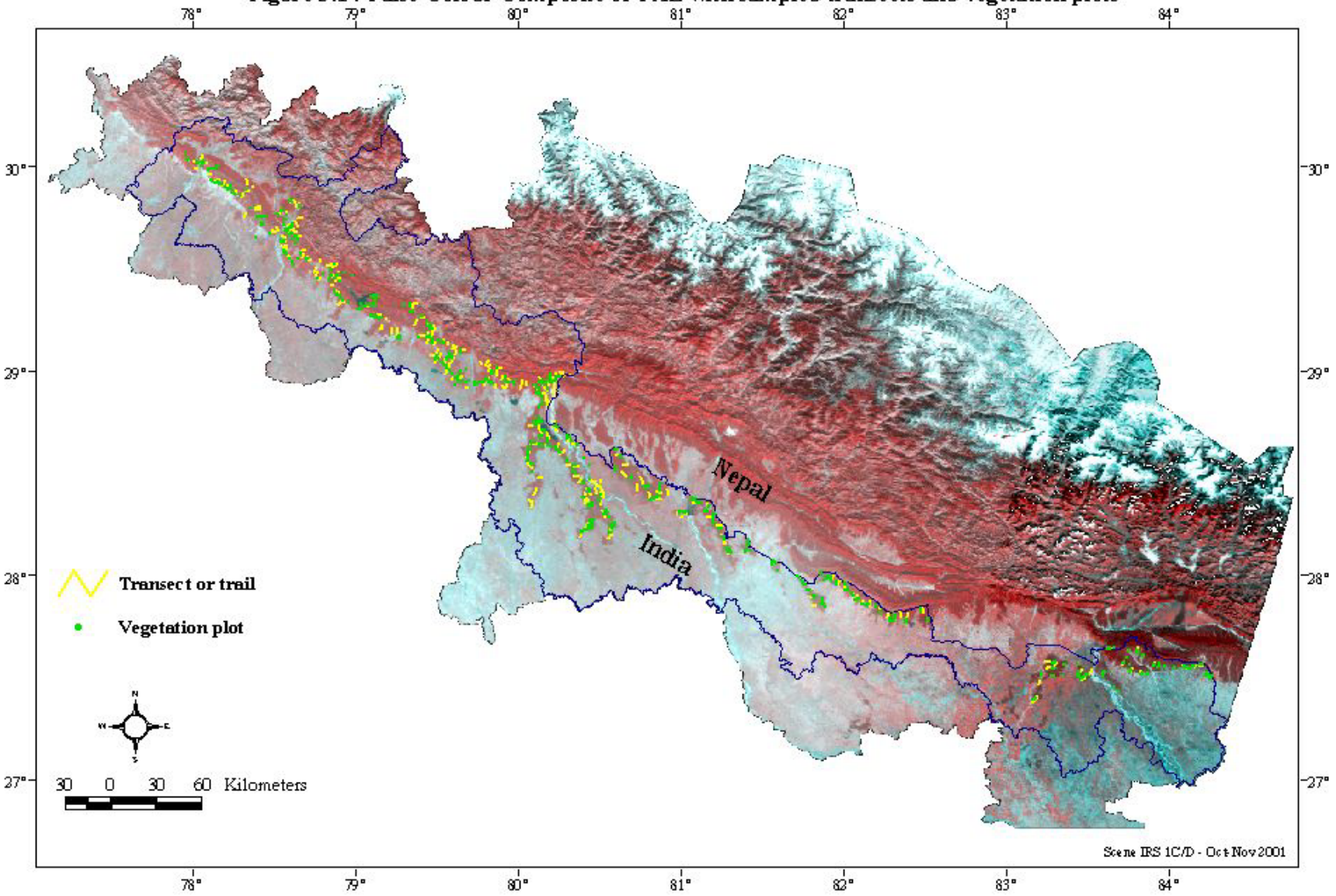
3.1 Distribution and status of tiger and prey species

Within 15-minute grids, forest cover distribution was identified using False Color Composite of WiFS imageries and Forest Division maps wherein the Forest Ranges are marked. The Ranges were taken as the basic sampling unit in each Forest Division and Protected Areas. The Range shape and size determined the number of transects or trails (*raus* in the *bhabar* region and forest roads in the *terai* region) to be surveyed. The transects ranged from 3 to 9km in length with an average of 4 km, and were spread 3 to 4 km apart. Three to four transects were surveyed each day in the morning hours (7.00am – 10.00am) by two well-trained field biologists and two field assistants, accompanied by Forest Staff who were simultaneously being trained on survey methods. In all, 246 transects totaling to 1001.2km were surveyed in the entire TAL (Figure 3.1). Geographic coordinates of start and end points of transects were recorded to map the transects for future referencing and monitoring. All other data collected in the field were recorded in a pre-designed data sheet (Appendix III).

3.1.1 Tiger distribution and status

The transects were divided into 250m segments and evidence of tiger presence (pug mark, scat and scrape marks) were recorded within each segment. Other carnivores such as black bear (*Ursus thibetanus*), sloth bear and leopard tracks were also recorded. Measurements were taken of length and breadth of tracks and pug marks to identify individuals on that trail. From this, an index of relative abundance of these carnivores occurrence was computed as pug mark encounter rate (no. of distinct pug marks / km). Intensity of use by these carnivores was established based on frequency of occurrence

Figure 3.1 : False Colour Composite of TAL with sampled transects and vegetation plots



Of signs in the surveyed segments (i.e. number of segments with carnivore signs / total number of segments surveyed).

3.1.2 Prey (wild ungulates) distribution and status

On the same transects, data on prey presence and frequency of occurrence was recorded within the 250 m segments. Presence of prey species was established largely based on indirect signs such as tracks and pellet groups and direct observations. In addition, 140 transects covering 2km each were laid across the Landscape and in each of the transects, circular plots of 5 m radius was laid at every 250 m to quantify pellet or dung group density of wild ungulates (Appendix IV and V). Prey Index for each transect, computed as: Prey Index = (species weightage x frequency of occurrence of species), indicates the status of transects with reference to preferred species. The weightage for each species was assigned on the basis of its preference ranking in tiger diet. Information on prey preference was compiled from five studies (Johnsingh 1983, Karanth and Sunquist 1995, Stoen and Wegge 1996, Biswas and Sankar 2002, Bagchi *et al*. 2003). These weightages are in descending order from the most preferred (e.g. sambar) to the least preferred (e.g. nilgai). In TAL, sambar, chital, hog deer, wild pig, barking deer and nilgai were assigned weightages of 0.93, 0.86, 0.83, 0.70, 0.26 and 0.20 respectively.

3.1.3 Disturbance index

Disturbance indicators such as dung and sightings of livestock (cattle and buffalo), tracks and sightings of domestic dogs and people, lopping and cutting signs were quantified within 250m segments along the transects. These signs were also recorded in the circular plots (10m radius for lopping and cutting signs, and 5m radius for cattle dung) at 250m intervals along the 2 km transects laid for vegetation sampling (see below, Appendix III, IV and V).

3.2 Vegetation and landscape characteristics

3.2.1 Communities and structural components

In 15x15 minute grids, 140 transects of two-kilometer each were laid across the Landscape. Concentric nested plots of ten-meter radius for trees, 5m radius for shrubs and $1m^2$ quadrats for ground cover were laid at every 250m on each transect. A total of 1150 such plots were sampled across the Landscape (Figure 3.1). Additional plots were laid in crucial areas such as corridors and highly disturbed areas (see Relev'e sampling below). Tree species composition, density, canopy cover, and lopping and cutting signs were quantified in 10-m radius plots, while 5-m radius plots and $1m^2$ quadrats, positioned at the centre of each plot, were used for recording shrub species composition and density, and ground cover (herb and grass cover) respectively (Appendix IV). In addition to information gathered from vegetation sampling, the relevé method (380 plots) was used to obtain ground-truthing points for interpreting the

satellite data. In each relev'e plot, vegetation type, dominant trees and shrubs, with maximum of five species for each group were noted in the order of their dominance (Appendix V).

3.2.2 Spatial database and landscape status

Remote sensing data and topographic maps were extensively used to develop spatial layers on the land use and vegetation characteristics of the study area. IRS (1C & 1D) – WiFS images (2 scenes) having 188m spatial resolution and two bands spectral resolution, were used to map and quantify broad categories of land use and land cover. For mapping forest cover and landscape pattern, 14 scenes of IRS IC & D – LISS III (23.6 m, 4 bands) were used. These imageries were from October 2001- January 2002. The procured imageries were then georectified, WiFS data had 50m of Root Mean Square Error and LISS III error ranged from 10 to 20m. A total of 1530 ground-truthing points were obtained from field data on vegetation sampling (concentric nested plots – 1150 and Relev'e plots – 380, Figure 3.2). The vegetation classification was done by hybrid method combining Unsupervised Isodata Cluster Analysis and Supervised Maximum Likelihood Classification. The overall accuracy for vegetation map is 85%. Grassland-Sugarcane, vegetation in and around the villages, and plantations contributed to the error considerably.

Spatial layers on various habitat features along with field data on vegetation characteristics provided the basis for describing landscape characteristics of TAL. Fragstats 3.3 software (McGarigal and Marks 1995) was used to ascertain the landscape composition and configuration. The indices used for landscape configuration include patch, class and landscape matrices, along with area, core and shape statistics (McGarigal and Marks 1995, Frohn 1998). Landscape cohesion model (Opdam *et al.* 2003) was used to evaluate landscape values.

3.3 Demography and socio-economic profile of people

The demographic profile of the TAL was derived primarily from the raw data of 1991 Census (Anon 1991). Data from Village Directories and Primary Census Abstract having 136 variables for over 19,000 villages and 40 variables for 118 towns and cities were pooled to tehsil level. Tehsils, districts and states within TAL have been subdivided or realigned in the two-decade period (1981 and 1991). All data was collapsed to 1981 administrative units as it is easier to pool units than to split them, given non-availability of appropriate administrative boundary maps. To examine patterns of development and dependency on natural resources, a subset of variables from the Census 1991 dataset was used. These included basic demographic attributes such as total, urban and rural population, occupation and fuel use, proportion of arable land and access to developmental amenities (medical, education, post and telegraph, road and rail, electricity and irrigation).

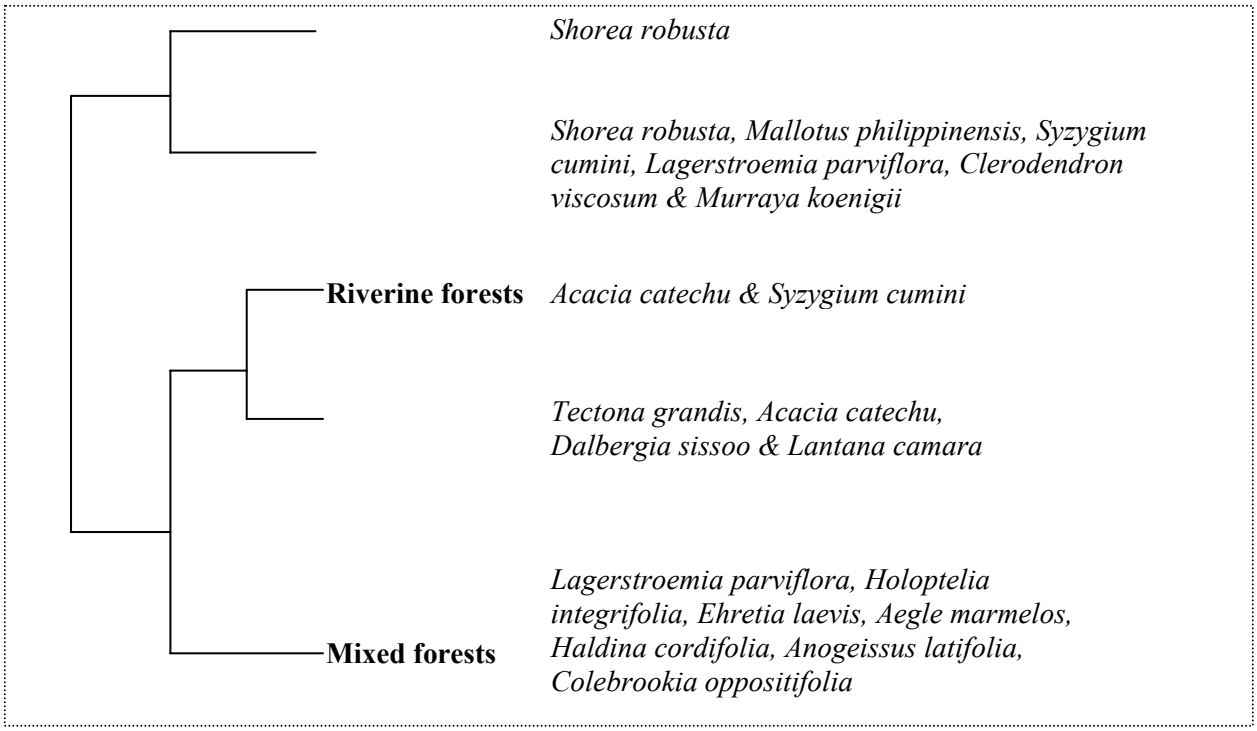
4. VEGETATION AND LANDSCAPE CHARACTERISTICS

The natural vegetation in the entire TAL (India and Nepal) covers 28,036km^2, of which, ca. 15,000km^2 is in the Indian portion of TAL. Broadly, the vegetation here comprises a mosaic of dry and moist deciduous forests, scrub savannah and alluvial grasslands. Even though this Landscape scores low on plant species richness and endemism, it harbours some of the most productive ecosystems in the world (Wikramanayake *et al.* 2001). On the basis of similarities in the woody vegetation, the Indian side of TAL is classified into three physiographic zones: (i) Western Himalaya, (ii) Northern plains and (iii) Eastern plains (FSI 2001). Champion and Seth (1968) have reported twenty-seven types and sub-types of vegetation from this region based on their associations with soil and rainfall (Appendix VI). Vegetation communities have been described in detail for parts of this Landscape based on both graminoid and woody vegetation (Singh 1982, Chaturvedi and Mishra 1985, Joshi *et al*. 1986, Rodgers *et al*. 1990, Singh *et al*. 1995, Rawat *et al*. 1997 and Agni *et al*. 2000). Most of the published literature on vegetation communities and their associations in the last two decades have been from locations in the western part of the landscape. Very little information exists for places east of Dudhwa NP. With the advent of remote-sensing techniques, there have been attempts to map and classify vegetation using satellite imageries, but only for parts of this Landscape (Pant and Chavan 2000, Hajra 2002 and Kumar *et al.* 2002). This study describes the vegetation communities, structural components and landscape configuration for the entire stretch of Indian portion of TAL, based on extensive field sampling and satellite data.

4.1 Vegetation communities

Cluster Analysis on the field data yielded five broad vegetation communities viz., (i) Sal forests (dominated by sal *Shorea robusta*), (ii) Sal-mixed forests (*Shorea robusta,* rohini *Mallotus philippinensis,* jamun *Syzygium cumini,* dhaura *Lagerstroemia parviflora,* bhant *Clerodendron viscosum* and kari-patta *Murraya koenigii*), (iii) Riverine forests (khair *Acacia catechu*, shisam or sissoo *Dalbergia sissoo* and *Syzygium cumini*), (iv) Mixed or miscellaneous forests (*Lagerstroemia parviflora,* papri *Holoptelia integrifolia,* chamror *Ehretia laevis,* bel *Aegle marmelos,* haldu *Haldina cordifolia,* bakli *Anogeissus latifolia* and binda *Colebrookia oppositifolia*) and (v) Plantations (teak *Tectona grandis, Acacia catechu Dalbergia sissoo, Eucalyptus* and lantana *Lantana camara*) (Figure 4.1). The relev'e data accounted for two additional vegetation types namely, Grasslands and Open Scrub. Besides the forest cover, the satellite-based classification resulted in 12 landcover classes, represented by eight vegetation communities, three non-forest classes (habitation, barren land and water) and one could not be classified, largely the shadow area in the hills (Figure 4.2 & Figure 4.3). Sal dominated forest and mixed forests occupy bulk of the forest cover in the TAL (25%), almost 70% area is under human habitation and agriculture and other vegetation types occupy rest of the area. The most dominant and widely distributed

tree species in this landscape is sal, followed by *Mallotus philippinensis* and *Syzygium cumini*. Plantations constitute a significant part of the landscape, which was reflected in the plantation species such as teak (*Tectona grandis*) and *Dalbergia sissoo*, figuring in the list of 10 dominant and widely distributed species in this Landscape. Kari-patta (*Murraya koenigii*) is the most dominant and widely distributed shrub species, followed by bhant (*Clerodendron viscosum*) and lantana.



The following description on the vegetation types in TAL corroborates with the Champion and Seth (1968) classifications for this area, excepting for sugarcane-grassland type which is due to patches of grasslands indistinguishable in satellite image from that of sugarcane and vice versa.

4.1.1 Sal forests

These represent the northern limit of dipterocarp forests having sal as the predominant species that occupies about 50% or more of the total basal area. Sal may reach 45m in height, but, it generally ranges between 25 and 40m. It is considered a dominant ecotype in this area, *albeit* several ecotypes governed by edaphic conditions are reported from the region. It constitutes one of the most important forest types throughout the TAL both in the *terai* and Shivaliks. Due to resistance to fire and adaptability to various soil and site conditions, sal continues to retain its hold as a major species. Common associates

Figure 4.2: Forest cover of TAL

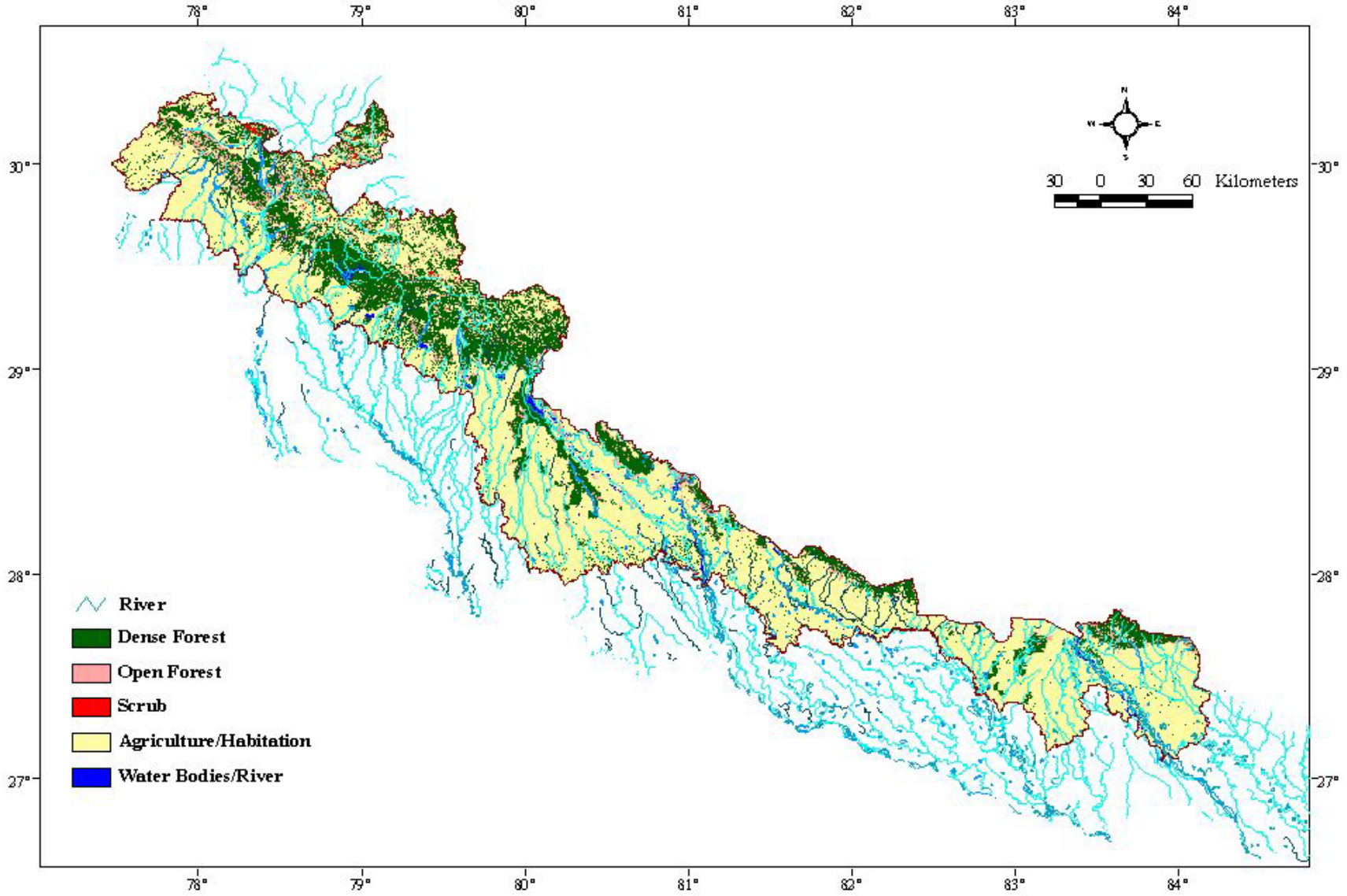
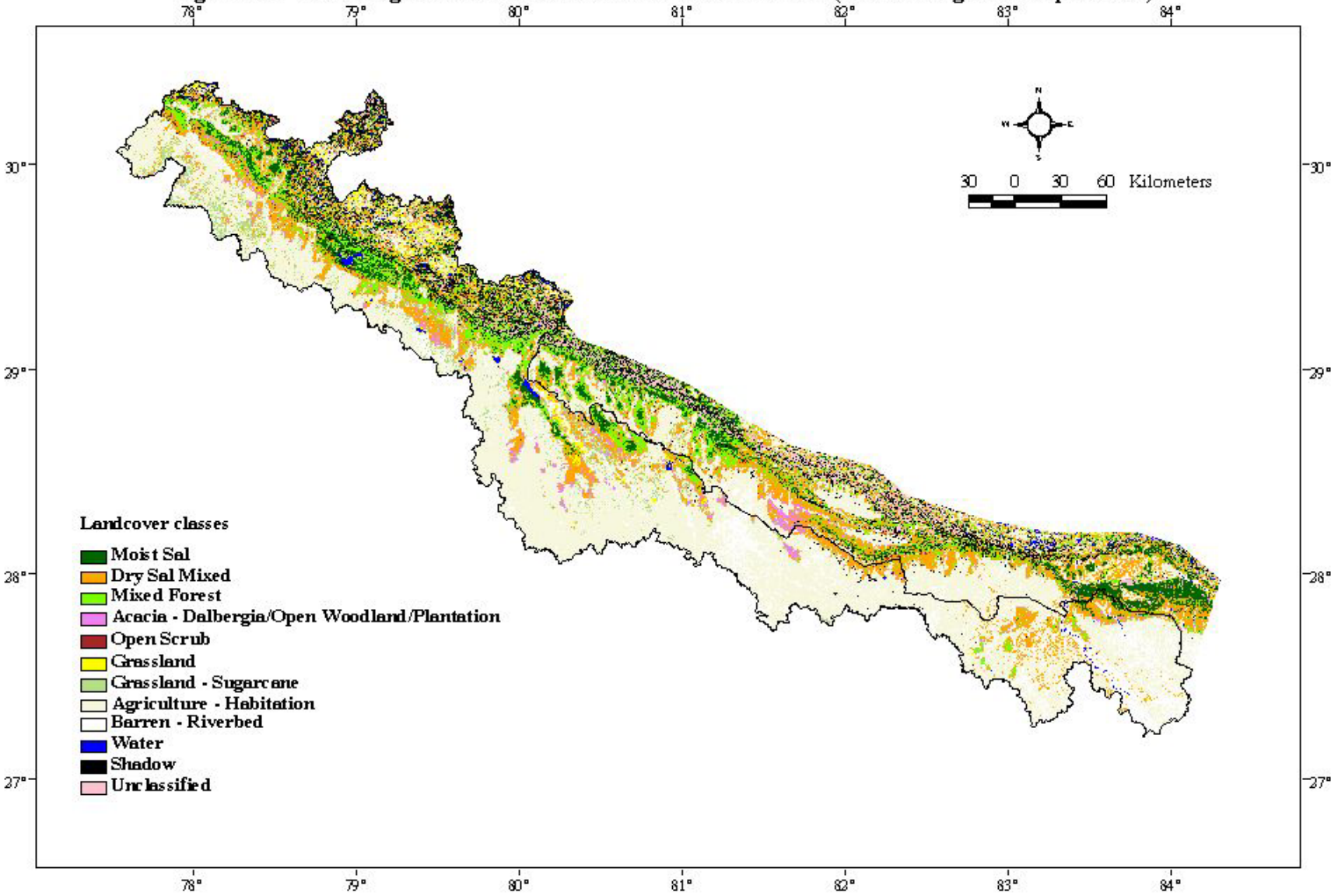


Figure 4.3: Broad vegetation and landcover classification of TAL (based on digitial interpretation)



of sal in the area include sain *Terminalia alata*, *Syzygium cumini* and bakli (*Anogeissus latifolia*). Three vegetation communities described by Champion and Seth correspond to this category (3C/C2/2b(ii), 3C/C2/2d(ii), 5B/C1/1b, refer Appendix VI). Other classes of sal mixed forest grade into this category, when worked to exclude other species and promote the growth of sal.

4.1.2 Sal mixed forests

Some of the most common associates of sal in these forests include *Terminalia alata*, *Syzygium cumini*, *Anogeissus latifolia* and *Haldina cordifolia.* These forests, which occur along both the Shivalik hills and *terai-bhabar* plains, range from very wet, swampy types with undergrowth of cane *Calamus tenuis*, to drier and more open types. Mixed stands of chir *Pinus roxburghii* and sal occur along the Shivalik ridges. Seven forest types identified by Champion and Seth (1968) correspond to this vegetation type (3C/2a, 3C/C2/2b(i), 3C/C2/2C, 3c/c3/3a, 3C/C2/2d(i), 3C/C2/2d(iii), 5B/C1/1a, see Appendix VI)

4.1.3 Riverine forests

Riverine areas, in the moist as well as dry deciduous forests constitute a distinct vegetation type. Characteristic overstorey includes *Syzygium cumini* and tumri *Trewia nudiflora*, replaced by paniala *Bischoffia javanica* along hilly ravines. The unique khair-sissoo formation is seen along gravelly streambeds in flatter terrain. This category forms mid seral stage in the successional trajectory of the TAL, the early stages being *Saccharum spontaneum – Imperata* grasslands followed by *Zizyphus mauritiana* and other shrubs. Five Champion and Seth classes correspond to this vegetation type (4C/FS2, 4D/SS3, 4E/RS1, 5/1S1 & 5/1S2, Appendix VI).

4.1.4 Mixed or miscellaneous forests

Several subgroups, in each of which one species is dominant, are represented in this type. Sain (*Terminalia alata*) stands are among the most important subtypes occurring throughout the *terai* on heavy, wet or clayey soil. Bakli (*Anogeissus latifolia*) stands, which occur on drier sites, are almost pure in the western *terai*. A total of nine mixed forest types identified by Champion and Seth (1968) classes correspond to these vegetation types (3C/E1, 3C/C3/3a, 4D/SS4, 4D,SS2, 5B/C2, 5/E6, 5/1S3, 8B/C1/1a & E1, Appendix VI).

4.1.5 Plantations

Considerable proportion of the landscape, mostly in *terai* region, is under plantation. These were set up as part of forestry operations to supply timber and generate income for the States. The most commonly occurring plantations are those of teak, eucalyptus and mixed plantations consisting of sal, teak, papri (*Holoptelia integrifolia*) khair and sissoo. About 250km^2 is under monoculture plantation of *Acacia catechu*, *Dalbergia sissoo* and *Syzygium cumini*.

4.1.6 Grasslands

The *terai* includes some of the tallest grasslands in the world. Today, these grasslands constitute less than 500km^2 of the landscape and are very patchily distributed. The grass community occurs in a succession along the flood plains. *Saccharum spontaneum* is among the first to colonize fresh alluvium and exposed riverbanks after floods. The next terrace is generally occupied by *Saccharum bengalense*. On intense grazing by herbivores, shorter grassland types appear with a mixture of grasses such as *Imperata cylindrica*, *Chrysopogon aciculatus* and *Eragrostis* spp. The tall grasses *Arundo donax* and *Phragmites karka* surround oxbows and lakes (Champion and Seth types 3C/1S1 and E1, Appendix VI).

4.1.7 Open scrubs

Open scrub can be seen on steep and drier hill slopes of Shivaliks dominated by karaunda *Carissa carandas* and dawi *Woodfordia fruticosa* or in the degraded sites in the plains (secondary scrub) mostly dominated by invasive species such as *Lantana camara*, and at times by khajur *Phoenix acaulis* and vasaka *Adhatoda vasica* (Champion and Seth – 5/DS1, 5/DS2, Appendix VI).

4.1.8 Grassland-Sugarcane patches

Sugarcane (*Saccharum officinarum)*, the popular cash crop in *terai* belt, largely mimics the tall grassland and therefore, the grassland patches, located at the fringe areas, were difficult to distinguish from the sugarcane. However, the contribution of grassland area in this type is minimal and in the entire landscape, this particular land cover category (grassland-sugarcane) constitutes a very small proportion (3.4%).

4.2 Structural components

The structural components in this landscape are heterogeneous and that the spatial arrangement appears as a mosaic of high (closed) and low (open) density areas (Table 4.1, also see Appendix VII). This is evident from the high variations in all the parameters (canopy cover, tree density and richness, shrub density and richness, sapling density and richness, herb cover and grass cover) across TAL. Species richness of tree and shrub species, and shrub density was significantly higher in *bhabar* areas compared to *terai* regions (Student t test, $p < 0.05$), while canopy cover, sapling species richness and density were higher in *terai* (Student t test, $p < 0.05$). *Bhabar* areas contain forests that are more open and harbour diverse plant species due to undulating topography and variable moisture regimes, whereas *terai* areas are largely dominated by sal, which forms large stretches of forest with dense cover. The status of these habitat features are specifically no better in Protected Areas and in fact, several Forest Divisions outside Protected Areas support relatively intact habitat as indicated by higher sapling, shrub and tree density and species richness (Student t test, $p < 0.05$, Appendix VII). This can be attributed to

the fact that some very disturbed areas such as Suhelwa, Sohagibarwa and Valmiki come under PAs, while Forest Divisions with more intact habitat such as Haldwani, Ramnagar and Pilibhit FDs are outside the PA network. This was further substantiated by Cluster Analyses (Bray-Curtis measure, group average) in that better protected Forest Divisions and very disturbed Divisions separated out as two end groups, and other Divisions experiencing moderate pressures were placed between these. Forest Divisions with extensive sal forests formed a distinct cluster, falling between the disturbed and undisturbed extremes (Figure 4.4). Between groups variance was found to be significant for sapling diversity, shrub density, richness and tree density for these clusters (Kruskal Wallis test, $p<0.01$). While disturbance factors such as lopping and usage by cattle were not significantly different between the clusters. However, the Forest Divisions and PAs exhibited an overall similarity of about 60% in the structural components.

Table 4.1: Vegetation structure of landscape and management units
(n = #of plots; values are means ± standard deviation/plot,
plot size = 10m radius for tree and 5m radius for shrub)

Variables	TAL (n = 1150)	*Terai* (n = 444)	*Bhabar* (n = 706)	PA (n = 646)	Forest Division (n = 504)
% Canopy cover	24.1 ± 11.6	25.2 ± 11.6	23.5 ± 11.5	24.3 ± 11.0	24.0 ± 12.2
Tree density	8.3 ± 4.8	8.3 ± 4.9	8.4 ± 4.7	7.9 ± 4.7	8.8 ± 5.0
Tree species richness	3.2 ± 1.5	3.0 ± 1.5	3.4 ± 1.5	3.3 ± 1.5	3.1 ± 1.6
Shrub density	13.4 ± 14.3	7.4 ± 15.8	17.2 ± 8.8	11. ± 12.3	15.8 ± 16.3
Shrub species richness	1.5 ± 1.2	1.0 ± 1.2	1.9 ± 1.0	1.3 ± 1.1	1.7 ± 1.3
Sapling density	8.6 ± 9.3	10.4 ± 8.1	7.4 ± 10.8	7.9 ± 8.4	9.4 ± 10.3
Sapling species richness	1.7 ± 1.4	1.9 ± 1.4	1.6 ± 1.3	1.7 ± 1.2	1.8 ± 1.5

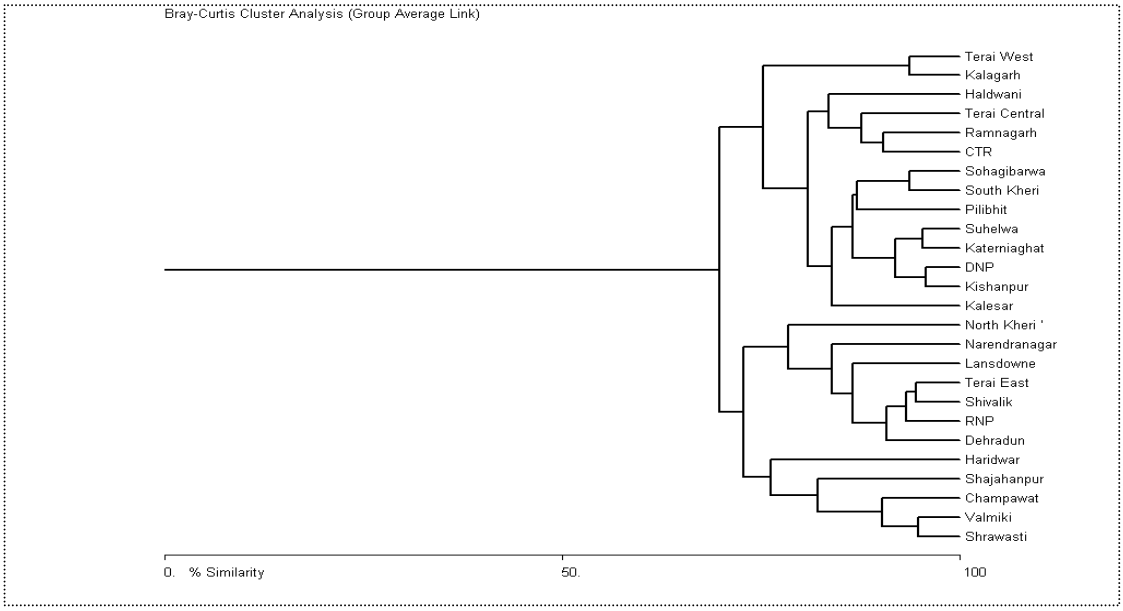


Figure 4.4: Dendrogram of Forest Divisions and PAs based on vegetation attributes

Each of the structural attributes varied significantly between the Tiger Habitat Blocks (THBs) (Kruskal Wallis test, $p<0.05$, Table 4.2). Tree density and species richness scored above average in THBs II, III, IV, VII and VIII (Ganges-Gola, Gola-Khatima, Pilibhit-Kheri, Suhelwa and Sohgibarwa-west). Sapling density and species richness was above the average in Gola-Khatima, Pilibhit-Kheri and Sohagibarwa-west. Shrub density and species richness were highest in the Ganges-Gola Block. Cluster Analysis (Bray-Curtis measure, group average) placed all THBs into three broad groups based on the structural attributes and disturbance level (Figure 4.5). The *terai* woodlands in Pilibhit-Kheri, Dudhwa NP and Sohagibarwa-west form one group and similarly, most of the *bhabar* habitats fall in one cluster. Katerniaghat WLD resembles *bhabar* areas in terms of more open habitats, high shrub density and high level of disturbance, and perhaps because of this, it has been placed along with *bhabar* areas (Figure 4.5). Although Valmiki TR and Shrawasti FD are dissimilar in terrain features, representing hilly and flat terrain respectively, the forests in these blocks appear similar in most of the structural attributes and disturbance level (Table 4.2, Figure 4.5, and Appendix VII).

In the entire TAL (*terai* and *bhabar*) regardless of PA status, invasives such as bhant (*Clerodendron viscosum*), lantana, adathoda and *Tiliacora acuminata* (in Dhudwa NP) dominate the understorey. These invasives figure in the top three shrubs of most Forest Divisions (Appendix VII). Bhant and lantana occupy 21% and 17% of 1150 plots respectively. On an average, there were 2 ± 6 bhant (mean ± SD) and 1 ± 5 lantana plants per plot. The extent to which such invasives alter plant species diversity, productivity and diversity of dependent fauna needs to be investigated.

Table 4.2: Vegetation structure of Tiger Habitat Blocks
(n = #of plots; values are mean ± SD/plot, plot size = 10m radius for tree and 5m radius for shrub)

Tiger Habitat Block	Canopy cover	Tree density	Tree species richness	Shrub density	Shrub species richness	Sapling density	Sapling species richness
Simbalbara-Ganges (n=86)	21.8 ± 12.4	7.9 ± 5.7	2.7 ± 1.2	17.1 ± 10.5	2.1 ± 1.1	5.5 ± 6.9	1.2 ± 1.2
Ganges-Gola (n=202)	23.2 ± 12.1	9.2 ± 5.4	3.4 ± 1.5	25.7 ± 19.8	2.3 ± 1.3	6.4 ± 6.7	1.4 ± 1.1
Gola-Khatima (n=145)	26.8 ± 13.2	9.8 ± 5.4	3.5 ± 1.9	16.9 ± 16.3	2.0 ± 1.3	11.7 ± 11.6	2.3 ± 1.8
Surai-Kheri (n=155)	24.7 ± 11.4	9.0 ± 4.5	3.1 ± 1.6	6.9 ± 8.9	0.9 ± 1.0	12.7 ± 11.9	2.2 ± 1.4
Dudhwa (n=61)	26.4 ± 10.8	8.1 ± 4.7	2.9 ± 1.3	7.3 ± 9.3	0.9 ± 0.8	8.6 ± 11.2	1.5 ± 1.3
Katerniaghat (n=97)	23.4 ± 11.6	7.8 ± 5.0	3.1 ± 1.5	10.9 ± 9.4	1.4 ± 1.0	7.8 ± 6.9	1.3 ± 0.9
Suhelwa (n=147)	24.6 ± 10.0	8.8 ± 3.7	3.8 ± 1.4	13.1 ± 10.1	1.5 ± 0.9	7.8 ± 6.6	1.8 ± 1.2
Sohagibarwa (n=95)	28.8 ± 12.4	8.6 ± 5.0	2.7 ± 1.6	3.6 ± 5.5	0.6 ± 0.9	12.7 ± 12.0	2.3 ± 1.4
Valmiki (n=126)	19.8 ± 8.3	5.2 ± 2.1	3.1 ± 1.3	8.8 ± 8.2	1.3 ± 0.9	5.1 ± 4.8	1.4 ± 1.2
No tiger area (n=36)	20.7 ± 7.4	6.6 ± 3.1	2.9 ± 1.2	10.5 ± 8.5	1.2 ± 0.7	5.2 ± 4.6	1.1 ± 0.8

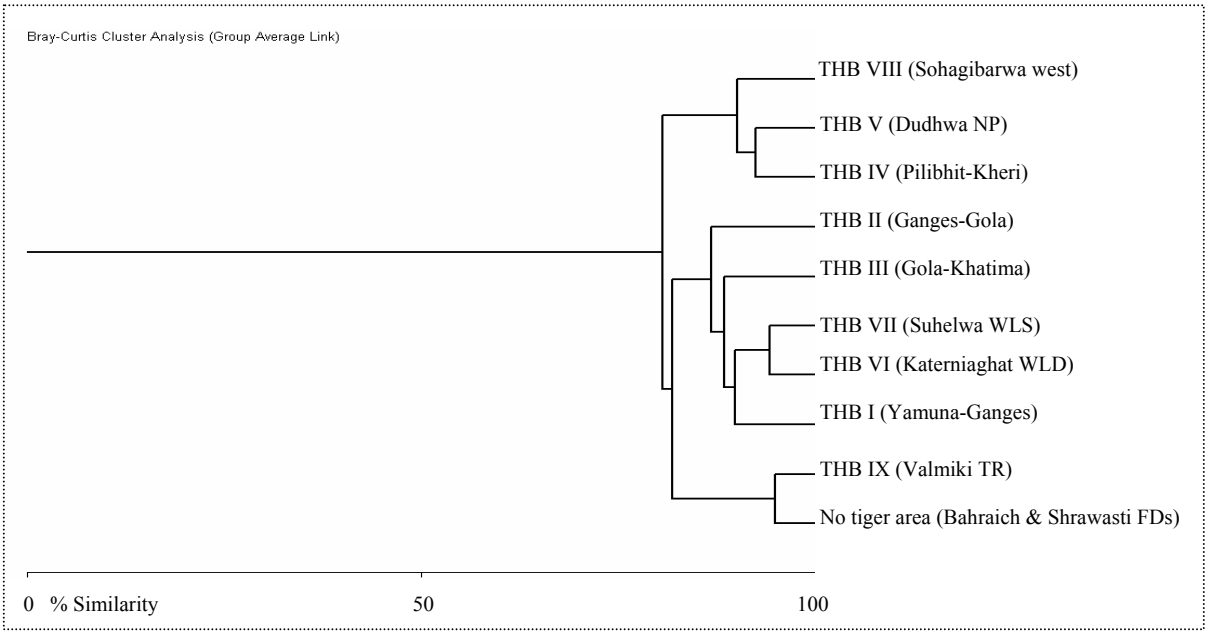


Figure 4.5: Dendrogram of Tiger Habitat Blocks based on vegetation attributes

4.3 Landscape characteristics and configuration

The total area in TAL including Nepal, having natural vegetation up to 1000m elevation, is 26,292 km^2. Within Indian limits, this area is 14,947 km^2, which includes 23% closed forest, 7% open forest and 0.4% scrubland. The dry sal mixed association dominates the Landscape (44%). Moist sal mixed and miscellaneous forests contribute 21% each, *Acacia* - *Dalbergia* 7%, grassland 4% and scrub occupy the least, 1%. While there are 17 patches of size >100km^2, forming almost 90% of the Landscape, the majority of the patches are <5km^2. Though there are lesser number patches per unit area (1.9 patches/100km^2), the Landscape is generally fragmented in nature, particularly in the eastern part (*terai*).

Although the tiger habitats on the Indian part of the TAL are in nine disjunct THBs, when the connectivities with the Nepal side are considered, these THBs form five larger units (Tiger Units, TU) (Figure 2.2). These units are: (TU I) Simbalbara WLS-Kalesar WLS-Shivalik FD-west bank of Ganges, (TU II) East bank of Ganges-Corbett TR-Gola river, (TU III) Gola river-Tanakpur:Khatima Highway, (TU IV) Surai Range (Pilibhit FD)-Sukhlaphanta WLR-Kishanpur WLS-Dudhwa NP-Bardia NP-Katerniaghat WLD and (TU V) Suhelwa WLS-Lamahi:Dovan bottlenecks-Sohagibarwa WLS-Chitwan NP-Valmiki TR (Figure 2.2). The TU I, TU II and TU III are in the *bhabar* tract and are largely in the state of Uttaranchal, TU IV, largely in *terai*, is in Uttar Pradesh and Nepal, and TU V, largely in *terai,* is in Uttar Pradesh, Nepal and Bihar. The proportion of habitat available for tiger in these units ranges between 15 and 39%.

Table 4.3: Landscape metrics (fragmentation and shape indices) derived for TAL (Fragstats 3.3)

Landscape parameters	Tiger Unit (TU)				
	TU I	**TU II**	**TU III**	**TU IV**	**TU V**
Potential habitat (km^2)	2925	4054	1410	8337	9077
Percent potential habitat	15.78	19.01	23.18	39.36	15.08
Patch/unit area (potential habitat/100km^2)	10.21	6.47	3.05	1.5	6.97
Large patch index	15.05	18.94	12.40	27.85	12.11
Splitting index	43.58	27.86	56.43	12.33	68.06
Total core area (up to 2km depth)	235.4	192.2	37.28	1017.75	378.46
Number of disjunct core areas	27	32	4	68	47
Number of patches having core areas	2	1	2	4	3
% of core area in potential habitat	8	4.74	2.64	12.20	4.17

The large patch index indicates the proportion of large patches in the total area and is indicative of compactness in a unit (Table 4.3). The splitting index, indicating level of habitat fragmentation, was highest in TU V, while TU IV was the lowest. As indicated by patch/unit area statistics (Table 4.3), larger number of small patches are prevalent in TU I, followed by TU V and TUII. Though the TUs were large connected networks, due to their narrow shape, considerable proportion of the forested areas of the Landscape are exposed to disturbances. The field data indicated that generally, anthropogenic pressure operates up to 2km depth from the forest edge and in some areas, as deep as 4km. The core area estimate (after excluding a 2km buffer from the patch) ranges from 4 to 13% of the size of individual patches. As the core areas of patches are relatively disturbance free, these are valued crucial for breeding of tiger and cervid populations, particularly sambar that prefers a disturbance free habitat. But, these core areas are small and disjunct in large parts of the TAL, particularly more so in TU IV and TU V, presumably making it less suitable for breeding of these species. Further, the number of patches having core (number of cores) are few and contribute a very small proportion of potential habitat. These core areas are largely contributed by patches of >500km^2 area and thus, even in fragmented landscape, these patches (>500km^2) assume greater conservation importance.

Forests in each TU have at least one key patch in which tigers can have higher probability of persistence and can act as a source for adjoining patches in the given landscape network. These key patches are the western portion of Rajaji NP in TU I, Corbett TR in TU II, Pilibhit FD-Sukhlaphanta Reserve-Kishanpur WLS- Dudhwa NP-Bardia NP in TU IV and Chitwan NP in TU V. Of these units, TU V can harbor demographically viable population of tigers only because of their contiguity with forests in Nepal.

5. UNGULATE DISTRIBUTION AND STATUS

Wild ungulates represent an important constituent of faunal assemblage in the TAL, contributing to diversity, biomass and conservation values. Including the one-horned rhinoceros, TAL supports nine species of wild ungulates; the other eight being sambar (*Cervus unicolor*), chital, nilgai *(Boselaphus tragocamelus),* wild pig (*Sus scrofa*), swamp deer, hog deer, goral and barking deer (*Muntiacus muntjak*). Domestic ungulates seen are cattle (*Bos indicus*), buffalo (*Bubalus bubalis*), goat (*Capra hircus*), sheep (*Ovis aries*) and pony (*Equus cabellus*). It is stated that the greatest ungulate biomass in south Asia is found in areas like the TAL, where grassland and forests form a mosaic and this juxtaposition of diverse vegetation types are capable of supporting rich ungulate communities (Eisenberg and Seidensticker 1976, Karanth and Sunquist 1992). Typically, the ungulate assemblage here includes both endemic (e.g. subspecies of swamp deer *Cervus duvauceli duvauceli*) and obligate species (e.g. hog deer, a grassland obligate) (Wemmer 1998). Being the major prey base, these species have a key role in the survival of tiger (Seidensticker 1976a, Stoen and Wagge 1996). The evidence on evolutionary history suggests that ungulate communities act as a determinant of tiger distribution and abundance across the distribution range (Seidensticker *et al*. 1999). According to Karanth and Stith (1999), the most important threat to tiger occurrence is the depletion of prey base. Herbivore and vegetation interactions and their specific role in structuring the vegetation communities and succession are also well known, particularly in grassland mixed ecosystems (Hobbs 1996, Augustine and McNaughton 1998, Hester *et al*. 2000, Gill and Beardall 2001). However, as indicated by anecdotal information and the present survey, the current status of these species in TAL is in fragmented populations and is subjected to enormous anthropogenic pressures including poaching (Sankaran 1990, Smith *et al.* 1998, Javed *et al.* 1999, Biswas and Mathur 2000). Prudent conservation measures ideally warrant empirical data on species distribution and abundance in the spatial context, along with the reasons for decline in population. In this study, efforts are made to document the status of ungulates in the entire TAL, and further, data collection at much finer scales enabled modeling the influence of these species on tiger occurrence in TAL.

5.1 Species association

Hierarchical Cluster Analysis revealed that the ungulates of TAL can broadly be classified into three assemblages; (i) sambar and chital, (ii) nilgai and wild pig, and (iii) swamp deer, hog deer and barking deer (Figure 5.1). However, at a finer scale, only swamp deer and hog deer show close association and all other species appear to have distinct distribution patterns, suggesting that they differ in habitat occupancy at micro scales. Sambar is largely restricted to the hilly terrain. Chital, although share the habitat with sambar to some extent, occurs more commonly in the flatter terrain. Similarly,

although both nilgai and wild pig are found in plains, the attachment of nilgai to the plains is much stronger. Sample size on barking deer was too low, most of which were in the forests close to grasslands in *terai*, and this could be the reason for barking deer being grouped along with swamp deer and hog deer (obligate species of grasslands) (Figure 5.1). However, the distance between barking deer and the grassland assemblage (swamp deer and hog deer) is considerably wider (Figure 10). Goral was not included in the analysis, because it is an outlier, exclusively restricted to steeper slopes in Shivalik hills. These variations clearly demonstrate that these ungulates represent different habitat units and therefore, tiger conservation has to accommodate these diverse habitats.

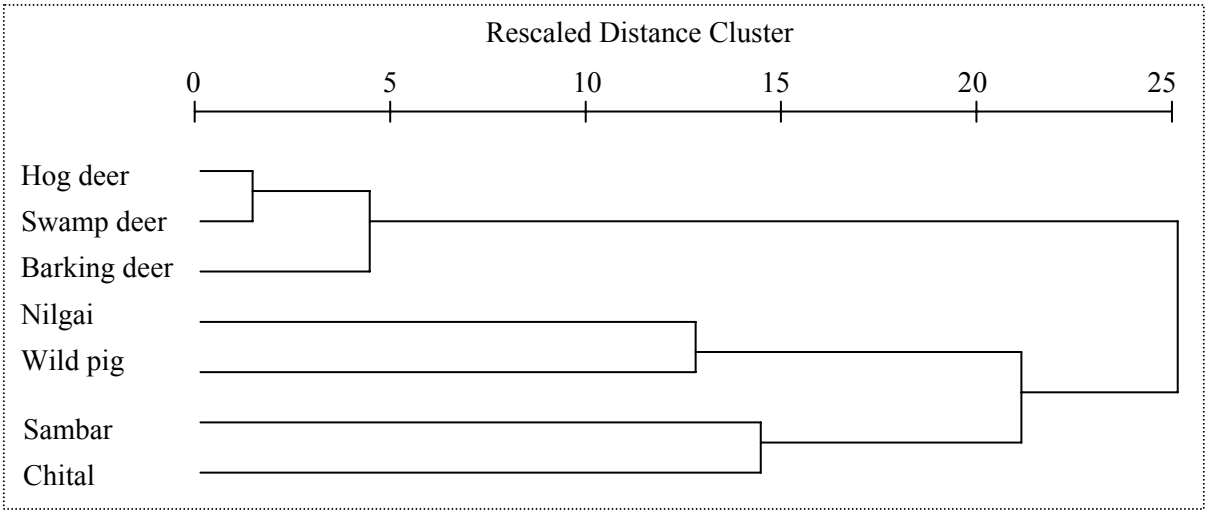


Figure 5.1: Dendrogram depicting ungulates association in TAL (Ward's method)

5.2 Distribution and relative abundance

Frequency of occurrence or proportional occurrence (number of segments with presence signs/total segments sampled), which is a potential surrogate for relative abundance, indicates that the habitat occupancy of wild ungulates varies highly between species (Table 5.1, Appendix VIII). Sambar is mostly restricted to *bhabar* habitats (Pearson ^{2} test, $p < 0.001$), whereas wild pig, chital and nilgai occupy significantly greater proportions in *terai* (^{2} test, $p < 0.001$). However, chital is found in substantial numbers in *bhabar* too. Most of the swamp deer and hog deer populations in the Indian side of TAL are confined to *terai* (Table 5.1), as exemplified in Dudhwa TR. Pilibhit FD also holds small populations of these two species. There are unconfirmed reports that few individuals of swamp deer occur in the swampy grass patches, in the southern part of Haridwar Forest Division. Barking deer is common in *bhabar* and its distribution in *terai* is largely restricted to areas receiving good protection, such as Dudhwa TR. Goral is obviously restricted to *bhabar* habitats and the steeper slopes of Shivalik hills and Outer Himalayas. When comparing the status of all these species between Protected Areas and

Reserved Forests, Protected Areas support more of chital, wild pig, swamp deer and hog deer (Table 5.1, ^{2} test, $p < 0.001$). Nilgai, on the contrary, occur significantly in higher proportion outside Protected Areas. This difference is not so apparent for sambar (^{2} test, $p = 0.14$), goral (^{2} test, $p = 0.11$) and barking deer (^{2} test, $p = 0.10$). Wild ungulate pellet group density (pooled for all the species) was marginally higher in *bhabar* (Table 5.2, Mann-Whitney U test, $Z = -1.871$, $p = 0.06$) and was similar across Protected Areas and Reserved Forests (Mann-Whitney U test, $Z = -0.797$, $p = 0.43$).

Table 5.1: Frequency of occurrence of wild ungulates in landscape and management units
(n = transects, s = segments, and the values are mean percentage ± standard deviation)

Species	Landscape (n = 246, s = 4012)	*Terai* (n = 79, s = 1366)	*Bhabar* (n = 167, s = 2646)	Protected Area (n = 85, s = 1451)	Reserved Forests (n = 161, s = 2561)
Sambar	38.5 ± 39.3	6.9 ± 17.6	53. 5± 37.8	40.7 ± 39.7	37.4 ± 39.1
Chital	54.2 ± 36.9	61.0 ± 35.7	51.0 ± 37.1	61.0 ± 36.3	50.7 ± 36.8
Nilgai	33.4 ± 37.9	56.8 ± 37.2	22.3 ± 32.9	24.2 ± 30.8	38.2 ± 40.4
Wild pig	46.4 ± 36.8	68.8 ± 33.5	35.8 ± 33.5	50.9 ± 36.0	44.0 ± 37.2
Swamp deer	0.4 ± 6.4	1.4 ± 11.3	0.0	1.2 ± 10.8	0.1 ± 0.7
Hog deer	2.1 ± 12.8	6.4 ± 22.0	0.0	5.7 ± 21.3	0.1 ± 1.1
Goral	1.4 ± 9.0	0.0	1.4 ± 7.7	1.1 ± 5.7	0.9 ± 6.7
Barking deer	7.9 ± 17.5	1.3 ± 6.5	11.1 ± 20.0	8.1 ± 18.7	7.9 ± 16.9

Table 5.2: Pellet group densities of wild ungulates (number of pellet groups/plot) in landscape and management units

	Landscape (n = 1150)	*Terai* (n = 444)	*Bhabar* (n = 706)	Protected Area (n = 639)	Reserved Forests (n = 511)
Mean	0.6	0.4	0.7	0.6	0.5
SD	1.27	0.96	1.43	1.36	1.15
SE	0.04	0.04	0.05	0.05	0.05

Among the THBs, there was a significant variation in relative occurrence of these ungulates (Pearson ^{2} test, $p < 0.001$). However, the general pattern of distribution and frequency of occurrence of these ungulates are encouraging in that, the prey availability is not wanting in most parts of TAL and at least, sambar, chital, nilgai and wild pig occur interchangeably in considerable proportion (ca. 50% and above) of the habitats (Table 5.3, Appendix VIII). Yamuna-Ganges and Ganges-Gola THBs in *bhabar* and Pilibhit-Kishanpur and Dudhwa in *terai* are currently the best areas for wild ungulates. Interestingly, despite being surrounded by human habitations and intense human activity, prey base in Suhelwa and Sohagibarwa THBs is relatively better, perhaps due to the robust habitat connectivity across Nepal and effective anti-poaching measures by the Forest Department. Rest of the THBs were either poorly represented by these ungulates or are restricted to certain parts of the blocks. For instance, in Katerniaghat WLD, only the northern portion supports relatively undisturbed, rich habitats for wild ungulates, whereas the southern portion is heavily disturbed by train and vehicular traffic and is also

under profuse human disturbance. Gola-Khatima THB experiences heavy disturbance from cattle grazing, wood cutting and lopping, and more significantly, poaching. It is likely that these factors collectively have resulted in low prey availability in this block. Similar situation exists in Valmiki TR, with poor prey base. It should be noted that the status of prey availability in Bahraich and Shrawasti Forest Divisions (THB X) was precariously low and that these areas are no more used by tiger.

Table 5.3: Frequency of occurrence of wild ungulates in Tiger Habitat Blocks
(n = transects, s = segments, and the values are mean percentage ± standard deviation)

Tiger Habitat Blocks	Sambar	Chital	Nilgai	Wild pig	Swamp deer	Hog deer	Goral	Barking deer
Simbalbara-Ganges (n=27, s= 404)	78 ± 27	67 ± 29	5 ± 18	34 ± 34	0.0	0.0	3 ± 9	14 ± 22
Ganges-Gola (n = 73, s= 1209)	58 ± 39	58 ± 38	34 ± 39	39 ± 34	0.0	0.0	2 ± 9	11 ± 21
Gola-Khatima (n = 35, s = 530)	43 ± 38	33 ± 35	13 ± 26	21 ± 27	0.0	0.0	2 ± 7	8 ± 12
Surai-Kheri (n = 47, s = 820)	6 ± 17	66 ± 32	68 ± 36	78 ± 26	2 ± 15	2 ± 14	0.0	2 ± 8
Dudhwa NP (n = 9, s = 172)	20 ± 29	83 ± 33	24 ± 27	83 ± 16	0.0	26 ± 43	0.0	4 ± 12
Katerniaghat WLD (n=13, s = 158)	3 ± 11	55 ± 37	40 ± 36	56 ± 36	0.0	8 ± 25	0.0	0.0
Suhelwa WLD (n = 13, s = 259)	34 ± 26	48 ± 30	30 ± 29	61 ± 29	0.0	0.0	0.0	8 ± 17
Sohagibarwa WLS (n = 6, s = 115)	9 ± 11	46 ± 29	62 ± 19	46 ± 51	0.0	8 ± 20	0.0	0.0
Valmiki TR (n = 20, s = 321)	31 ± 34	33 ± 34	20 ± 28	30 ± 34	0.0	0.3 ± 1	0.0	14 ± 26
No tiger area (n = 3, s = 24)	0.0	0.0	29 ± 32	33 ± 7	0.0	0.0	0.0	0.0

5.3 Influence of ungulates on tiger occurrence

In the conceptual space on two dimensions (Nonmetric Multidimensional Scaling-NMDS, stress value = 0.16, R^2 = 0.9), chital measures significantly closer to tiger indicating that tiger distribution is more closely related to chital than the other species (Figure 5.2). Sambar and wild pig are almost equidistant from tiger and given the distribution of these two species, tiger has other important prey as sambar in *bhabar* and wild pig in *terai*. Both the ungulates and tiger are placed away from disturbance indicators (domestic dog, cattle and lopping) meaning that they avoid areas of disturbance. Logistic regression analysis revealed with 74% classification accuracy that tiger occurrence is strongly influenced by cervid distribution, particularly chital followed by sambar (Figure 5.3). The domestic dog represents a disturbance regime that is unsuitable to tiger, as dogs are consistently associated with human activities such as livestock grazing, firewood collection and poaching. This reflects that on the one hand, large ungulates having wider spatial distribution determine tiger occurrence, while anthropogenic disturbances induce negative influence, on the other.

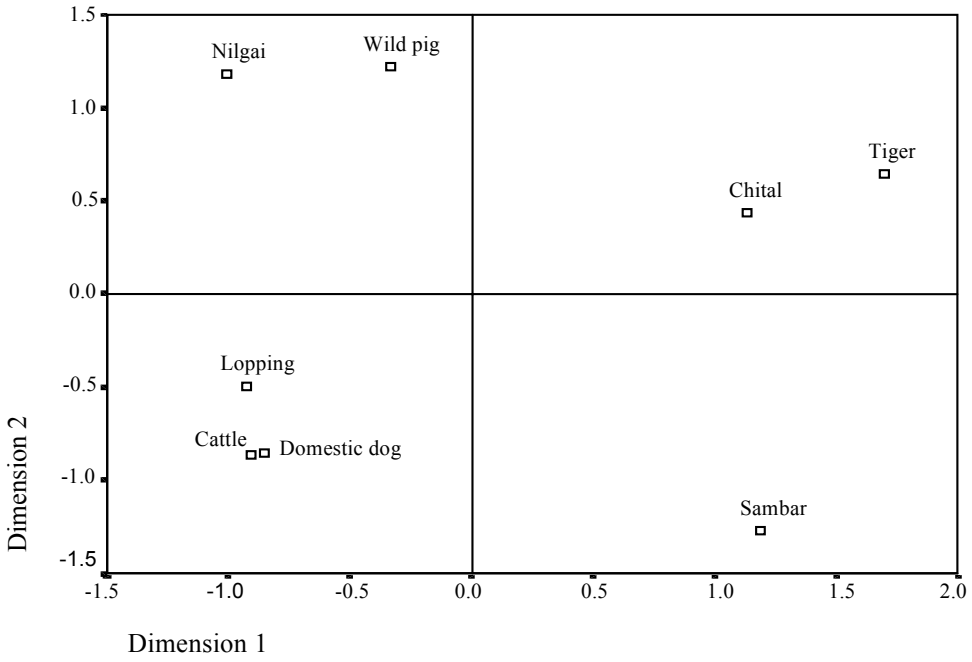


Figure 5.2: Distribution of tiger, ungulates and disturbance indicators in two dimensional space (NMDS) in TAL

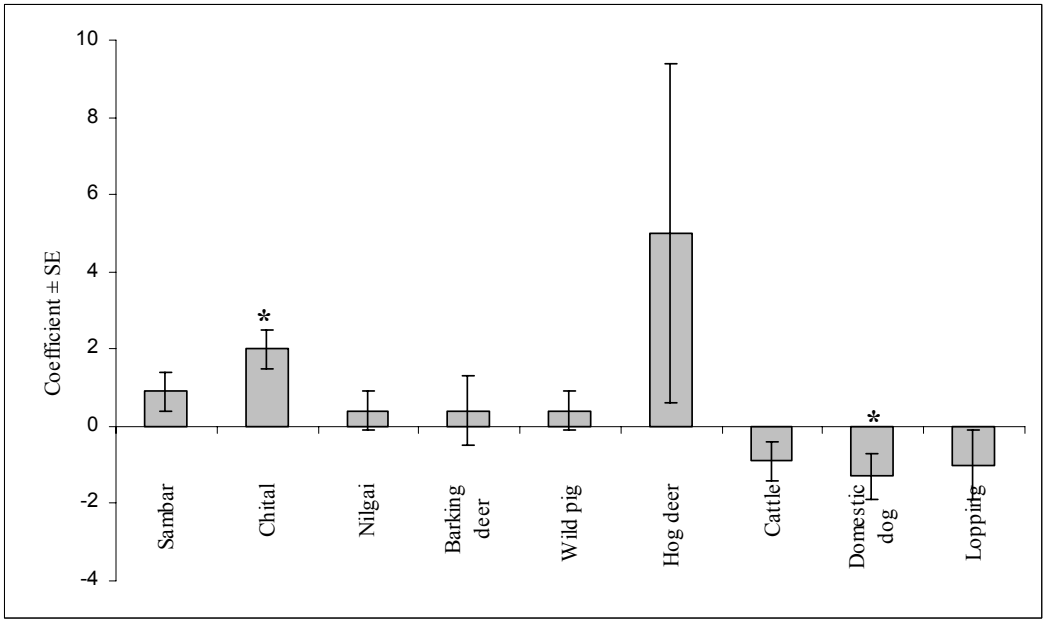


Figure 5.3: Results of logistic regression depicting relationship of ungulates and disturbance indicators with tiger in TAL (* statistical significance at $p < 0.05$)

Specifically for the *bhabar* region, all the large prey species (sambar, chital and nilgai) together positively influence tiger occurrence, whereas the domestic dog has negative influence on tiger occurrence. However, in *terai*, tiger distribution is related primarily to chital followed by wild pig. The negative influence of disturbance indicators is negligible here, perhaps because, most of the forests in *terai* are under PA network, and even the non-protected areas such as Pilibhit FD are relatively well protected from human disturbance.

6. DEMOGRAPHY AND SOCIO-ECONOMIC PROFILE

The Terai Arc Landscape has experienced a varied history of settlement and land use by people. Throughout the 19th and 20th centuries, and in significant measure even to the present day, population growth driven quest for agricultural frontier expansion are in apparent conflict with forest management. For large parts of the TAL, Flint (1998) and Habib (1999) provide a detailed account of the forest – agricultural frontier configuration from the Mughal period onwards. During the colonial administration, increased provisioning for forest products (primarily timber), added another dimension to the anthropogenic influences on TAL forests. This led to the emergence of many economically significant market towns (Tucker 1998). The main centres to emerge were Ramnagar, Kaladhungi, Haldwani and Tanakpur in the *bhabar* region, and Kashipur, Bazpur, Gadarpur, Lalkuan, Kichha and Sitarganj in the *terai* areas. From 1881 to 1981, human population has reportedly grown by 130% (Flint 1998). Development of road and rail communication infrastructure added newer and more efficient lines of export for timber and forest products, and agricultural produce. Demand for labour for agricultural commodity production, construction of the Ganges Canal (1836-1854), and expansion of the rail network in the plains placed additional pressures on these forests. A gradual process of increased monetization of the regional economies that had already begun under the colonial administration was further augmented by the developmental thrust of independent India's governments. Post colonial development of infrastructure in the form of rail and road expansion, dams and irrigation canals and the growth in human population have contributed to the present configuration of the forests - agricultural frontier.

6.1 Ethnic groups of the TAL

Malaria was a major impediment to settlement in the TAL. Being resistant to malaria, the *tharus* are among the earliest tribal settlers of forests in the TAL (Tucker 1998). They trace their origin to *rajput* forefathers (Singh 1994) and are widely dispersed in the districts of Bharaich, Gonda, Gorakhpur, Kheri, Bettiah and Nainital practicing settled agriculture. *Gujjars* lead a semi-pastoral existence, subsisting by selling milk and milk products across the western part of TAL. Dependency of *gujjars* on fodder for their livestock is of continued concern for wildlife management. Efforts to resettle *gujjars* outside PAs such as in Rajaji NP are ongoing. *Oraons* are a tribal group occurring in Gorakhpur and Bettiah districts (Singh 1994). Origins of *oraons* can be traced to the Chhotanagpur plateau of Bihar and they are mainly settled cultivators and wage labourers. Another major endogamous group that settled in the western TAL after the 1950's, are the *rai sikhs*. They are not a tribal group, but followers of the Sikh pantheon and have contributed much to the agrarian economy of these areas. *Kanjars* are a small and scattered nomadic group (largely blacksmiths). We also need to note the professional group called *taungyas.* The British

introduced the *taungya* system of forestry practice wherein people were engaged in timber tree plantations and in exchange, were allowed to grow crops within forest areas. Across the TAL, there are a number of unsettled *taungya* villages within forests and the fringe areas. Further, settlers in the form of erstwhile East Pakistan refugees, retired soldiers from hills and agriculturists from Punjab comprise large part of the population influx observed over the last four decades (Randhawa 1986).

6.2 Demography of the people

The landscape is among the most populous regions of the country, with an average of 543 individuals/km^2 (range: 137 in Champawat tehsil to 1872 in Haldwani tehsil) (Figure 6.1), which is much above the national average of 324 individuals/km^2. According to provisional figures released by the Census Directorate for 2001, 2, 38, 94,443 persons reside within TAL (Table 6.1). There has been rapid growth in human population ever since people began to occupy the fertile *terai* plains after independence. Between the year 1981 and 2001, the population within TAL has grown by a phenomenal 54.19%, which is 9% above the national average for the same period. The density for TAL was 425 individuals/km^2 in 1991, which has increased to 543/km^2 in 2001. The proportion of rural population ranges from 23.5% in Dehradun tehsil to 97.2% in Shrawasti tehsil, with an average of 82%. Scheduled Castes and Tribes comprise 23% of the population.

Table 6.1: Human population and density for TAL

Year	Total	Density (Persons/km^2)	Maximum Density (Tehsil)	Minimum Density (Tehsil)
1981	1,54,96,554	346	813 (Haldwani)	76 (Champawat)
1991	1,90,44,166	425	1120 (Haldwani)	91 (Champawat)
2001*	2,38,94,443	543	1872 (Haldwani)	137 (Champawat)

Source: Census Directorate, New Delhi, * Provisional figures

6.3 Dependency on natural resources and access to services

The existing forest cover is highly variable across TAL ranging from 72% (Haldwani tehsil, Nainital district, Uttaranchal) to 2% (Naugarh tehsil, Sidddarthnagar district, Uttar Pradesh) and significantly higher in *bhabar* areas, in particular. On considering the proportion of arable land to the total area, Dehradun tehsil that has high urbanization (55%) and forest cover (65%), had only 18% of its area arable . In contrast, Hata and Nauagarh tehsils in *terai* had 89% of their total area amenable to agriculture.

All figures in the section pertain to Census of 1991 aggregated rural data

Among the ten occupational categories recorded in the Census 1991, proportion of the total work force engaged in transport and communication, trade and commerce, manufacturing and processing indicate the degree of monetisation of the economy. Categories such as cultivators, agricultural labourers and people engaged in livestock, forestry and fishing are associated with natural resource dependency. Natural resource based occupations are predominant across TAL, averaging 669/1000 workers and ranging from 264/1000 (Dehradun tehsil, Dehradun District, Uttaranchal) to 895/1000 (Powayan tehsil, Shahjahanpur District, Uttar Pradesh) (Figure 6.2). Monetized occupations formed a smaller proportion, with an average of 331/1000 workers across TAL and Dehradun tehsil had the largest proportion of people engaged in monetized occupations (736/1000 workers).

The fuel use profile for people of TAL revealed a heavy reliance on the subsistence fuels such as dung and firewood, ranging from 99% (Dehradun tehsil) to 67% (Kashipur tehsil, Nainital district, Uttaranchal) of the households. Only 73 households/1000 relied on purchased fuels such as LPG, coal and kerosene in the entire TAL, indicating high levels of dependency on natural resources. Further, relationship between land use, occupation and fuel use illustrate patterns of dependency on natural resources. As expected, natural resource related occupations and proportion of households dependent on subsistence fuels such as dung and firewood showed a positive relationship ($r = 0.136$, $p < 0.01$) and also between monetized occupations and purchased fuels. This seems to point towards a decreasing reliance on subsistence fuels as monetization increases. Natural resource based occupations had a high positive correlation ($r = 0.421$, $p < 0.01$) with proportion of arable land. However, this was highly negatively correlated with forest proportion ($r = – 0.758$, $p < 0.05$). This negative relationship is probably due to the fact that agricultural frontier expansion was at the cost of forest cover and also because *bhabar* areas have a higher proportion of forest cover and monetized occupations. There was a significant difference in human density between *bhabar* and *terai*, with *bhabar* being lower at 334/km^2 and *terai* at 436/km^2. In spite of comparable fuel use profiles, higher forest cover and lower human density in *bhabar* areas, as against *terai* area, *bhabar* areas are in a better position to buffer firewood dependency of people.

Principal Component Analysis (PCA) and Hierarchical Clustering (using Ward's method and Euclidean distances) were done for characterization of tehsils in terms of the development and dependency attributes. The variables used include proportion of villages having access to educational, medical, post and telegraph facilities (within 5km radius), communication facilities (paved or unpaved roads) along with the demographic and fuel use attributes. PCA extracted four factors relating to (i) forest-agricultural frontier interface, (ii) agricultural development, (iii) access to developmental services and (iv) energy provision. Cluster analysis on these variables revealed three broad homogenous groups of tehsils within TAL (Figure 6.3). The first cluster was composed largely of *terai* tehsils (e.g. Pilibhit, Maharajganj and Bharaich) and the second was of *bhabar* tehsils (e.g. Dehradun, Hardwar and

Figure 6.1: Human population density (2001) for tehsils of TAL

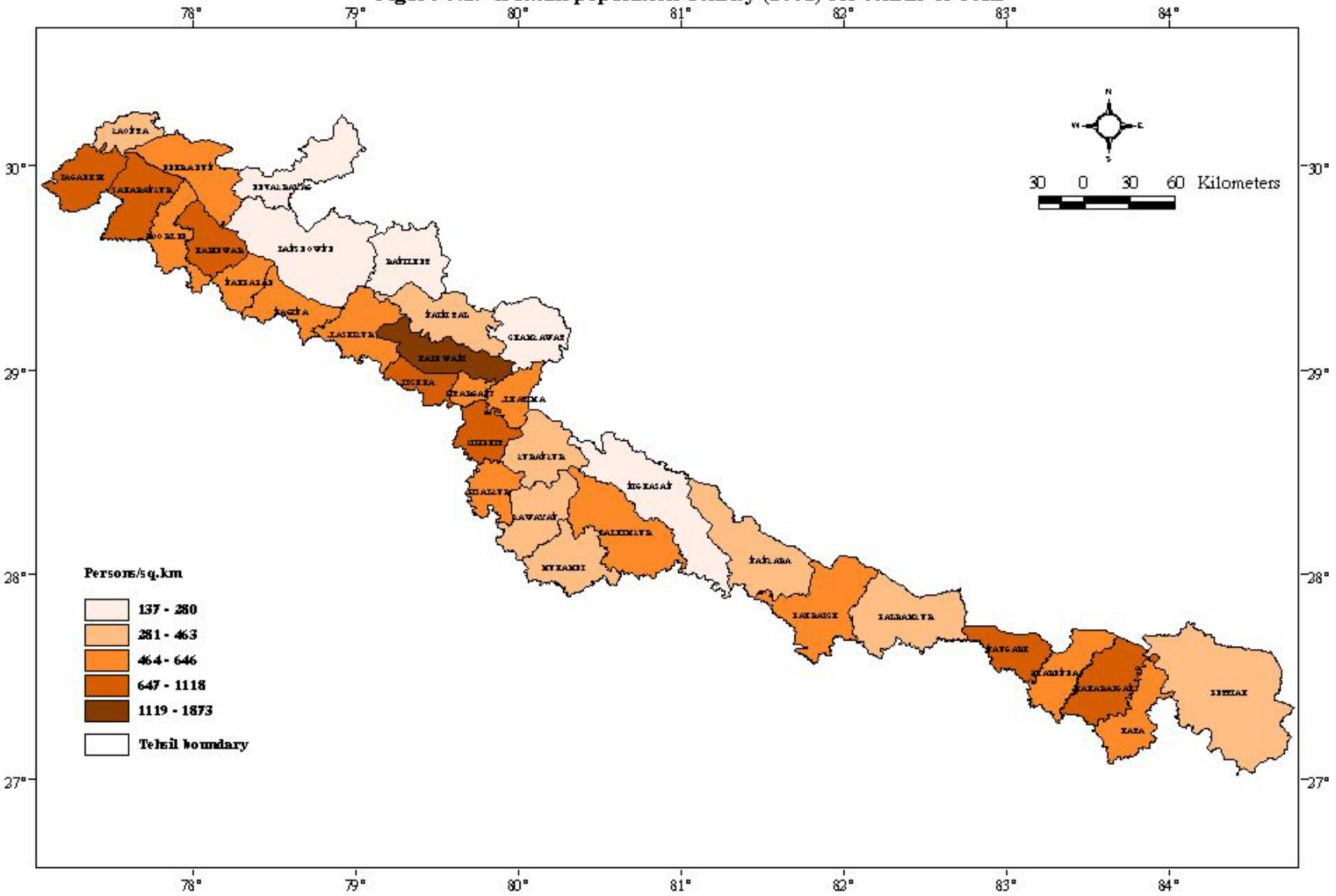
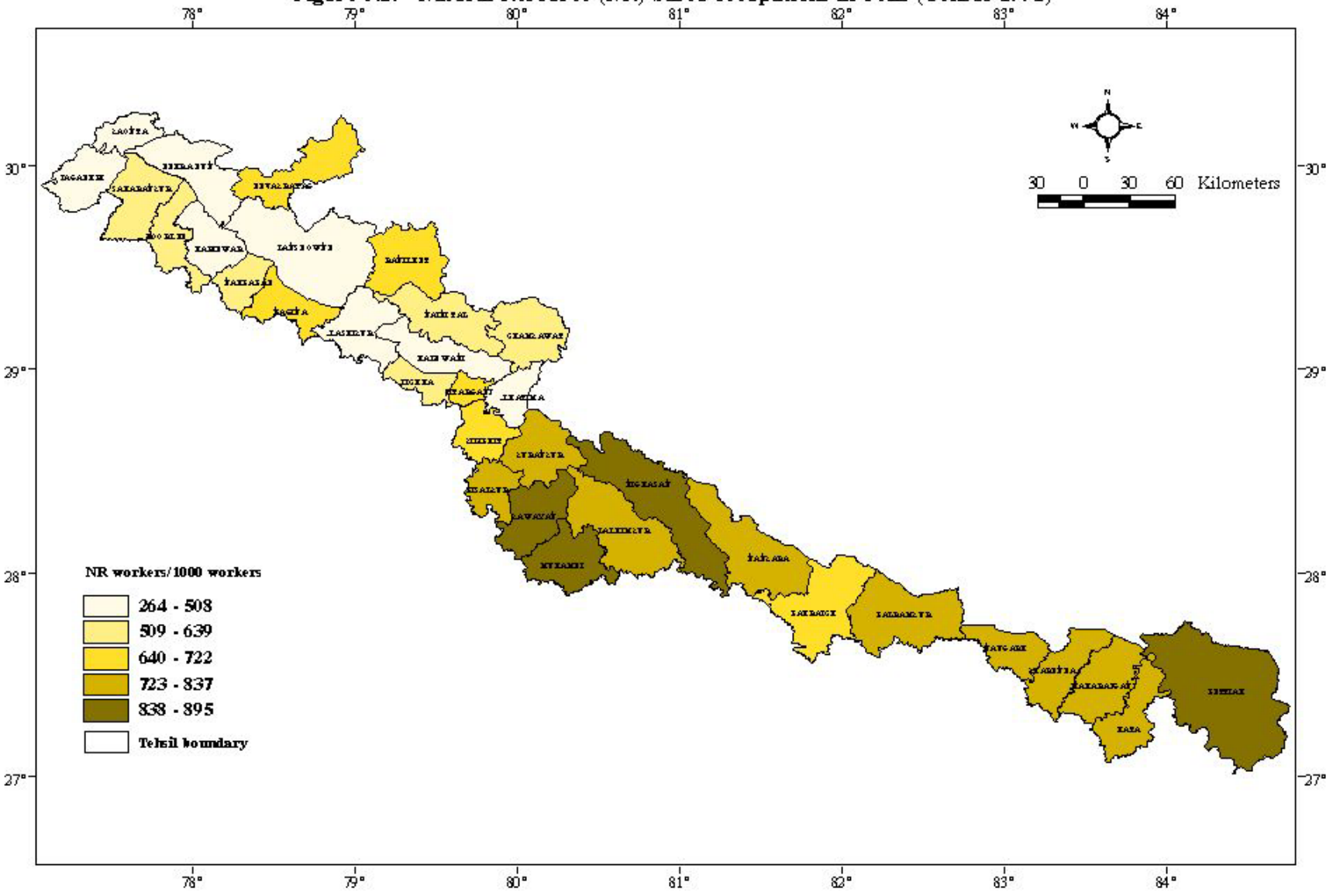


Figure 6.2: Natural Resource (NR) based occupations in TAL (Census 1991)



Haldwani). The *terai* tehsils had relatively higher natural resource related occupations and connectivity by unpaved roads along with lower urbanization and forest cover as compared to *bhabar* tehsils. The third cluster was of hill tehsils such as Lansdowne and Devprayag that had high forest cover and lowest road connectivity and urbanization. This broad characterization in terms of the socio-economic attributes clearly points to the wide variation in the socio-economic context that any tiger conservation effort within TAL has to contend with.

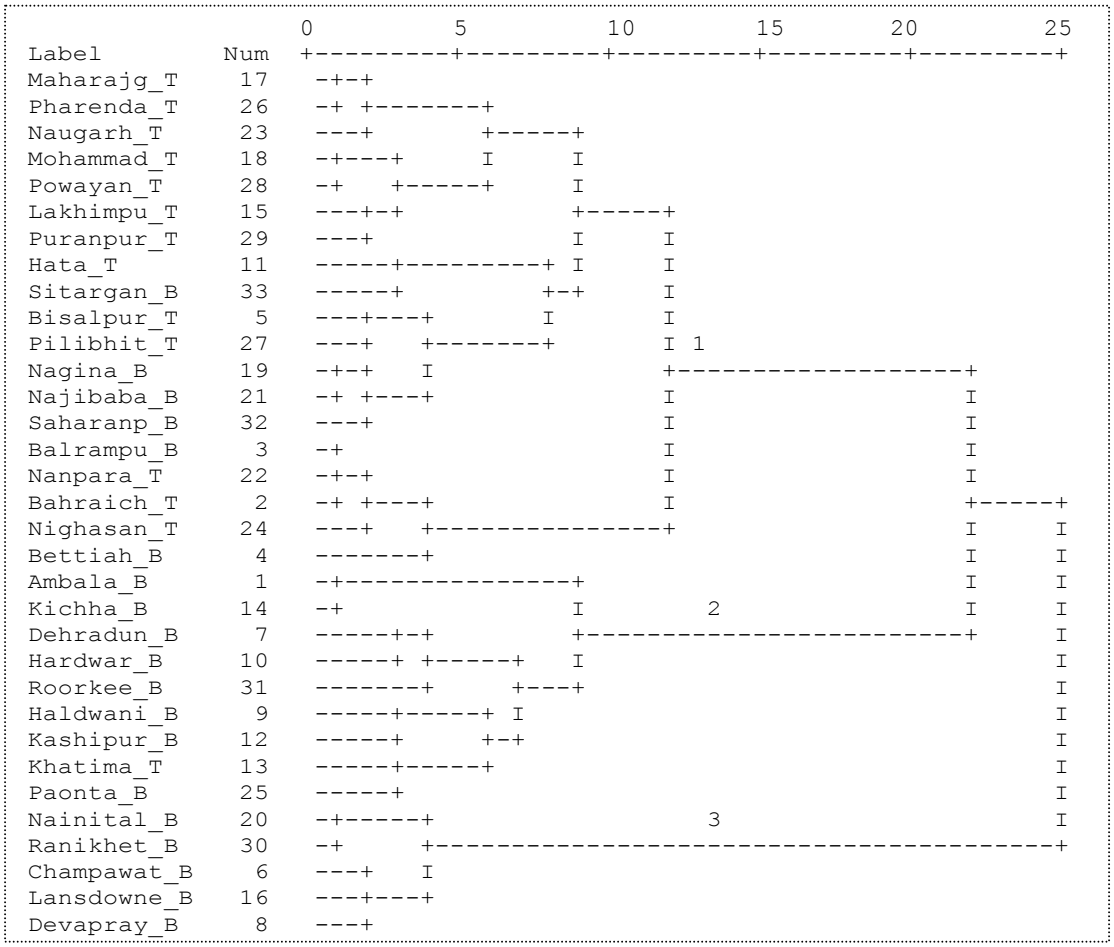


Figure 6.3: Hierarchical Clustering of TAL tehsils based on socio-economic variables
(_B: *bhabar*, _T: *terai*)

In a nutshell, the Indian side of TAL is one of the most densely populated regions of the country and the population is growing at a much higher rate than the rest. Agricultural frontier expansion into the forested tracts occurred at varying extents across TAL, largely determined by the ease of access and arability. Most of the fertile *terai* plains have been taken over by agriculture and only *bhabar*-shivalik belt retains a large proportion of its area under forests. Most of the workforce here is engaged in natural resource dependent occupations and only about 10% are engaged in monetized occupations. Purchased

fuels are used by only 7% of the households and there is heavy reliance on subsistence fuels, even in highly urbanized regions (e.g. Dehradun tehsil: 55% urbanized and 99% dependent on subsistence fuels). Higher monetization levels of the economy are generally associated with lower dependency on natural resources. However, varying levels of economic integration into the larger market economy needs to be balanced with high reliance on forest based resources. While the relative advantage of *bhabar* areas to buffer natural resource dependency over the *terai* areas is evident, the question of leveraging such advantages is largely open.

7. CONSERVATION STATUS OF TIGER

Tiger populations in the Indian portion of TAL are distributed in nine disjunct forest blocks (named as Tiger Habitat Blocks - THBs). Linear breakages in the habitat caused by alignment of canal and road networks, and in some cases, complete isolation of habitat (e.g. Dudhwa NP) due to anthropogenic factors have resulted in the insularization of these populations. An index of relative abundance and the extent of habitat use, documented based on encounter rate (ER) and relative frequency of occurrence (Frq.Occ) respectively provide an insight to the status of tiger in these blocks. Note that the validity of using pug marks to enumerate population size has been questioned even in recent literature (Karanth *et al.*2003). In the present study, pug mark encounter rate is treated only as an index and there was no attempt to estimate tiger populations. Further, we recognize that the encounter rate is possibly inflated due to the difficulties in accurately differentiating pug marks of different individuals. Therefore, frequency of occurrence was largely relied upon as an effective surrogate for ascertaining the status of tiger and associated species in TAL. In addition, prey index presents an overall status prey base in the sampling units. Given the vast area of the landscape and time constraint, the present survey had to be content with one time sampling. The findings, though, could form a baseline for monitoring the status of tiger and prey species, adequate psuedoreplicates (repeated measures) would increase the validity of the results and interpretation.

On an average, tiger used only about 12% of the area in TAL and even within better tiger habitats; the proportion of habitat use did not exceed 50% (Table 7.1 & 7.2, Appendix VIII). These figures roughly correspond to the potential habitat and prey availability in the entire TAL (Table 4.3, Figure 7.1). Pug mark encounter rate for the entire TAL was 0.3 ± 0.4/km (mean ± SD) and did not vary significantly between *terai* and *bhabar* regions (Mann-Whitney U test, $Z = -0.41$, $p = 0.7$). Both the frequency of occurrence and encounter rate had much higher variance around the mean, indicating that tiger distribution is patchy across the Landscape. PA network had relatively higher space use by tiger (13.7 ± 21.8, n = 85) than the Reserved Forests (10.7 ± 15.8, n = 161), substantially contributed by PAs such as Corbett NP (41.2 ± 22.0), Kishanpur WLS (31.9 ± 31.1) and Dudhwa NP (35.2 ± 36.6). These PAs are of greater significance at the landscape level, contributing to the higher occurrence of tiger in Ganges-Gola, Pilibhit-Kheri and Dudhwa THBs (Table 7.1). Among the non-PAs, the Lansdowne, Ramnagar and Terai West FDs that are contiguous with Corbett TR had higher proportion of tiger use (Table 7.2), implying that these areas benefit from Corbett TR. Prey Index ranged between 0.3 ± 0.03 (Bahraich-Shrawasti FDs) and 1.8 ± 0.5 (Dudhwa NP). In terms of disturbance status, as indicated by frequency of occurrence of domestic dogs, THB I and Bahraich-Shrawasti FD scored the highest and the lowest was in THB V (Dudhwa NP) (Table 7.1).

Figure 7.1: Spatial distribution of tiger and wild prey (chital, sambar and wild pig) in TAL

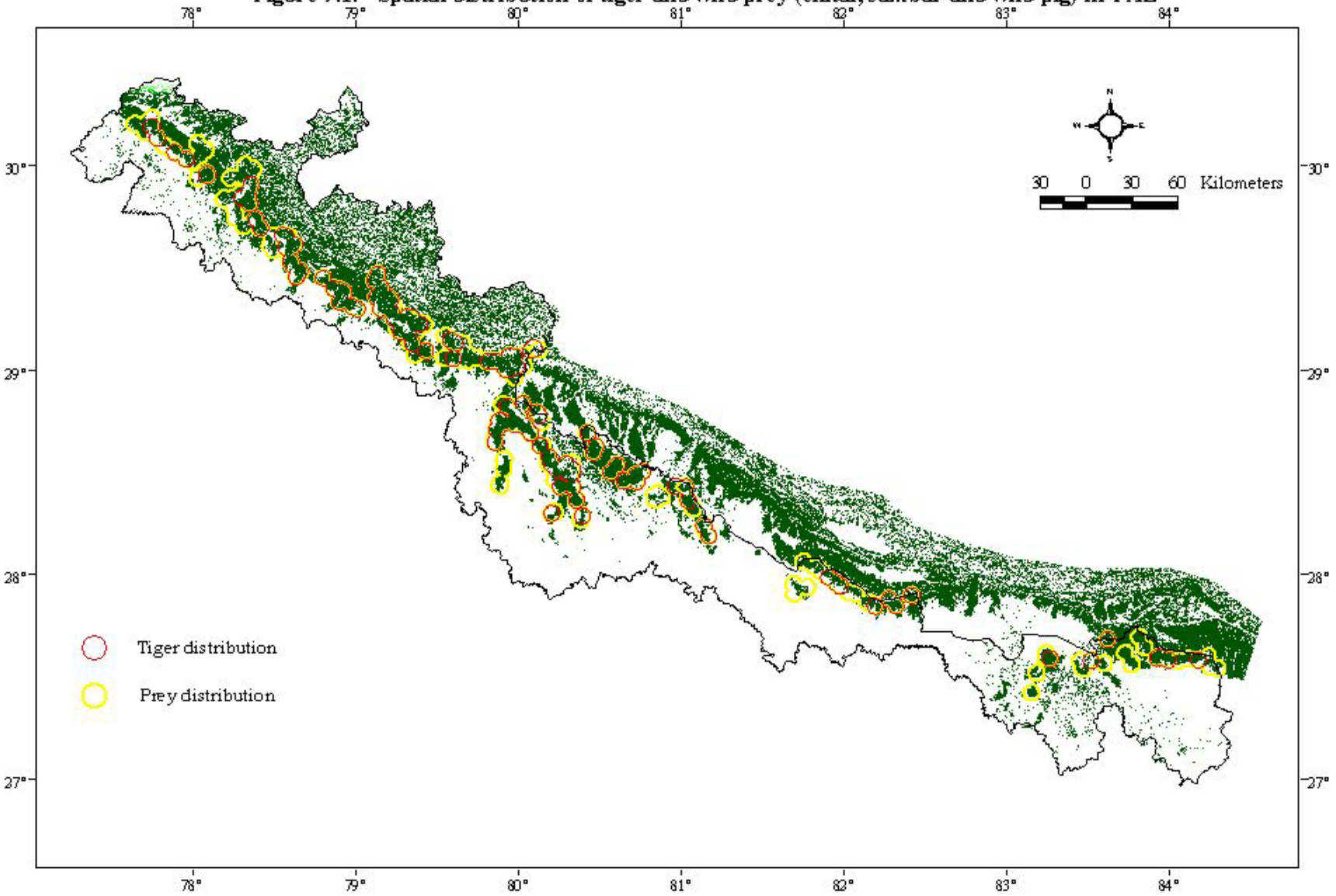


Table 7.1 Mean (± SD) pug mark encounter rates (No./km) and frequency of occurrence (%) of tiger and associated species across sampling units

Sampling Units (n = # of transects)	Tiger		Leopard		Prey Index	Cattle		Dog	Human
	%	No./km	%	No./km		%	No./km	%	No./km
Entire TAL (n = 246)	11.8 ± 18.1	0.3 ± 0.4	11.1 ± 15.1	0.2 ± 0.3	1.3 ± 0.6	73.8 ± 34.4	5.1 ± 8.9	16.8 ± 27.4	2.9 ± 3.7
Terai (n = 79)	13.8 ± 20.9	0.3 ± 0.4	2.3 ± 6.2	0.05 ± 0.1	1.2 ± 0.6	71.3 ± 34.5	4.2 ± 7.4	12.9 ± 23.9	4.0 ± 4.2
Bhabar (n = 167)	10.8 ± 16.6	0.3 ± 0.4	15.3 ± 16.3	0.3 ± 0.3	1.3 ± 0.6	75.0 ± 34.4	5.6 ± 9.6	18.6 ± 28.8	2.3 ± 3.2
Yamuna-Ganges (n = 27)	4.4 ± 8.3	0.1 ± 0.2	26.1 ± 21.7	0.5 ± 0.3	1.6 ± 0.5	82.7 ± 30.4	6.8 ± 8.1	30.1 ± 25.8	2.3 ± 2.0
Ganges-Gola (n = 73)	15.8 ± 20.4	0.4 ± 0.4	16.3 ± 15.9	0.3 ± 0.3	1.4 ± 0.7	76.6 ± 34.1	5.8 ± 10.2	19.1 ± 30.9	1.9 ± 2.6
Gola-Khatima (n = 35)	8.3 ± 12.3	0.3 ± 0.4	12.6 ± 13.8	0.2 ± 0.2	0.9 ± 0.6	68.9 ± 35.6	7.6 ± 11.6	18.4 ± 33.1	3.9 ± 5.1
Surai-Kheri (n = 47)	15.4 ± 18.5	0.3 ± 0.3	2.6 ± 6.8	0.1 ± 0.1	1.3 ± 0.5	65.5 ± 34.7	2.8 ± 6.1	16.0 ± 28.8	3.9 ± 4.0
Dudhwa (n =9)	31.8 ± 35.7	0.4 ± 0.1	1.1 ± 3.3	0.02 ± 0.1	1.8 ± 0.5	46.7 ± 37.7	0	0	0.1 ± 0.4
Katerniaghat (n = 13)	8.4 ± 16.6	0.3 ± 0.6	1.5 ± 4.1	0.1 ± 0.2	1.0 ± 0.5	90.0 ± 23.6	8.0 ± 10.9	12.1 ± 16.9	3.9 ± 2.9
Suhelwa (n = 13)	5.4 ± 7.2	0.2 ± 0.2	8.2 ± 7.8	0.2 ± 0.2	1.2 ± 0.4	91.3 ± 18.5	4.6 ± 7.0	11.4 ± 14.8	0.8 ± 1.0
Sohagibarwa (west) (n = 6)	3.3 ± 8.2	0.1 ± 0.2	1.7 ± 4.1	0.03 ± 0.1	1.0 ± 0.6	84.2 ± 38.8	7.5 ± 5.6	1.7 ± 4.1	8.4 ± 6.3
Valmiki (n = 20)	6.2 ± 13.8	0.1 ± 0.2	5.2 ± 6.3	0.2 ± 0.2	0.9 ± 0.5	67.1 ± 38.6	2.3 ± 5.8	5.8 ± 10.4	2.7 ± 3.6
Bahraich-Shrawasti (n = 3)	0	0	8.3 ± 7.2	0.3 ± 0.3	0.3 ± 0.03	75.0 ± 43.3	1.7 ± 1.5	29.2 ± 26.0	4.5 ± 2.3
Protected Area (85)	13.7 ± 21.8	0.3 ± 0.4	9.7 ± 15.9	0.2 ± 0.3	1.4 ± 0.6	70.8 ± 37.6	4.0 ± 6.8	11.1 ± 18.2	2.5 ± 3.5
Reserved Forest (161)	10.7 ± 15.8	0.3 ± 0.4	11.9 ± 14.7	0.3 ± 0.3	1.2 ± 0.6	75.4 ± 32.6	5.7 ± 10.0	19.8 ± 30.8	3.1 ± 3.7

Table 7.2 Frequency of occurrence of tiger, leopard, wild prey species and disturbance indicator (domestic dog) in management units

Management Units	Distance (km)	Tiger	Leopard	Sambar	Chital	Nilgai	Wild pig	Domestic Dog
Bijnor FD (n = 2)	5	**22.6 ± 8.4**	7.1 ± 10.1	39.3 ± 55.6	**100.0 ± 0.0**	**75.0 ± 35.4**	32.1 ± 45.5	**48.8 ± 48.8**
Bijnor PD (n=3)	12.3	0.0	**26.3 ± 11.6**	6.7 ± 11.5	47.7 ± 37.1	**79.4 ± 18.3**	39.7 ± 31.9	15.0 ± 26.0
Corbett TR (n = 4)	18.8	**41.2 ± 22.0**	2.6 ± 5.3	**93.6 ± 7.8**	**80.0 ± 22.0**	0.0	24.7 ± 19.9	0.0
Champawat FD (n=7)	14.9	10.0 ± 9.4	7.0 ± 9.8	31.0 ± 35.3	9.5 ± 25.2	0.0	8.3 ± 18.6	0.0
Dudhwa NP (n=8)	37.9	**35.2 ± 36.6**	1.3 ± 3.5	22.6 ± 29.8	**84.5 ± 34.6**	19.1 ± 23.2	**82.4 ± 16.9**	0.0
Dehradun FD (n=5)	17	0.0	18.1 ± 20.8	**63.0 ± 41.0**	**79.7 ± 21.0**	0.0	35.4 ± 48.5	14.8 ± 16.7
Haldwani FD (n=18)	73.9	8.3 ± 12.7	15.5 ± 14.1	**54.0 ± 37.6**	34.8 ± 32.1	8.4 ± 15.7	18.6 ± 20.9	21.3 ± 34.0
Haridwar FD (n=7)	29	0.0	27.5 ± 18.2	45.5 ± 34.3	**73.8 ± 20.0**	45.2 ± 38.7	**63.1 ± 37.9**	**37.3 ± 35.2**
Sonanadi WLS (n=2)	5	12.5 ± 17.7	**47.9 ± 20.6**	**79.2 ± 5.9**	**100.0 ± 0.0**	**68.8 ± 44.2**	33.3 ± 47.1	8.3 ± 11.8
Kalesar FD (n=3)	8.9	0.0	13.9 ± 12.7	**94.4 ± 9.6**	**63.9 ± 48.8**	33.3 ± 50.7	41.7 ± 38.2	**30.6 ± 17.3**
Kalsi FD (n=2)	6.1	0.0	7.7 ± 10.9	**64.7 ± 26.3**	24.0 ± 1.4	3.8 ± 5.4	27.9 ± 4.1	**69.2 ± 43.5**
Katerniaghat WLD (n=9)	30.7	12.1 ± 19.1	0.6 ± 1.7	4.4 ± 13.3	**58.9 ± 38.8**	29.6 ± 33.2	**64.9 ± 36.4**	11.5 ± 18.3
Kishanpur WLS (n=6)	25.1	**31.9 ± 31.1**	0.0	0.0	**80.0 ± 23.5**	**51.9 ± 45.3**	**84.7 ± 18.8**	6.9 ± 9.8
Lansdowne FD (n=15)	65.75	16.8 ± 28.3	14.3 ± 12.7	**55.5 ± 41.4**	28.1 ± 36.6	1.5 ± 4.6	23.1 ± 33.1	1.4 ± 4.2
North Kheri FD (n=12)	47.4	13.7 ± 20.1	3.2 ± 5.8	9.6 ± 23.6	**50.5 ± 29.2**	**54.6 ± 31.6**	**61.1 ± 31.4**	17.3 ± 24.0
Narendranagar FD (n=1)	2.7	0.0	9.1 ± 0.0	9.1 ± 0.0	27.3 ± 0.0	0.0	0.0	**36.4 ± 0.0**
Pilibhit FD (n=22)	90.8	12.0 ± 12.9	3.1 ± 9.0	4.7 ± 16.0	**77.6 ± 30.5**	**68.6 ± 34.8**	**84.4 ± 22.5**	19.3 ± 36.0
Rajaji NP (n=16)	67.3	12.9 ± 17.6	**33.4 ± 21.8**	**90.6 ± 10.5**	**88.3 ± 19.8**	4.5 ± 11.5	42.0 ± 29.8	27.0 ± 27.6
Ramnagar FD (n=16)	63.4	**20.7 ± 18.0**	9.1 ± 10.4	**80.5 ± 22.1**	**58.8 ± 36.5**	19.4 ± 28.5	36.0 ± 30.7	14.6 ± 31.2
South Kheri FD (n=7)	30.9	7.1 ± 9.1	1.2 ± 3.1	6.1 ± 16.2	44.8 ± 36.8	**99.2 ± 2.1**	**70.4 ± 42.0**	8.7 ± 11.9
Shahjahanpur FD (n=2)	9.2	0.0	0.0	0.0	41.9 ± 23.9	**100.0 ± 0.0**	47.4 ± 24.5	0.0
Shivalik FD (n=7)	30.5	7.0 ± 7.4	**36.5 ± 18.9**	**78.8 ± 15.6**	**58.4 ± 15.9**	2.8 ± 5.4	31.8 ± 31.6	26.9 ± 18.4
Shrawasti FD (n=3)	6	0.0	8.3 ± 7.2	0.0	0.0	29.2 ± 31.5	33.3 ± 7.2	29.2 ± 26.0
Sohagibarwa FD (n=10)	47.7	3.0 ± 6.7	3.0 ± 6.7	6.2 ± 9.3	42.3 ± 28.5	**60.7 ± 27.5**	40.2 ± 45.3	9.0 ± 13.5
Suhelwa FD (n=13)	64.7	5.4 ± 7.2	8.2 ± 7.8	34.3 ± 26.4	48.3 ± 29.5	30.0 ± 29.4	**61.3 ± 29.4**	11.4 ± 14.8
Terai Central FD (n=10)	43.4	9.7 ± 16.7	8.2 ± 6.7	22.4 ± 38.0	29.0 ± 31.0	**80.0 ± 25.7**	33.5 ± 39.2	**33.3 ± 37.1**
Terai East FD (n=13)	58.2	10.1 ± 15.2	10.4 ± 13.6	25.8 ± 35.3	48.7 ± 37.4	31.6 ± 37.7	42.5 ± 39.1	25.5 ± 37.8
Terai West FD (n=7)	27.7	14.1 ± 9.0	16.7 ± 12.8	44.7 ± 33.0	**75.6 ± 32.8**	**63.4 ± 35.5**	**65.6 ± 21.5**	**34.4 ± 44.7**
Valmiki TR (n=16)	60.9	7.1 ± 15.2	5.2 ± 5.5	38.9 ± 33.7	32.6 ± 35.9	10.0 ± 11.3	29.9 ± 34.2	2.3 ± 4.4

The status of tiger, the problems and the possible mitigation measures specific to each subpopulation in each of the THBs are discussed in detail below. Further, over 10 corridors or connectivity potentially enabling movement of tigers between these subpopulations have been identified in TAL (Appendix IX, Figure 7.2a, Figure 7.2b), which have significant management implications. West to east (Figure 4.5), the subpopulations in the THBs are:

7.1 THB I (Simbalbara WLS to west bank of Ganges)

This subpopulation is restricted to Simbalbara WLS and Kalesar WLS, Shivalik FD, Kalsi FD, part of Narendranagar FD, Dehradun FD and part of Rajaji NP (west of Ganges). There is no record of tigers ranging beyond Simbalbara and Kalesar WLSs. Similarly, in the eastern end of THB, tigers do not move across the Ganga river (Johnsingh and Negi 2003, Appendix IX). Three transects covering 8.9km were surveyed in Kalesar WLS with no sign of tiger use, though leopard tracks (3 tracks) were found. However, in the afternoon of 25th January 2003, fresh pug marks of a large male tiger were observed in Langadiwala *nallah* of Ambawali *rau* (south-eastern part of Kalesar WLS). On the following morning, fresh tracks of a large tiger/tigress were recorded in Kaludeo *rau* in Simbalbara WLS. These two locations are about 15km apart, separated by dense jungle and Shivalik hills, and therefore, both these observations were possibly of different tigers. In Shivalik FD, seven transects covering 30.5km were surveyed, and pug marks of a male, and a female with a large cub were observed to use five *rau*s (overall pug mark ER: 0.2/km, Frq.Occ: 7.0 ± 7.4). The tigers here are likely to be moving from the adjacent Rajaji NP. The Division is highly disturbed by people (human encounter rate, 2.4/km) and livestock (7.2/km). However, the prey status was relatively better, with prey index of 1.5, largely contributed by high frequency of sambar and chital (Table 7.2). Three years earlier, when a similar effort was made in this Division, with the assistance of Forest Staff, no evidence of tiger was recorded (Johnsingh and Negi 2003). It is likely that either the pug marks were missed or tigers were not using Shivalik FD then. Two transects were surveyed in Kalsi FD (one in Mundiawali *kala*, 3km and the other in Binaul *rau*, 3km which is between Kalsi and Shivalik FDs) and there was no sign of tiger use. Woodcutters and *gujjars* heavily disturb Mundiawali *kala*. Poaching is also reported to be a regular phenomenon. Although Binaul *rau* was under heavy disturbance from *gujjar* camps, sambar continue to use this area considerably (64.7 ± 9.6) and the area benefits from the location of a forest check post here. No evidence of tiger was recorded in both Dehradun FD (5 transects: 17km) and in Narendranagar FD (one transect: 2.7km). However, the prey index in Dehradun FD was relatively higher at 1.6 (also see Table 7.2), but is under heavy human (ER, 1.5/km) and livestock disturbances (ER: 10.5/km). Leopards were observed to use these two FDs (ER: 0.3/km and 0.4/km respectively). In the western portion of Rajaji NP, areas around Dholkhand support relatively higher abundance of tiger and wild ungulates. Tiger pug mark ER

Figure 7.2a: Location of corridors in TAL

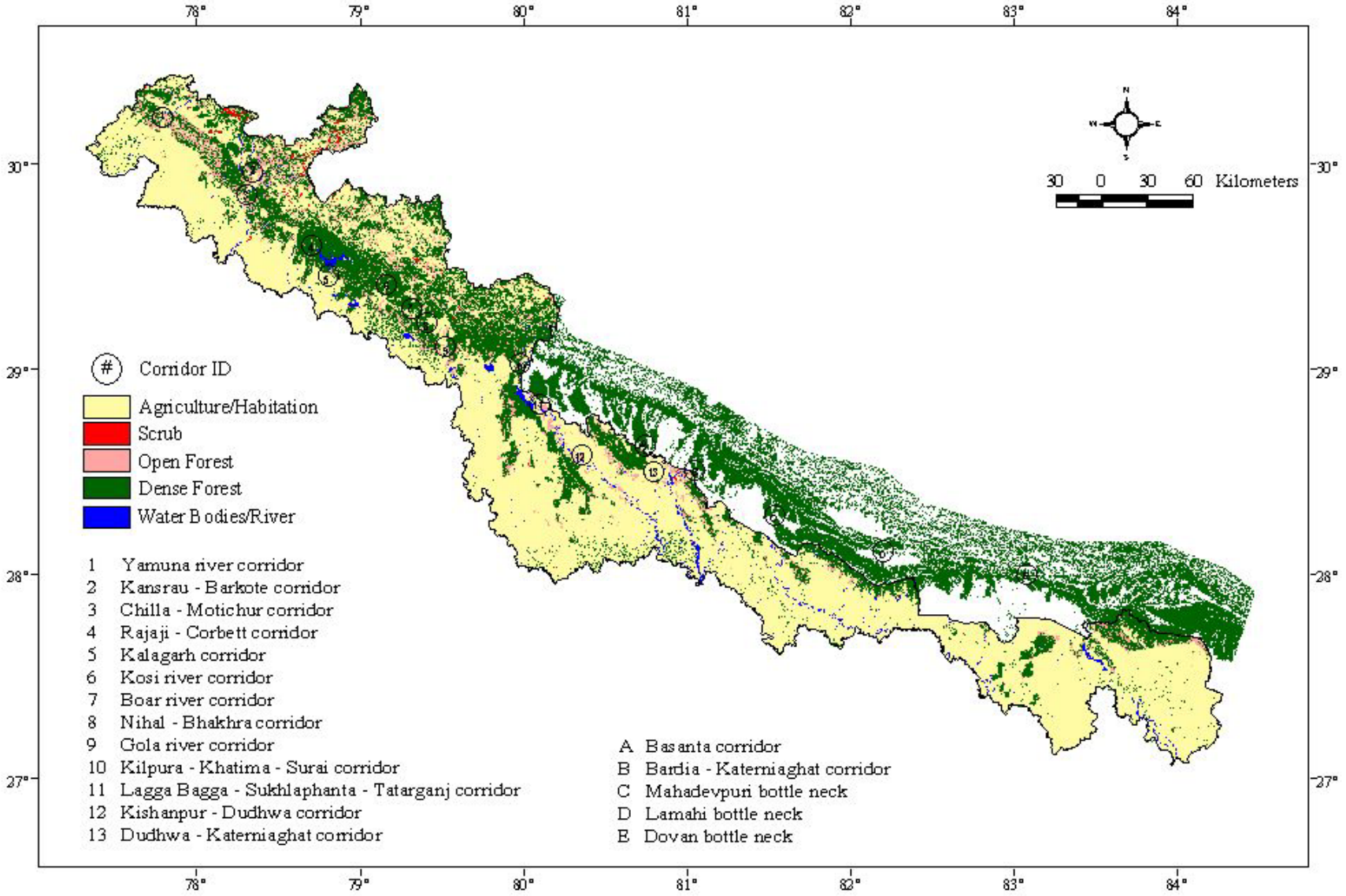
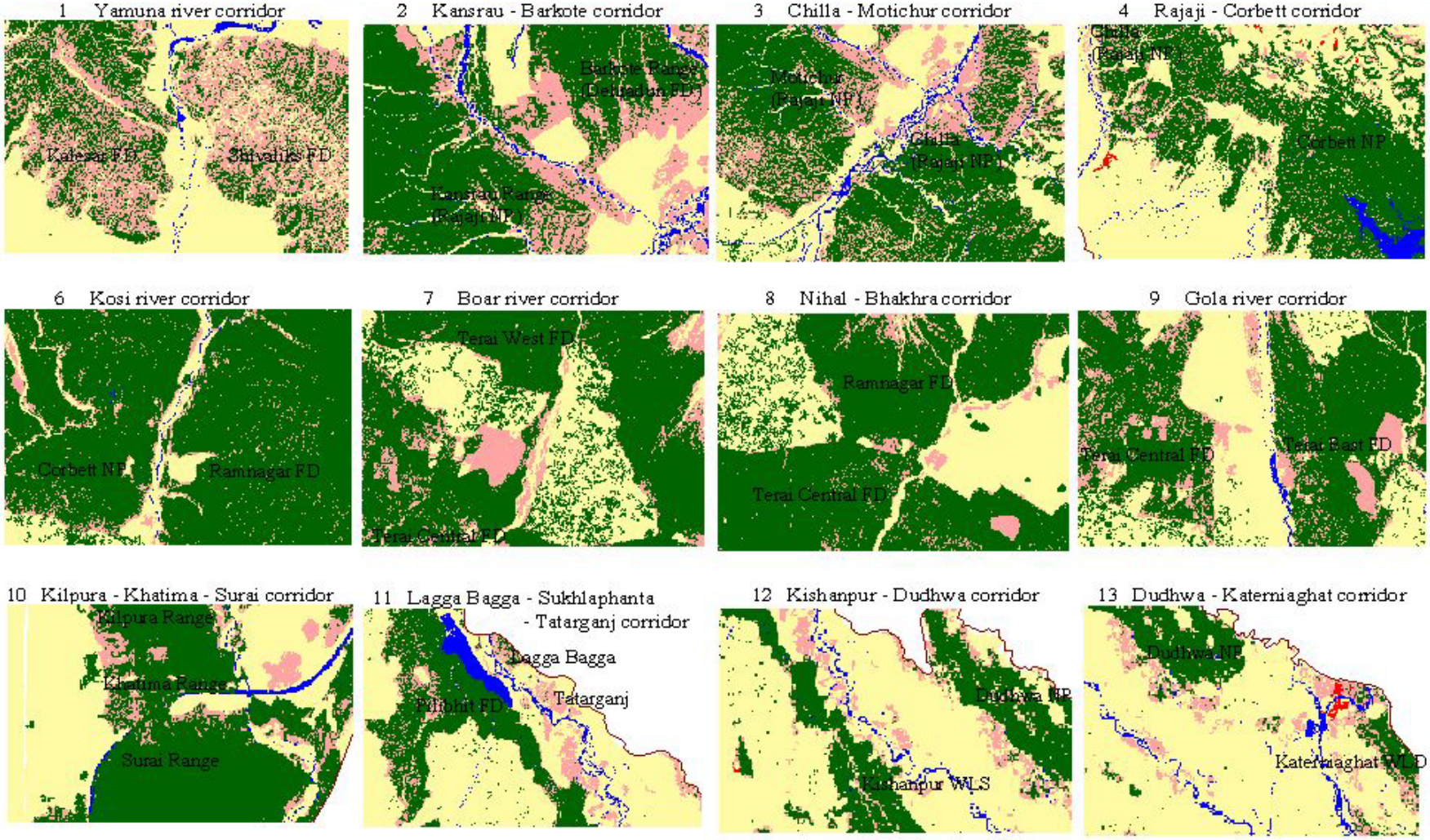


Figure 7.2b: Corridors identified in TAL



for the best areas in three *raus* in Dholkhand (15km) was 0.6/km. The overall frequency of occurrence of tiger signs in these *raus* was 23% and, for sambar and chital, these were 93% and 95% respectively.

In general, the status of tiger in this THB is poor, in spite of better wild prey availability (Table 7.1 and also see, Table 5.3). It appears that disturbance indicators (such as cattle, human and domestic dog) play a decisive role more on tiger and also, potential habitat available for tiger in this THB is relatively less (15.8%). The canal along the Yamuna river has created a linear break between Shivalik FD and the forests, west of Yamuna (Kalesar and Simbalbara WLSs) and the movement of tigers which is largely observed during winter months, is only through aqueducts below the canal (see Appendix IX). Even these areas are under disturbance from boulder mining and other human activities. To enable continued movement of tiger across Yamuna and to sustain this subpopulation to remain as one unit, initiatives such as establishment of 'Rajaji-Shivalik Tiger Reserve' are required (Johnsingh *et al.* 2003, Johnsingh *et al.* in press). The disturbances along Yamuna river such as boulder and sand mining in the western part of TAL should be controlled (Appendix X). It is reiterated that the Chilla-Motichur corridor between Chilla (east bank of Ganges) and Motichur (west bank of Ganges) should be established to enable tigers to move across the Ganga river (Appendix IX).

7.2 THB II (East bank of Ganges to west bank of Gola river)

This is the most intact and extensive forest block in TAL, with 4053.5km^2 potential habitat for tiger. This THB includes the Chilla portion of Rajaji NP, Lansdowne FD, Haridwar FD, Bijnor Plantation Division, Bijnor FD, Corbett TR (inclusive of Sonanadi WLS and Corbett NP), Ramnagar FD, Terai West FD, southern border areas of Nainital FD and Terai Central FD. There was no evidence of tiger along the west (1 transect: 2km) and east bank (1 transect: 5.9km) of the river Ganga. Besides, two other transects covering 12km surveyed along the east bank for bird count, also resulted in no evidence of tiger. Absence of tiger pug marks along the east bank, where frequently encountered until a few years ago, is perhaps due to increasing anthropogenic disturbances from the west bank of Ganges. The subsistence demands from Ganga-Bhogpur *Talla* and *Malla*, and Kunaun *goth* settlements (together about 250 families) are increasingly putting pressure on the forests, which need to be addressed to save the tiger habitat on the east bank of Ganges.

In the interiors of Chilla Range, a 5km transect along the Amgaddi *sot* (narrow valley with perennial water) where the anthropogenic pressures were low, had much high evidence of tiger (frequency of occurrence: 65%), elephants (100%) and wild ungulates (e.g. sambar: 95%, & chital: 95%). This exemplifies what these forests are capable of supporting if anthropogenic disturbances are either low or absent. There were tracks of two tigresses, one tiger, 2-3 leopards, a large Himalayan black bear (possibly a male; right hind foot track measured 22cm), and elephants. Besides, there were wide

varieties of avifauna and signs of other wildlife activities (track of a large python, drag marks of a chital killed by a leopard and tiger at a kill were seen), indicating significance of this tract. This wildlife abundance was possible only because there were no *gujjar deras*, and firewood, fodder and *bhabar* grass collectors (all of whom are known to steal kills) not venturing into the valley. In Chilla portion of Rajaji NP, 7 transects (31.6km) were surveyed and tiger pug mark ER was 0.3/km and leopard pug mark ER was 0.6/km. The overall FO of tiger signs in these transects was 20%.

Tiger pug mark ER for the hilly portion of Rajaji-Corbett corridor (8 transects: 35.2km), which falls in Lansdowne FD, was 0.1/km. Leopard pug mark encounter rate was 0.2/km. Prey index here was 0.4, human and cattle ERs were 3.6/km and 4.5/km respectively. Johnsingh and Negi (2003) observed that use of the heavily disturbed Rajaji-Corbett corridor by tiger is occasional. Outside the corridor area in Lansdowne FD, seven more transects (30.6 km) were surveyed and the tiger pug mark encounter rate was 0.4/km, leopard pug mark encounter rate 0.2/km, human encounter rate 2.1/km, and cattle encounter rate 3.6/km. Prey index was 1.6. There was no evidence of tiger in Haridwar FD (7 transects: 26 km) and the Bijnor Plantation Division (3 transects: 12.5 km). Both are located south of the hilly portion of Rajaji-Corbett corridor. Both the Divisions, however, had high leopard pug mark ER: 0.6/km for Haridwar FD and 0.7/km for Bijnor Plantation Division. Prey index in Haridwar FD was 1.6, human ER 4.8/km and cattle ER 20.7/km, the highest in the entire Landscape. It is obvious, even too much of cattle grazing keep tigers away. In Kalagarh FD (Sonanadi WLS, part of Corbett TR), two transects (5km) were surveyed and the tiger pug mark ER was 0.6/km and leopard pug mark ER was 0.8/km. Tiger pug mark ER in Bijnor FD (2 transects: 5 km), just south of Corbett TR, was 0.8/km and leopard pug mark ER was 0.2/km. The prey index was 1.6 and human ER was 1.2/km. Four transects (18.8 km) in the core area of Corbett TR, all in the hilly area, were surveyed and tiger pug mark ER was 1.1/km (Frq.Occ: 41.2 ± 22.0), the highest recorded in the entire Landscape (Table 7.2). Human and cattle were not encountered and prey index was 1.8. However, use of this hilly area by leopard was negligible (ER: 0.1/km, Frq.Occ: 2.6 ± 5.3).

Kosi river flows between Corbett TR and Ramnagar FD, and certain stretches of forests along the river provide connectivity between these two areas. Tiger pug mark ER along the river (3 transects: 13km, all in Ramnagar FD) was 0.8/km and Frq.Occ was 25%. Human and cattle ER were 2.4 and 3.6 respectively. Prey index was 1.9 (Frq.Occ: sambar = 80%, chital = 89%). Perennial water is the major attractant here for the prey. Interestingly, no leopard signs were seen. Thirteen more transects (50.4km) were surveyed in Ramnagar FD and the tiger pug mark ER was 0.4/km. Human and cattle ERs were 1.0/km and 3.1/km respectively. Prey index was 1.5, substantially contributed by sambar (Frq.Occ: 80.5%). Terai West FD, adjoining Corbett TR, had relatively high ER and frequency of occurrence of tiger and wild prey species. From 7 transects (27.7 km) surveyed, tiger pug mark ER was 0.4/km

(Frq.Occ: 14.1 ± 9.0) and leopard pug mark ER 0.3/km (Frq.Occ: 16.7 ± 12.8). However, there was high amount of anthropogenic disturbance in this FD (Frq.Occ: domestic dog = 34.4 ± 44.7). Prey index was 1.7 (Frq.Occ: sambar = 44.7 ± 33.0, chital = 75.6 ± 32.8, wild pig = 65.6 ± 21.5).

Ten transects (43.4km) were surveyed in Terai Central FD. Both tiger and leopard were observed to use the area in almost similar proportion (Frq.Occ: tiger = 9.7 ± 16.7, leopard = 8.2 ± 6.7) which is relatively low as compared to other FD in *bhabar* region. This FD is heavily disturbed from all sides and there is extensive human and cattle use (human ER: 1.9/km, cattle ER: 1.7/km), which is further substantiated by high presence of domestic dog in this FD (Frq.Occ: 33.3 ± 37.1). Prey availability was poor, except for nilgai (Frq.Occ: 80.0 ± 25.7) that presumably compensate for other wild prey species (Table 7.2). There are two small corridors that enable tiger movement between Ramnagar FD and Terai Central FD, which otherwise would be an isolated forest block, as there is no connectivity with Terai East FD across Gola river. These corridors are Nihal-Bhakra and Gadappu *nallah.* Tiger and elephant populations continue to use these corridors for ranging into Terai Central FD. Four transects (13.4km) were surveyed along Nihal-Bhakhra, and the tiger pug mark ER was 0.3/km. In the heavily disturbed Gadappu *nallah* (2 transects: 10km), only one pug mark of tiger was recorded. Near Lalkuan (Terai Central FD) along Gola river at eastern end of the FD, two transects (7.4km) were surveyed, but use of tiger here was very low and there was only one pug mark recorded. However, this is the area where there is a possibility of restoring connectivity with Terai East FD across the Gola river, which at present is ravaged by boulder and sand mining.

Overall, 73 transects covering 302km were surveyed in this THB, and the frequency of occurrence of tiger was 15.8% (±20.4 SD), and encounter rate was 0.4/km (±0.4 SD). High variation in these two parameters is largely contributed by high density areas such as Corbett TR, in contrast to some of the FDs having very poor tiger distribution. Tiger movement between forest patches of this THB are facilitated by corridors such as Rajaji-Corbett, Kosi river, Boar river, Nihal-Bhakra and Kadappu, and anthropogenic disturbances on these corridors need to be curtailed so as to enable this population to remain as a unit. Large-scale boulder mining and human habitation along Gola river obstructs tiger movement between Terai Central FD and the forests across Gola river (Terai East FD).

7.3 THB III (East bank of Gola river to Tanakpur-Khatima Highway)

This THB includes the major portion of Terai East FD, entire Haldwani and Champawat FDs. The latter has a tenuous connectivity with the forests of Nepal along the Sharda river (Figure 4.5). Tanakpur and Khatima townships, infrastructure development related to Sharda irrigation project and encroachments of the past that are gradually spreading, largely confine this subpopulation to Terai East and Haldwani FDs (Appendix IX, Appendix XI). Tiger and wild prey species were poorly represented in

this THB. Frequency of occurrence and encounter rate of tiger in this THB were 8.3% (±12.3 SD) and 0.3/km (±0.4) respectively. Frequency of occurrence of sambar and chital were 43.6% and 38.5% respectively. Poaching seems to be a serious problem here (Appendix XII). However, in Champawat FD, while surveying along the Ladhya river (a tributary of Sharda river) and on interviewing the villagers of Chuka, it was learnt that poaching is minimal from the Nepal side, as the Mao insurgents have taken guns away from most of the Nepalese villagers. The rest have deposited the guns with the police to avoid them being taken away by the insurgents. Patrolling by Indian para-military forces along the border has also helped in the reduction of poaching. Along the Ladhya river bed, two black bear and an impressive number of sambar tracks were recorded. In addition, an elephant population numbering ca. 30-40 are restricted to this THB. This population is completely isolated from other elephant populations and rarely, one or two bulls manage to cross over to Nepal through Khatima forests, which was a regular phenomenon until a few years ago.

Terai East FD was poorly represented in tiger and wild prey species distribution (Table 7.2). From a total of 13 transects covering 58.2km, tiger and leopard pug mark ERs was 0.2/km. Prey index was 1.1. The area was under tremendous anthropogenic disturbance from cattle grazing and fire wood collection, particularly Doli Range (along Gola river), which has potential to enable tiger movement between forests of western and eastern banks of Gola river. During the survey, the ER of people and cattle were 3.8/km and 6.5/km respectively. Frequency of occurrence of dog here was 25.5 ± 37.8. No tiger pug mark was seen in Khatima and Ranshali Ranges, largely due to extensive human activities in these areas. There was, however, evidence of leopard in Khatima Range. Three tracks of leopard were recorded along Jhagbora river (1 transect: 5km) in this Range. Similarly Haldwani FD was heavily disturbed. At present, this FD does not support extensive tiger population (Frq.Occ: 8.3 ± 12.7), largely owing to anthropogenic disturbances. This FD is heavily exploited for firewood requirement of Haldwani township and people around the area. Though the habitat has potential to support reasonable populations of prey species, only sambar fares relatively better (Table 7.2) and there was strong indication that poaching takes a major toll of wild prey species in this Division. Given the better habitat condition including wide spread perennial water sources; this FD has potential to harbour more tigers, if the problems cited are controlled. Despite being relatively less disturbed, wild prey availability is poor in Champawat FD (Table 7.2) and this perhaps has resulted in low occurrence of tiger here (Frq.Occ: 10.0 ± 9.4). The habitat condition is less supportive of wild prey species, particularly because, the landscape here is dominated by moist sal (*Shorea robusta*) and considerable proportion of weedy species such as *Lantana camara* occupy the under storey (also see, Figure 4.3, Appendix VIII). Only the forests that are closer to Haldwani FD support tiger and there is no possibility of tiger movement from Pilibhit FD through Surai and Khatima Range of Terai East FD, since the human settlements along Sharda canal and Tanakpur-Khatima Highway have broken the connectivity between these forests. Presently, Surai Range,

the eastern part of Terai East FD, is cut off from rest of the Ranges of this Division, but is contiguous with Pilibhit FD.

7.4 THB IV (Surai Range of Terai East FD to South Kheri FD)

Surai Range of Terai East FD is contiguous with the Mahof and Mala Ranges of Pilibhit FD. On the eastern part of the Pilibhit FD, a narrow strip of forest (4 – 7 km wide and 25km long) from Barahi and Haripura Ranges of Pilibhit FD provides connectivity with Shahajahanpur FD and Kishanpur WLS, which in turn is contiguous with South Kheri FDs on the south and part of North Kheri FD on the north. Unlike the situation along the Ganga and Sharda rivers, where anthropogenic pressures from large towns caused disruption to habitat connectivity, this narrow belt of forest is still intact and serves as a corridor between Pilibhit FD and Kishanpur WLS. During the survey, tiger and wild prey were observed to use most parts of this narrow stretch, indicating that this corridor is functional. In addition, this stretch has the potential to facilitate movement of tiger and other large mammals from Sukhlaphanta Reserve in Nepal through Lagga Bagga (Barahi Range, Pilibhit FD) and Tatarganj Block (left bank of Sharda, Sampurnanagar Range of North Kheri FD) to Kishanpur WLS and surrounding forests. However, except for Chuka Block (Haripura Range of Pilibhit FD) on the right bank of Sharda, which has *terai* grasslands, this narrow stretch dominated by *Shorea robusta* is unlikely to provide suitable habitat conditions for tiger to establish a population in this forest stretch.

Pilibhit FD, despite being under Reserved Forest category, showed exemplary wildlife values and field observation indicated that this FD supports reasonable populations of tiger, sloth bear and wild prey species including hog deer. Lagga Bagga forest block, in particular, supports populations of hog deer, rhinos (coming from Sukhlaphanta Reserve), swamp deer and the rare, hispid hare. Mahof and Mala Ranges (an area of ca. 300 km^2), with tall grass habitat along Mala river and on either side of Sharda canal, together have potential to support a breeding population of 10-15 tigers and 30-50 rhinos. In addition, a population of ca. 50 swamp deer is reported to occur in these two ranges. A total of 22 transects covering 90.8km surveyed in Pilibhit FD and all Ranges except Deoria, which is an isolated block on the south, had tiger. Deoria was devoid of even leopard signs. Excluding the data from Deoria Range, the tiger pug mark ER was 0.3/km and prey index was 1.5. Although this FD is surrounded by settlements, the human ER (4.2/km) and cattle ER (1.2/km) are comparable with other PAs (Table 7.1). As expected, leopard use of this FD was relatively low (ER: 0.03/km, Frq.Occ: 3.1 ± 9.0). The overall frequency of occurrence of tiger was 12.0 ± 12.9, and wild prey availability was substantially higher (Frq.Occ: chital = 77.6 ± 30.5, nilgai = 68.6 ± 34.8 and wild pig = 84.4 ± 22.5). The frequency of occurrence indicates that the disturbance indicator (domestic dog) was highly variable (19.3 ± 36.0), with Mahof and Mala Ranges being less disturbed as compared to Deoria Range and a portion of Barahi

Range. On the border of Lagga Bagga block (which abuts Sukhlaphanta Reserve on its southwestern side), two transects (9km) were surveyed on the left bank of Sharda river. In the upstream transect (4km), two tiger pug marks were recorded close to Nepal's Sukhlaphanta Reserve, but there were no tiger pug marks along the downstream transect. Interestingly, along the upstream transect in the Indian part (first 2km), there was high human (60) and cattle (20) use. In contrast, the Nepal side had no people, but 20 cattle were seen. There were 88 people and 47 cattle recorded in the downstream transect. Tracks of a tigress and its grown up cub were recorded inside Lagga Bagga during an opportunistic search of 5km, indicating its potential for tiger survival. Controlling human disturbance on Lagga Bagga is a huge challenge; as large number of people on both sides of Sharda river rely on Lagga Bagga for firewood, thatch grass and fodder. Intensive protection and participatory management with these people are required to restore the area.

Kishanpur WLS (203km^2), being one of the few remnant terai habitats in India, has significant wildlife values, supporting considerable number of tiger, swamp deer and hog deer. This WLS is believed to harbour a source population of tiger that range into North Kheri and South Kheri FDs, and perhaps move as far as Pilibhit FD. The frequency of occurrence recorded for tiger in this WLS was the third highest (31.9 ± 31.1, n = 6 transects, 25km) in the entire Landscape (Table 7.2). Tiger pug mark was 0.5/km and there was no leopard sign in this WLS. Human and cattle ERs were 1.9/km and 1.1/km respectively. Prey index (1.5), largely contributed by chital (80.0 ± 23.5) and wild pig (84.7 ± 18.8) was among the highest in TAL (Table 7.2). Sampling was done to ascertain the movement of tigers from Kishanpur WLS crossing Sharda river (through Palia or Sampurnanagar Ranges) to Dudhwa NP in the east. A total of 10km were surveyed (5km upstream and 5km downstream) and tracks of a tigress with two cubs were recorded on the left bank of Sharda. The survey team also tracked pug marks of a tiger from Kishanpur WLS to left bank of Sharda river. Extensive disturbance (lopping and grazing) in Sampurnanagar and Palia Ranges (North Kheri FD), which are left with a narrow stretch of *khair* (*Acacia catechu*) dominated forests, indicates that the tigers may not permanently reside in these ranges. It is likely that one or two tigers from Kishanpur WLS may range into Satiyana Range of Dudhwa NP, through Sampurnanagar Range and the bordering sugarcane fields. Survey along the left bank of Sharda river (seven transects, 33.8km) towards Lagga Bagga revealed that tigers may not be directly ranging between Lagga Bagga and Kishanpur WLS, as the forests along the left bank of Sharada river are fragmented, interspersed with human habitation. However, there was an indication that tigers move between Chuka block (Haripura Range) and Sukhlaphanta Reserve, through Tatarganj. Further, a few elephants are reported to move between Tatarganj and Sukhlaphanta Reserve. It is possible to strengthen the habitat connectivity of Sukhlaphanta Reserve–Tatarganj–Chuka, as this stretch has very few human

settlements. The tendency of Sharda river to change course makes this area unviable for permanent human settlement.

Shahajahanpur FD, on the southwestern border of Kishanpur WLS across Kheri canal, provides a buffer to the Sanctuary. The forests here are narrow (2-3km) along the Kheri canal and are heavily disturbed by human and cattle populations from southern boundary. There was no tiger pug mark within 2 transects (9.2km) surveyed in Khuttar Range of this FD. Chital (Frq.Occ: 41.9 ± 23.9) and nilgai (Frq.Occ: 100 ± 0.0) were the major prey species available here. Efforts need to be undertaken to keep this forest disturbance free so as to enable this stretch to remain as a buffer.

South Kheri FD (415 km^2) has extensive forest cover, but mostly plantations of teak (*Tectona grandis*) and *sal*, with insufficient cover for wild prey species. Tigers (Frq.Occ: 7.1 ± 9.1) frequent these areas, but the habitat appears to be shrinking and becoming increasingly unsuitable due to growing anthropogenic pressures from south, east and west. Prey index was 1.1. Only nilgai (FO: 99.2 ± 2.1) and wild pig (Frq.Occ: 70.4 ± 42.0) were widely found here, while chital (Frq.Occ: 44.8 ± 36.8) was largely restricted to the northern part (Mailani and Bhira Ranges), adjoining Kishanpur WLS. Overall tiger pug mark ER in this FD was 0.2/km (n = 7 transects, 30.9km). Human and cattle ER were 3.3/km and 3.2/km respectively. Gola and Mohamadi Ranges were highly exposed to anthropogenic pressures, largely due to proximity of the villages and narrow shape of the forest. Mohamadi Range, in particular, is fragmented and wildlife signs in these forests were poor. There was a report that during 2001-2002, two tigers came into conflict with people in Mohamadi Range, and one was shot dead after it had injured a few and killed two persons (*pers*. *com*. Field Director, Dudhwa TR).

7.5 THB V (Dudhwa National Park)

Dudhwa NP (680km^2) is an isolated tiger habitat and though this THB has tenuous connectivity with Katerniaghat WLD to the east and Basantha forests in Nepal to the north, tiger movement between these forests is reported to be only occasional. Within the NP, distribution of tiger was uneven (Frq.Occ: 35.2 ± 36.6), largely concentrated in the southern and southeastern part (Satiyana, Dudhwa, South Sonaripur and Belrayan Ranges). In these four ranges, 24.6km were surveyed and the tiger pug mark ER was 0.4/km, among the highest in TAL (Table 7.1). These Ranges experience low anthropogenic disturbance (Human and cattle ER: 0/km). Prey index was 1.7, again among the highest in the entire TAL. In the other ranges (Gauriphanta, Bankatti and North Sonaripur), in spite of high prey index of 1.4, tiger pug mark ER was lower at 0.2/km (13.3km), human and cattle ER being 0.3/km and 0/km respectively. This apparent variation in tiger occurrence can be attributed to habitat quality and lack of disturbance in the southern Ranges. Satiyana, Dudhwa, South Sonaripur and Belrayan Ranges have more of *terai* grasslands when compared to the rest that are largely characterized by *sal* as dominant species.

Absence of palatable shrub cover in sal forests and abundance of *Tiliacora acuminata* (Menispermaceae), an unpalatable climber, are also problems in this area. Presently, the prey availability in Dudhwa NP is the highest recorded for the TAL with the prey index of 1.8 (Table 7.1). Large proportion of area was observed to be used by chital (84.5 ± 34.6) and wild pig (82.4 ± 16.9). Nevertheless, both tiger and prey populations are vulnerable to habitat isolation and factors related to habitat quality.

The subpopulation in this THB has been isolated in the recent past by habitation and agricultural expansion, and forest clearing along the international border. There is tenuous connectivity between Dudhwa NP and Katerniaghat WD to the north, in the form of an arc from Belrayan Range (Dudhwa NP) along Basanta forests, *Churia* hills, Bardia NP and the northeastern part of Katerniaghat Range. The gap between Belrayan Range and Basanta forests is less than a kilometer, and here, the chances of establishing connectivity are greater. Efforts to restore this connectivity by colleagues in Nepal are underway. There is also a possibility of establishing corridors between these forests on the Indian side through the forests of North Kheri FD (see Appendix IX).

7.6 THB VI (Katerniaghat Wildlife Division)

Katerniaghat WLD (400 km^2) and eastern parts of North Nighasan Ranges (Latwa-Batwa and Majra Blocks) constituting this THB is another disjunct tiger habitat on the Indian side. The northern portion of this WLD (Katerniaghat Range) between Geruwa and Kaudiala rivers is the Indo-Nepal border, which runs east west. The area, further north on the Nepal side between the Kaudiala and Geruwa, is devoid of forests except for few small-degraded patches, and much of the area is essentially under agriculture. Bardia NP (Nepal) is located east of Geruwa and its southern boundary along the Geruwa river is about 12km from the northern boundary of Katerniaghat WLD. Geruwa is a large river and its riverine forests may be able to provide a corridor for the movement of tigers, rhinos and elephants between these two Protected Areas (Appendix IX). Although this THB is unique in terms of species diversity, supporting substantial populations of Gangetic dolphin, two species of crocodiles (Gharial and Mugger), hog deer, swamp deer and immigrant populations of rhino and elephants from Nepal, tiger distribution was poor (Frq.Occ: 8.4 ± 16.6, n = 13 transects) and it was one of the highly disturbed THBs in the entire TAL (Table 7.1).

During the field survey, Katerniaghat WLD provided an initial impression of being a better habitat for tiger than Dudhwa NP, but exploration in all the forest ranges revealed that suitable tiger habitats exist only in the northern part of the Division, in Katerniaghat and Nishangara Ranges. In comparing the overall frequency of occurrence of tiger in the entire WLD (12.1 ± 19.1, n = 9 transects; 30.7km), these two Ranges scored above the average (Frq.Occ: 19.2 ± 18.9, n = 5 transects; 15.7km),

while rest of the Ranges together had much low Frq.Occ. (3.3 ± 3.9, n = 4 transects; 15km). Similarly, tiger pug mark ER was relatively high in the two northern Ranges (0.3/km) as compared to the rest (0.1/km). Human and cattle ERs were 1.5/km and 2.5/km respectively. Interestingly, prey base was marginally higher in southern Ranges (prey index = 1.2, Frq.Occ: chital = 76.3 ± 16.1, nilgai = 46.5 ± 34.0, wild pig = 70.0 ± 23.2) indicating that prey availability was not a factor contributing to low use of these Ranges by tiger. The prey index in the northern Ranges was 1.1, and the Frq.Occ. of chital, nilgai and wild pig were 45.2 ± 40.4, 44.1 ± 16.2 and 76.0 ± 37.5 respectively. The southern Ranges (Kakraha, Dharmapur, Motipur & Mutihar) form a narrow conical patch dominated by plantations of teak and *sal*, and are bordered by villages from three sides. Further, motor and rail tracks cut through the forests in the middle, dividing the forests into two spatial units. All these have increased human activity in the forests, creating unfavorable conditions for tiger to move and establish a population in these Ranges. Human and cattle ERs were 5.3/km and 4.4/km respectively.

An elephant group (5-8 individuals) and two rhinos that have emigrated from Bardia NP (Nepal) to Katerniaghat WLD appeared to have taken refuge in Katerniaghat Range (Sinha 2003). It appears that in the years to come only Katerniaghat and Nishangara Ranges may be able to support tigers. Reducing pressures and making the habitat suitable for tiger in other parts of Division is a demanding challenge. It should be noted that the entire Division is probably also subjected to heavy poaching. In the Katerniaghat WLD, only one village (Bharthapur) is located in the very important trans-Geruwa area of the Sanctuary, and if this village could be translocated, the entire biodiversity-rich trans-Geruwa area would be free from permanent human habitation. It should be possible to persuade the people to move out, as this village is situated between Geruwa and Kaudiala rivers that destroy crops and other assets, while changing course occasionally.

7.7 THB VII (Suhelwa Wildlife Sanctuary)

Suhelwa WLS (482 km^2), falling under *bhabar* zone, has seven Forest Ranges and the forest is somewhat rectangular, extending along an east-west axis, about 80km long and 5-6km wide. It is not connected with any other forests on the Indian side. This THB is characterized by mixed vegetation of *Shorea robusta-Anogeissus latifolia-Syzygium cuminii*. The entire stretch was surveyed along 13 transects (64.7 km) and overall frequency of occurrence of tiger was 5.4 ± 7.2, among the lowest in the TAL (Table 7.1). This THB is highly disturbed by human population on the southern boundary and also by scattered settlements on the Nepal side along Indo-Nepal border. Cattle usage was extensive and consistently high across the entire THB (Frq.Occ: 91.3 ± 18.5). This frequency of occurrence recorded of cattle here was the highest in the entire TAL. The prey base was relatively poor (prey index = 1.2) and was largely contributed by wild pig (Frq.Occ: 61.3 ± 29.4) followed by chital (Frq.Occ: 48.3 ± 29.5). As

a result of high anthropogenic pressures and low prey base, evidence of tiger use was largely restricted to Suhelwa and Bankatwa Ranges, towards the western part of this Sanctuary. One or two tigers stray as far as Bhambar Range in the eastern-most part of the Sanctuary, where habitat conditions do not appear to be conducive for tiger survival. Tiger and leopard pug mark ER in Suhelwa was 0.2/km. Human and cattle ER were 0.8 ± 1.0/km and 4.6 ± 7.0/km respectively. Further details on the wild prey and disturbance status are given in Table 7.1 & 7.2.

The positive aspect of this THB is that its northern part is contiguous with Nepal forests, which along Lamahi and Dovan bottlenecks reportedly continue as far as Chitwan NP in the east. Similarly, there is also connectivity between the Sanctuary and Bardia NP along Mahadevpuri bottleneck (WWF Nepal Program 2003). This connectivity, in October 2003, has evidently enabled movement of a few elephants from Nepal to the western part of this Sanctuary possibly from Bardia NP. Anthropogenic pressures on this Sanctuary include poaching, cattle grazing and firewood collection, by people on both sides of the border. If the disturbances are brought under control, this THB, in conjunction with the forests on the Nepal side, can significantly contribute to tiger conservation.

7.8 THB VIII (Western portion of Sohagibarwa WLS)

Sohagibarwa WLS (405 km^2) is highly fragmented and is distributed in four major forest patches. West to east, these patches are represented by (i) Pakri Range, (ii) South Chauk, North Chauk, Lachimipur and Maduvalia Ranges, (iii) Nichlaul Range and (iv) Shivpur/Sohagibarwa Range. Lachimipur, North Chauk, Madhuvalia and South Chauk Ranges form the largest forest patch and a kilometer away to the south, Pakri Range is another isolated patch (Figure 2.2). These two forest patches, west of Nichlaul town, constitute THB VIII, on account of their proximity and reported movement of tiger between these patches. This THB is separated distinctly from Nichlaul and Shivpur/Sohagibarwa Ranges by extensive human habitation, agricultural land and Nichlaul township and the gap is about 10km wide. Further east, Gandhak river that forms the eastern boundary of Nichlaul Range bisects Shivpur/Sohagibarwa Range, which is contiguous with forests of Valmiki TR.

It appears that only a handful of tigers are left in this THB, mostly along the Payas river in North Chauk and Maduvalia Ranges. The frequency of occurrence (3.3 ± 8.2, n = 6 transects; 28.7km) and pug mark encounter rate (0.1 ± 0.2) estimated for tiger in this THB were the lowest in the entire TAL (Table 7.1). Leopard also was poorly represented (Pug mark ER: 0.03 ± 0.1, Frq.Occ: 1.7 ± 4.1) in this THB. Anthropogenic pressures are enormous, from the *taungya* villages located inside the forest and villages on the fringes, and there was intense human and cattle usage of the forests (Table 7.1). Specifically, Pakri Range has large tract of *terai* short grasslands, but given the heavy pressure on this patch from fodder collection and cattle grazing, the existence of this unique vegetation type and associated species in

the future is uncertain here. However, overall prey base of this THB was moderate, perhaps due to stringent anti-poaching measures by the Forest Department. The prey index was 1.0 ± 0.6 and the frequency of occurrence of chital, nilgai and wild pig were 46.3 ± 29.3, 62.0 ± 18.6 and 46.2 ± 50.9 respectively.

Reducing anthropogenic pressures, translocating *taungya* villages located right inside the forests and restoring the habitat connectivity between the forest patches are important management interventions if the tiger population has to survive and expand in this THB. However, the Forest Staff struggling to mitigate the problems are faced with an uphill task. For instance, the activities pertaining to translocation of the *taungya* villages initiated several years ago are yet to get off the ground. The small size and patchiness of habitat with severe anthropogenic pressure and lack of connectivity (functional and potential) with other THBs indicate that if the current populations of tiger in TAL are to become extinct, it is likely to begin from this THB.

7.9 THB IX (Eastern portion of Sohagibarwa WLS to Valmiki TR)

As the eastern Ranges of Sohagibarwa (Nichlaul and Shivpur/Sohagibarwa) are contiguous with Valmiki TR and as tiger movement is reported between these forests, these Ranges together with Valmiki TR are regarded as one habitat block, *i.e.* THB IX. Within this THB, although Gandhak river bisects Nichlual and Shivpur Ranges, there is possibility that tigers can range between these forests and the adjoining forests (Madanpur Range) of Valmiki TR. Three transects (14.8km) were surveyed in the Nichlaul Range and tiger pug mark ER was 0.1/km, the only pug mark recorded being along the west bank of Gandhak river. Leopard also was poorly represented in this Range (pug mark ER: 0.1/km). This Range was among the highly disturbed areas (Human ER: 5.9/km, Cattle ER: 7.0/km) and was with relatively low prey base (prey index: 0.9). The frequency of occurrence of chital, nilgai and wild pig were 46.7 ± 28.4, 78.3 ± 14.4 and 41.7 ± 42.5 respectively. The situation was worse in Shivpur Range, with no evidence of tiger (1 transect, 4.2km) and except for few records of chital tracks (Frq.Occ: 6%), there was no other prey species recorded in this transect.

Valmiki TR (880km^2) represents extensive *bhabar-dun* landscape, located along the northern boundary of West Champaran District of Bihar, bordering Nepal. There are seven Forest Ranges within the Reserve, administered under two Forest Divisions. Division I includes Forest Ranges in the eastern sector of the Reserve (from east to west: Manguraha, Govardhana and Ragia) and Harnatan, Chutaha, Ganoli and Madanpur Ranges constitute Division II. The entire forest stretch is conical on west-east axis, with the western boundary tenuously connected to Shivpur/Sohagibarwa Range of Sohagibarwa WLS and there is no forest cover beyond the eastern boundary. However, Chitwan NP (Nepal) across the hill ridges, forms strong contiguity on the northern side. Between the forests of Harnatan-Chutaha Ranges to

the south and Ragia-Govardhana Ranges to the north, there is a huge forest gap (6-8km wide and 15-20km long), forming a *dun* dominated by short grasslands. *Tharu* tribals among others inhabit both the *dun* and the southern and eastern boundaries of the Reserve, placing heavy pressures on the Reserve. Madanpur Range, the western limit of the Reserve, is narrow in shape along the Gandhak river and the vegetation here is a mix of tall grasslands and degraded forests. Rhino from Chitwan NP apparently stray into this Range, as deep as 10km from the Nepal border. Although this Range forms contiguous habitat along with Shivpur Range of Sogahibarwa WLS, it largely remains as an isolated patch, except for the fragile connectivity to the east with Ganoli Range. The entire Range is enveloped by human population, even along the Gandhak river, and the habitat destruction has been further aggravated by construction of road and railway line through this Range. At present, this Range is reportedly supporting a substantial population of swamp francolin and few hog deer, and there are extensive tall grasslands having potential to support rhinos and other endemic or obligate species. In order to save the existing species populations and augment tiger and wild ungulates occurrence including rhino, this Range needs enhanced management intervention.

The status of tiger in general was not encouraging in Valmiki TR as indicated by pug mark ER (0.1/km) and Frq.Occ. (7.1 ± 15.2, n = 16 transects, 61km), which are among the lowest in the entire TAL (Table 7.2). Tiger occurrence was patchy in the Reserve and was largely found in the Ganoli, Ragia and Govardhana Ranges that have better connectivity with Chitwan forests and had relatively higher prey base (Appendix VIII). During the survey, only one tiger pug mark in Manguraha Range and none in Harnatan and Chutaha Ranges was recorded. Harnatan and Chutaha Ranges, almost surrounded by settlements, have perhaps become unsuitable for tiger survival. Though evidences of human activity and cattle use were relatively lower inside the Reserve (Human ER: 1.8/km and Cattle ER: 0.1/km), poor habitat condition (Figure 4.3) including low prey availability (prey index 0.9, Table 7.2) possibly explains the low occurrence of tiger in Valmiki TR. However, the forest cover and species richness remains relatively superior as compared to several patches surveyed in Uttar Pradesh and it represents one of the last patches of forests having unique combination of *terai-bhabar* vegetation. With adequate protection, the current status of tiger here can be improved and that this Reserve may function as a buffer to Chitwan NP.

7.10 Bahraich and Shrawasti FDs (no tiger areas)

Forests in Bahraich and Shrawasti FDs are distributed in relatively small and isolated patches, surrounded by densely populated human habitations and are no more used by tigers. The isolated patches east of Katerniaghat WLD are under Bahraich FD and another isolated patch (Bhinga forest), south west of Suhelwa WLS, is under Shrawasti FD (Figure 2.1). It appears that tigers extirpated from these patches

only recently, substantiating the widely held observation that habitat fragmentation compounded with anthropogenic pressure cause local extinction of species. Leopard, however, used this area, though in small proportion (Frq.Occ: 8.3 ± 7.2, n = 3 transects, 6km). Among the prey species, only nilgai (Frq.Occ: 29.2 ± 31.5) and wild pig (Frq.Occ: 33.3 ± 7.2) were found, and these forest patches were under profuse anthropogenic pressures (Human ER: 4.5 ± 2.3, Cattle ER: 1.7 ± 1.5, Cattle Frq.Occ: 75.0 ± 43.3). Two years ago, a tiger reportedly strayed into the forests in Bahraich FD, close to Katerniaghat WLD. However, given the high human pressures and low prey availability, enabling tigers to breed and establish a population in Bahraich and Shrawasti FD is a remote possibility.

The above discussion clearly reveals that the tiger populations in TAL are in several fragments (nine THBs in India, and including Nepal, in five TUs) and wherever, the forests are in small patches with heavy anthropogenic pressure, the tigers have extirpated. Further, distributions of these populations are largely centered around one or two source populations receiving better habitat protection and management inputs. In the current scenario, tiger conservation in TAL needs to focus on two broad aspects. (i) Existing source populations must be protected and reinforced, and appropriate conditions in other potential areas need to be created for tigers to establish and expand viable populations. This would involve accurately estimating population size of tiger and prey species along with demographic characteristics and their spatial arrangement. (ii) Habitat connectivity needs to be established and strengthened between the fragmented tiger populations. It should be noted that movement of tigers between these subpopulations are presumably stray incidents, and there is uncertainty regarding the functional status of the corridors connecting these populations. Therefore, further investigations as to whether or not there has been genetic exchange between these populations and the status of the existing corridor are required. Answers to these questions would provide greater insights into conservation strategies and enable effective use of conservation funds. At the landscape scale, even within the fragmented populations (THBs or TUs), some of the forest patches are more crucial than the rest, and identifying these patches and undertaking appropriate management intervention(s) is of greater consequence to tiger conservation.

8. SUMMARY AND RECOMMENDATIONS

Tiger populations in TAL are in fragmented spatial units, distributed in nine THBs in the Indian side of TAL. Given the forest connectivities along the Indo-Nepal border, these THBs together with Nepal side of TAL areas constitute five larger units (Tiger Units or TUs) of varying sizes and configurations. The TU I, TU II and TU III are in the *bhabar* tract, largely in the state of Uttaranchal (India) and the other two are in *terai*. TU IV is largely in Nepal and TU V is distributed along Indo-Nepal border, covering parts of Uttar Pradesh, Nepal and Bihar. It was found that each TU has at least one key patch in which tigers have higher probability of persistence and can act as a source for adjoining patches in the landscape network. These key patches include the western portion of Rajaji NP in TU I, Corbett TR in TU II, Pilibhit FD-Sukhlaphanta Reserve-Kishanpur WLS-Dudhwa NP-Bardia NP in TU IV and Chitwan NP in TU V (Figure 2.2). The shape and configuration of most patches in these TUs are narrow rectangles, exposed to anthropogenic pressures and consequently, the effective area (potential habitat) available for tiger in TAL is only between 15 and 39%. The fact that TU V can harbor demographically viable population of tigers is only because of its contiguity with forests in Nepal, making it imperative to have joint Indo-Nepal efforts for long term survival of tiger here. An overview of habitat condition and status of tiger in TAL including its relationship with terrain, configuration of forests, associated species (prey species and leopard) and disturbance indicators are given below. Further, the areas where our conservation efforts need to be focused are highlighted, along with specific recommendations and potential implementing agencies.

8.1 Terrain, status of forests and tigers

The Indian side of TAL has two major forms of terrain (hilly *bhabar* and flat *terai*) and is under two broad levels of management status (Protected Areas and Reserve Forests/Non-PAs). There was distinct variation in human population density and forest cover in TAL, with *bhabar* having a human density of 334/km^2 and a forest cover of 36%, while the corresponding figures for *terai* are 436/km^2 and 17% respectively. Analysis of pug mark frequency of occurrence and encounter rates revealed that tiger occurrence is patchy and varies significantly across the Landscape, largely decided by prey availability, cover and disturbance levels. The overall pug mark frequency of occurrence and encounter rate in the hilly terrain (*bhabar*) that supports many deep *nallahs* offering hideouts to the tiger were 10.8 ± 16.6 (n = 167 transects, 617.3km) and 0.3 ± 0.4/km respectively. These estimates for *terai* were 13.8 ± 20.9 (n = 79 transects, 383.9km) and 0.3 ± 0.4/km respectively. Although the overall results dot no provide clear support to the general perception that tigers fare better in *bhabar* tract, data from four transects in Corbett TR (18.8km), the best in the entire study area in terms of prey availability and protection level, accounted for the highest pug mark encounter rate of 1.1/km (Frq.Occ: 41.2 ± 22.0), implying that if

disturbances are minimized or eliminated, most of the *bhabar* areas, with sufficient prey, have potential to support high densities of tiger.

In general, populations at the extreme end or the periphery of the range of a species are usually sparse (Hengeveld and Haeck 1982) and have a greater chance of going extinct (Beddington *et al.* 1976, Lawton 1995). More over, smaller populations are at a higher risk of extinction than larger ones, on account of greater vulnerability to demographic, genetic and environmental changes (Gilpin and Soule 1986), and other stochastic events. The situation in TAL is in concurrence with these views that areas at the periphery of the range (e.g. Kalesar and Simbalbara WLS) and those that are isolated and small (Sohagibarwa WLS, Shrawasti FD and Bahraich FD) have either lost the tiger or are in the process of losing it. Suhelwa WLS would also have lost its tiger population, but for its habitat connectivity along the Churia hills to Chitwan NP. Similarly, the survival of tiger in THB IX (Sohagibarwa east-Valmiki TR) is also due to its connectivity with Chitwan NP. While THB IX may continue to have tigers for a few more decades, the same can not be vouched for Suhelwa WLS, as the forest connectivities (Lamahi and Dovan bottlenecks) may not remain for long. In the western most part of TAL, occasional ranging of tigers in the forests, across Yamuna river (Kalesar and Simbalbara WLS), may cease to continue if appropriate conservation actions like banning boulder mining in Yamuna river and establishment of Rajaji-Shivalik TR are not initiated at the earliest.

Of the total forest area of Indian part of TAL (ca. 15,000 km^2), only 4640.6km^2 (31%) are under Protected Area status, whereas the rest are classified as Reserve Forests. The pug mark frequency and encounter rate in the PAs were 13.7 ± 21.8 and 0.3 ± 0.4 (n = 85 transects; 367km) respectively, which were 10.7 ± 15.8 and 0.3 ± 0.4 (n = 161 transects; 634.2km) for non-PAs/Reserved Forests. In spite of higher disturbance, tiger occurrence in the non-PAs is comparable with the PAs. The major reason for this could be that PAs and non-PAs are interspersed in such a way that Non-PAs greatly benefit from PAs.

8.2 Prey availability, disturbance and tigers

The spatial variation in ungulate distribution corresponds to the differences in terrain features and vegetation characteristics in TAL. The analysis has revealed that these prey species occupy distinct habitat units at a micro scale, and therefore, tiger conservation has to consider these diverse habitats. Sambar, goral and barking deer showed high affinity to hilly terrain, whereas swamp deer and hog deer are restricted to flat terrain mostly in the *terai*. Species such as chital and wild pig use both hilly and flat habitats, and because of their greater adaptability to diverse habitats, they are widely distributed in this Landscape. The differences in habitat choice exhibited by these ungulates are not confined only to this Landscape, such patterns have been widely observed across their distribution range (De and Spillett

1966, Schaller 1967, Seidensticker 1976a, Bhat and Rawat 1995). Sambar, chital and wild pig are the key prey species for tiger in the *bhabar* tract, while chital, swamp deer, hog deer and wild pig constitute the major prey base in *terai*. Besides poaching of these species, the fact that swamp deer and hog deer now have a much reduced range and are restricted to isolated localities (Rahmani *et al.* 1988, Sankaran 1990, Biswas and Mathur 2000) is a cause for concern. Studies have demonstrated that these two species contribute significantly to tiger diet in *terai* region (Seidensticker 1976a, Stoen and Wegge 1996). The findings clearly demonstrate that large wild ungulates with wider spatial distribution (e.g. chital) play a significant role in deciding the occurrence of tiger. Interestingly, the domestic dog has emerged as a reliable indicator of disturbance that negates tiger and prey occurrence. Therefore, monitoring protocols in the future should include domestic dog while designing strategies for discerning disturbance status in TAL forests.

8.3 Leopards shun *terai* and high tiger density areas

Social dominance, habitat structure and abundant prey in the smaller size classes are the three factors that play major roles in deciding the co-existence of tiger and leopard (Seidensticker 1976b). Due to the availability of escape terrain in the form of steep hill slopes and many climbable trees, and prey species such as sambar, chital, barking deer, goral, wild pig, porcupine and langur, leopards would be expected to hold ground against the socially dominant tiger in the *bhabar* tract. In the *terai*, in spite of optimal prey base (swamp deer, chital, hog deer, barking deer, wild pig, porcupine and langur), absence of steep hills and trees largely in the form of 'difficult to climb' sal trees, cause difficulties for leopards to coexist with tiger here. The field data corroborate these observations that presence of leopard and tiger was inversely related (Figure 8.1). Both leopard and tiger pug mark Frq.Occ. and ER were higher in *bhabar* tract (Leopard FO: 15.3 ± 16.3, ER: 0.3 ± 0.3; tiger Frq.Occ: 10.8 ± 16.6, ER: 0.3 ± 0.4), while in *terai*, leopard was poorly represented (Frq.Occ: 2.3 ± 6.2, ER: 0.05 ± 0.1) as compared to tiger (Frq.Occ: 13.8 ± 20.9, ER: 0.3 ± 0.4). Wherever tigers occur at high densities, they may spatially exclude leopards through social dominance (Seidensticker *et al.* 1990), which was very much in evidence for the *terai* habitats such as Pilibhit-Kheri and Dudhwa THBs (Figure 8.1). Interestingly, this was seen even in the high tiger density *bhabar* area. Eight transects (four in Rajaji NP and four in Corbett TR) covering 38.8km had a tiger pug mark ER of 0.85/km, which is much higher than leopard pug mark ER (0.23/km). Significantly, the ER obtained for leopard in these transects was relatively lower than the estimate for entire *bhabar* tract (Table 7.1). Of the 122 transects (464.1km) where there was no tiger pug marks, leopard pug mark ER was 0.3/km, higher than the ER recorded for the entire TAL (0.2 ± 0.3/km). These areas also had high human and cattle ERs (4.1/km and 7.8/km) and high frequency of dog occurrence (21.8 ± 30.2), implying that leopard can tolerate disturbance and/or they are forced to such areas by tiger.

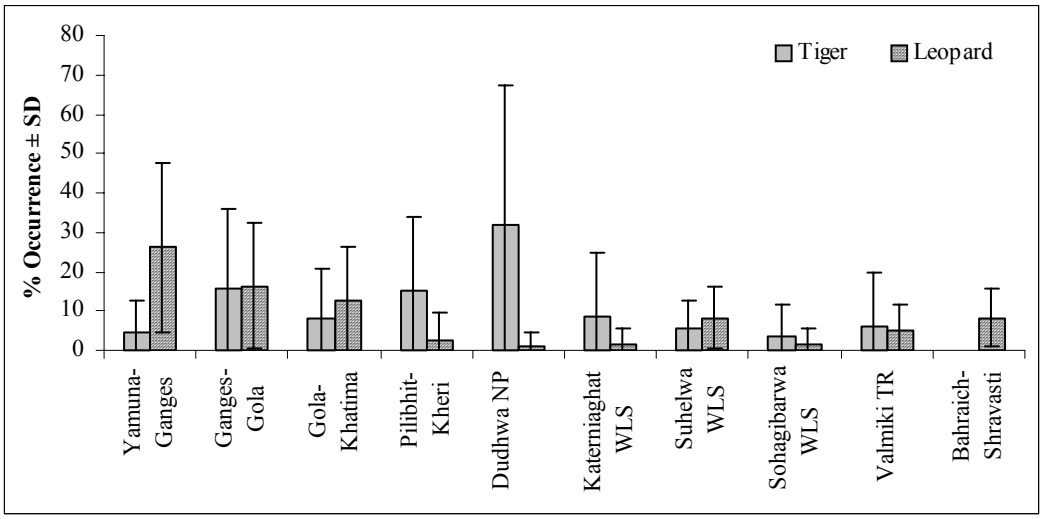


Figure 8.1: Frequency of occurrence of tiger and leopard across THBs

It is, therefore, plausible that in the event of tiger decline and continued availability of sufficient prey, leopard may expand its range and increase in abundance in these areas.

8.4 Where should the conservation efforts be focused in TAL?

Although every small population of tiger deserves maximum conservation inputs, it will be prudent to focus our efforts between Yamuna and Sharda rivers, covering THBs I (Yamuna-Ganges), II (Ganges-Gola), III (Gola-Khatima) and IV (Pilibhit-Kheri). The THBs (I, II & III) in the *bhabar* tract will constitute the largest contiguous tiger habitat of ca. 8,000km^2 anywhere along the foothills of the Himalaya, provided Chilla-Motichur and Gola river corridors are established, and Rajaji-Corbett and Nihal Bhakhra corridors are protected and strengthened. Similarly, one of the largest and finest *terai* habitats could be secured for tiger if strong connectivity is established between Pilibhit FD-Kishanpur WLS and Sukhlaphanta Reserve, Nepal. When compared to *terai* habitats, the western part of TAL has less people and more forest cover, but suffers from the growth of many large towns that exert enormous pressure on the forests. In addition, growth of habitations and encroachments (e.g. Ramnagar and Khatima Ranges), boulder mining, unrestricted use of forests for firewood, fodder and *bhabar* grass, and infrastructural development (widening and building more roads and increasing the frequency of trains) may gradually negate the advantage that the *bhabar* tract currently holds. Although this area supports significant populations of elephants (ca. 800), it has already experienced local extinctions of rhino and swamp deer due to various anthropogenic factors. Tiger conservation in this *bhabar* tract should accord adequate attention to Corbett TR, one of the finest reserves in Asia, which arguably functions as source population of tiger for western part of TAL.

Unlike the western most part of TAL, THB IV is free from large towns, and shifting course of Sharda river maintains patches of shrub and tall grass along the banks, enabling occasional movement of large mammals between Sukhlaphanta Reserve and Pilibhit FD-Kishanpur WLS. The major challenge in this area lies in creating a functional corridor between Lagga Bagga- Sukhlaphanta and Pilibhit FD-Kishanpur WLS. The efforts already underway in this area by the Forest Department and WWF-India should continue and need further intensification. Immediate conservation efforts are required in the Basanta corridor area to establish the connectivity between Dudhwa NP and Basanta forests in Nepal.

8.5 Recommendations

Based on the study findings and interactions with Forest Staff and others involved in the conservation of TAL, we propose the following specific measures along with potential implementing agencies for tiger conservation in TAL. We also recognize that there are several NGOs locally active across TAL and it would be useful to explore and involve such agencies for specific purposes.

Controlling of poaching

Poaching, although could not be quantified, is certainly a factor contributing to the status of tiger and prey base in TAL, and needs to be brought under control (Appendix X). The measures suggested by Johnsingh and Negi (2003), such as replacing the guns belonging to people around tiger habitats with specially made guns that cannot be used for poaching, giving substantial rewards to persons who apprehend poachers and recruiting and training staff for protection are useful in this direction. The involvement of local people, through conservation education and conservation programmes, is critical in bringing about their transformation, from being providers of expertise and logistical assistance to poachers, to protectors of wildlife. Employment opportunities need to be created for *kanjars* and persuade *rai sikhs* to give up poaching.

There might be a necessity to restructure the existing set up of Forest Department on the lines of police personnel, operating in a team, so that Forest Staff get required support and infrastructure to carry on patrolling and other anti-poaching and habitat protection activities. By doing so, the apprehensions of certain staff being targeted by poachers would be removed and their safety (including family) is taken care of, which are prerequisite for efficient protection measures. Many of the Range Officers interviewed in the field expressed a similar view. **Agencies:** Government of India; Government of Nepal; State Governments of Himachal Pradesh, Haryana, Uttaranchal, Uttar Pradesh and Bihar; WWF-India; Wildlife Protection Society of India.

Reclaim land and prevent encroachment

There is a dire need to remove encroachments at least from some crucial areas to arrest the growing threat to wildlife habitats (e.g. Sundar Khal in Ramnagar FD; Belha in Pilibhit FD) and to establish corridors (e.g. Kilpura-Khatima-Surai corridor) (Appendix XI). This would require an immediate attempt to map encroachments in the entire TAL. Intervention of **Central Empowered Committee** (CEC), constituted by the Supreme Court of India, should be sought to evict encroachments. **Agencies:** Government of India; Governments of Uttaranchal and Uttar Pradesh; Forest Department; Revenue Department; local NGOs.

Raising of fuel wood plantations and distribution of fuel-efficient *chulas*

Firewood demand in the TAL area, particularly during winter, is enormous. It is, therefore, necessary to raise fuel wood plantations in Reserve Forests and even along the periphery of Protected Areas to meet the firewood needs of the adjoining population. The people around TAL forests should be provided with fuel-efficient *chulas* and encourage their use, so that the pressure on the natural forest would be gradually reduced. **Agencies:** Government of India; Government of Nepal; Governments of Himachal Pradesh, Haryana, Uttaranchal, Uttar Pradesh and Bihar; WWF-India; Forest Research Institute; The Energy and Research Institute (TERI); Wildlife Institute of India.

Relocation of villages and industries

Gangabhogpur Talla and Malla villages and Kunaun *goth* (total number of families 250) on the east bank of Ganga river need to be translocated, which should be possible since there is land available for these people in Barkot Range of Dehradun FD. Ringora and Amdanda villages, and Tedha villages (these three villages originated as cattle camps and now have about 80 families) located on the west and east banks of Kosi river respectively should be translocated and the Gabua forest block (13 km^2) in Terai West FD is one such area available for resettlement. The Indian Medicines Pharmaceutical Corporation Limited on the west bank of Kosi river could be shifted closer to Ramnagar town, about 15km away from the present location of the factory, as most of its 200 or so employees come from this town. Gargia Chemicals (situated close to the Pharmaceutical Corporation) where less than 10 people work now, should be immediately closed. Otherwise, there is a danger of this area developing into an industrial complex.

Relocation of Laldhang village (100 families) on the southern boundary of Corbett TR, initiated in 1994, should be completed at the earliest. Most families have already moved to the relocation site in the Terai West FD. The population of Bharthapur (100 families), in the trans-Girwa area of Katerniaghat WLD, should be encouraged to move out to one of the isolated south-western forest patches in the

Kakraha Range. **Agencies:** Government of India, Central Empowered Committee, Governments of Uttaranchal and Uttar Pradesh, WWF-India, Wildlife Protection Society of India, Wildlife Trust of India, Centre for Environment Education, Wildlife Institute of India.

Improve trans-border cooperation

The Indo-Nepal border is a hotbed for smuggling of wildlife products and poaching. Concerted efforts of both the countries (India and Nepal) and all the border States (Uttaranchal, Uttar Pradesh and Bihar) are needed to curb all illegal activities. Such efforts are also required to strengthen corridors (e.g. Kilpura-Khatima-Surai, Lagga Bagga–Sukhlaphanta–Tatarganj and Dudhwa–Katerniaghat). **Agencies:** Government of India; Government of Nepal; Governments of Uttaranchal, Uttar Pradesh and Bihar; WWF-India; WWF-US (Nepal Program); Wildlife Protection Society of India; Wildlife Trust of India; Wildlife Institute of India.

Establishment of Chilla-Motichur and Gola river corridors

The decision to establish Chilla-Motichur corridor was made in 1984, but since then, regretfully, there has been very little progress. Shifting of the Army ammunition dump, resettling of Khand *Gaon* III village, freeing of islands on the Ganga from encroachers, and building a fly-over between Haridwar and Raiwala for vehicular traffic, are essential to establish this corridor. Establishment of the Gola river corridor will require enormous political will. This includes shifting the Uttaranchal Government timber depot, totally banning boulder mining between Haldwani and Lalkuan, and afforesting the degraded habitats between the Doli Range of Terai East FD and Tanda Range of Terai Central FD. **Agencies:** Government of India, Central Empowered Committee, Indian Army, Government of Uttaranchal, WWF-India, Wildlife Protection Society of India, Wildlife Trust of India, Wildlife Institute of India.

Ban boulder and sand mining in crucial wildlife corridors

Some of the crucial areas (e.g. Yamuna, Rawason and Gola rivers) are under extensive human activities, causing disruption to animal movement (Appendix XII). Boulder and sand mining rapidly accelerates the process of fragmentation and degradation, but it could be permitted in locations like the stretch of Song river north of Doiwala, far away from tiger habitats. Intervention of the **Central Empowered Committee** should be sought in this regard. **Agencies:** Government of India, Central Empowered Committee, Government of Uttaranchal, WWF-India, Wildlife Trust of India, Wildlife Protection Society of India, Wildlife Institute of India.

Resettle the *gujjars* in fringe forest areas

The lifestyle of *gujjars* residing within forests is incompatible with wildlife conservation. Following the resettlement model of Ghaindikatha (where *gujjars* have been resettled in fringe forest areas), the *gujjars* from Yamuna to Sharda river should be resettled. The ongoing recovery of Chilla Range after *gujjar* resettlement should inspire us to accomplish this recommendation with greater vigor. Land for Shivalik FD *gujjars* could be found in Bijnor Plantation Division. **Agencies:** Government of India, Central Empowered Committee, Government of Uttaranchal, WWF-India, Wildlife Trust of India, Wildlife Protection Society of India, local NGOs; Wildlife Institute of India.

Wean people from *bhabar* grass collection

This needs to be done on a priority basis, as the grasscutters wander throughout winter, collecting *bhabar* grass, disturbing habitats and stealing fresh tiger and leopard kills whenever they locate them. These people are known to use jungle crows (*Corvus macrorhynchos*), which look for and feed on kills, for locating kills. It should be taken cognizance of that these grasscutters live in abysmal poverty, and may earn Rs. 1200-1500 (US$25-30) annually from *bhabar* grass, and any programme to wean them should have a great concern for them and should have an acceptable alternative. **Agencies:** Government of India, Government of Uttaranchal, WWF-India, Wildlife Protection Society of India, Wildlife Trust of India, local NGOs; Wildlife Institute of India.

Monitor habitat and wildlife populations

The previous sections on habitat, tiger and prey base provide the baseline (both empirical data and methods) for initiating monitoring programmes in TAL. Besides the circular plots sampled during this survey, monitoring of habitats by establishing one hectare plots in PAs and FDs would be important. Changes in habitat conditions at landscape level could be ascertained using Remote Sensing and GIS. Monitoring of ungulates should be done along line transects, by counts along roads and pellet counts. The strategies adopted in this study could be improved by carrying out repeated measures on the same sampling units (trails/transects). Space use by tiger and other carnivores (leopard and sloth bear) could be assessed by monitoring the tracks and other signs along the transects and trails. However, it would be necessary to use advanced field (e.g. camera trap) and analytical (e.g. capture and recapture models) methods for detecting the change at population level. Following the Nepal model, recording and monitoring other biodiversity components (birds, mammals, insects and fish fauna, etc) would add value to the landscape units. **Agencies:** Forest Departments of Himachal Pradesh, Haryana, Uttaranchal, Uttar Pradesh and Bihar, Indian Institute of Remote Sensing, Forest Survey of India, Aligarh Muslim University, WWF- India, Wildlife Trust of India, Wildlife Institute of India.

Conservation education and awareness

Unless the local people recognize the significance of wildlife values of their immediate surrounding and the Landscape as a whole, implementing many of the recommendations that involve local participation would not yield desirable success. Both local and national media, print (news paper and magazines) and electronic (radio and TV), should extensively be made use of in highlighting the issues concerning the Landscape and the people. Involvement of local college students, specifically 2nd year undergraduates, for awareness campaign and wildlife monitoring would be effective. Not only would they get to understand the issues, but also form an valuable resource for spreading the conservation message. The preference for second year students is on account of them being better familiarized with the issues their seniors would have been exposed to and a relatively less demanding academic calendar. Carefully planned ecotourism would be a viable option for creating awareness among the people. **Agencies:** Centre for Environment Education; Garhwal University; Kumaon University; Pant Nagar University; WWF-India; Wildlife Institute of India and other local colleges and NGOs.

8.6 Strategies evolved in TAL Workshop

Following the mandate of the project, a workshop was organized at the Wildlife Institute of India on 6-7 November 2003, with the objective of sharing the research findings with the Forest Department, NGOs and various institutions involved in TAL conservation. The workshop was also used as a medium to plan strategies and to stimulate concerted efforts to carry on conservation activities in the field. The participants (Appendix XIII), forming four groups, deliberated on (i) people-related issues, (ii) habitat-related issues, (iii) Indo-Nepal border current conservation scenario & cooperation, and (iv) conservation of tiger and its prey.

The people-related group stressed on the need for context-specific socio-economic programmes, including capacity building of all the stakeholders, and reiterated the need for long-term interventions for making any significant mitigatory impact on the diverse human-wildlife interface conflicts being experienced across the TAL. Experiences of the Nepal TAL programmes need to be examined carefully, in order to provide meaningful insights for the Indian TAL initiatives.

The habitat-related issues group recognized the Tiger Habitat Blocks (THBs) identified by this study to be taken as basic conservation units in the Indian TAL. They specifically highlighted the need to (i) maintain, restore and monitor habitat quality and quantity, (ii) strengthen linkages between these habitat blocks, (iii) identify functional corridors and relevant corridor characteristics, and (iv) identify and recognize riverine habitats that often provide habitat connectivity (e.g. Lagga Bagga-Tatarganj-Chuka, and Mohana and Suheli rivers between Dudhwa NP and Katerniaghat WLD).

The third group identified stakeholders at various levels in India and Nepal involved with the TAL programme. They stressed upon the need for coordinated governance, research and monitoring, and through this, address trans-boundary issues such as (i) identification of connectivity of wildlife habitats, (ii) illegal trade – poaching, timber and forest produce smuggling, and (iii) impacts of large-scale development projects. They specifically suggested holding direct meetings of field enforcement staff at borders with appropriate encouragement from the center, coordinated research and joint monitoring programmes, devise mechanisms to avoid overlap (donors, facilitated by NGOs), exchange visits and sharing programs at field level (ministries & NGOs at appropriate levels), develop joint funding strategies especially at NGO level, increase enforcement staff presence at sensitive areas, train and apply important skills to transboundry staff, transboundary Environment Impact Assessment to be made mandatory for development projects, and day-to-day information sharing of animal movements such as elephants and rhinos.

The fourth group also recognized the nine THBs as basic conservation units and reinforced the conservation measures suggested by other groups at the landscape level. The specific issues considered important and urgent are; (i) controlling poaching of tiger and prey, and to do this, the group suggested that a database needs to be created to identify the affected areas and reasons for poaching, and efforts need to be prioritized accordingly, (ii) identify source and sink, and isolated populations within the Landscape, and activate or strengthen conservation efforts, (iii) employ scientifically conceived monitoring protocols for tiger and prey, and suggested that besides the data collected from this project, the tiger and prey populations need to be estimated with adequate confidence so that monitoring of these populations would be unbiased, and (iv) monitor health condition of wildlife in TAL.

All the participants unanimously agreed that Forest Department should co-ordinate, facilitate and spearhead all the conservation programmes in TAL with the able assistance of all identified agencies.

REFERENCES

Anon, 1991. Census of India 1991. Office of the Registrar General, India, New Delhi.

Agni, T., Pandit, A., Pandit, K., Tiwari, A., 2000. Analysis of tree vegetation in the *terai-bhabar* tract of Kumaun central Himalaya. Indian Journal of forestry 23, 252-261.

Atkinson, E.T., 1882. Geology of the Himalayas. Cosmo Publications, New Delhi.

Augustine, D.J., McNaughton, S.J., 1998. Ungulate effects on the functional species composition of plant communities: herbivore selecting and plant tolerance. Journal of Wildlife Management 62, 1165-1183.

Badola, R., 1998. Attitudes of local people towards conservation and alternatives to forest resources: a case study from the lower Himalayas. Biodiversity and Conservation 7, 1245-1259.

Bagchi, S., Goyal, S.P., Sankar, K., 2003. Prey abundance and prey selection by tigers (*Panthera tigris*) in a semi-arid, dry deciduous forest in western India. Journal of Zoology 260, 285-290.

Beddington, J.R., Free, C.A., Lawton, J.H., 1976. Concepts of stability and resilience in predator-prey models. Journal of Animal Ecology 45, 791-816.

Bhadauria, R.S., Singh, A.N., 1994. Cyclic pattern of predation on domestic livestock by the tigers of Corbett National Park, U.P., India. Tiger paper 21, 5-7.

Bhat, S.D., Rawat, G.S., 1995. Habitat use by chital (*Axis axis*) in Dhaulkhand, Rajaji National Park, India. Tropical Ecology 36, 177-189.

Bhat, S.D., Rawat, G.S., 1999. Some food plants of chital (*Axis axis*) in RNP, India. Journal of the Bombay Natural History Society 96, 467-468.

Bhatta, S.R., Bajimaya, S., Janawali, S.R., 2002. Status, distribution and monitoring of tigers in protected areas of Terai Arc Landscape-Nepal. A photographic documentation of camera-trapped tigers. WWF Nepal Programme.

Biswas, S., Sankar, K., 2002. Prey abundance and food habit of tigers (*Panthera tigris tigris*) in Pench National Park, Madhya Pradesh, India. Journal of Zoology 256, 411-420.

Biswas, T., Mathur, V.B., 2000. A review of the present conservation scenario of hog deer (*Axis procinus*) in its native range. Indian Forester 126, 1068-1084.

Champion, H.G., Seth, S.K., 1968. A revised survey of forest types of India. Government of India, New Delhi.

Chaturvedi, A.N., Misra, C.M., 1985. Ecological survey of grasslands at Dudhwa National Park. Indian Forester 111, 579-582.

De, R.C., Spillett, J.J., 1966. A study of chital in Corbett National Park, Uttar Pradesh. Journal of the Bombay Natural History Society 63, 576-598.

Dhungel, S.K., O'Gara, B.W., 1991. Ecology of the hog deer in Royal Chitwan National Park, Nepal. Wildlife Monograph, the Wildlife Society.

Dinerstein, E., 2003. Return of the unicorns: the natural history and conservation of the Greater One-Horned Rhinoceros. Columbia University Press.

Dinerstein, E., 1979a. An ecological survey of Royal Karnali-Bardia Wildlife Reserve, Nepal. Part I: vegetation, modifying factors and successional relationships. Biological Conservation 15, 127-149.

Dinerstein, E., 1979b. An ecological survey of Royal Karnali-Bardia Wildlife Reserve, Nepal. Part II: Habitat/Animal interactions. Biological Conservation 16, 265-300.

Dinerstein, E., Gyawali, S.R., 1993. Greater one-horned rhinoceros populations in Nepal. In: Ryder, O. A. (Ed.), Rhinoceros Biology and Conservation. San Diego Zoological Society, San Diego, CA, pp.196-207.

Dinerstein, E., Wemmer, C.M., 1988. Fruits rhinoceros eat: dispersal of *Trewia nudiflora* (Euphorbiaceae) in lowland Nepal. Ecology 69, 1768-1774.

Dinerstein, E., 1980. An ecological survey of the Royal Karnali-Bardia Wildlife Reserve, Nepal. Part III: ungulate populations. Biological Conservation 18, 5-38.

Dinerstein, E., Wikramanayake, E., Robinson, J., Karanth, U., Rabinowitz, A., Olson, D., Mathew, T., Hedao, P., Connor, M., Hemley, G., Bolze, D., 1997. A framework for identifying high priority areas and actions for the conservation of tigers in the wild. World Wildlife Fund, USA.

Eisenberg, J.F., Seidensticker, J., 1976. Ungulates in southern Asia: a consideration of biomass estimates for selected habitats. Biological Conservation 10, 293-305.

Flint, E.P., 1998. Deforestation and land use in northern India with a focus on sal *(Shorea Robusta)* forests. In: Grove, R.H., Damodaran, V. and Satpal, S. (Eds.), Nature and the orient: the environmental history of south and southeast Asia. Oxford University Press, New Delhi, pp. 421-458.

Forest Survey of India, 2001. State of Forest Report. 2001. Ministry of Environment & Forests, Government of India.

Frohn, R.C., 1998. Remote sensing for landscape ecology; new metric indicators for monitoring, modeling and assessment of ecosystems. Lensis Publishers. London.

Gill, R.M.A., Beardall, V., 2001. The impact of deer on woodlands: the effects of browsing and seed dispersal on vegetation structure and composition. Forestry 74, 209-218.

Gilpin, M.E., Soule, M.E., 1986. Minimum viable populations: Process of species extinctions. In: Soule, M.E., (Ed.), Conservation Biology: The science of Scarcity and diversity. Sinauer Associates. Sunderland. Massachussets, pp. 19-34.

Gupta, A.K. and Kumar, A. 1994. Feeding ecology and conservation of the Phayre's monkey (*Presbytis phayrei*). Biological Conservation 69, 301-306.

Habib, I., 1999. The agrarian system of Mughal India, 1556- 1707. 2nd revised edition, Oxford University Press, New Delhi, pp. 11-22.

Hajra, A., 2002. An ecological study of the vegetation and wildlife habitats in and around Rajaji-Corbett corridor area. PhD Thesis, Forest Research Institute, Dehradun.

Hengeveld, R., Haeck, J., 1982. The distribution of abundance – I measurements. Journal of Biogeography 9, 303-316.

Hester, A.J., Edwnius, L., Buttenschon, R.M., Kuiters, A.T., 2000. Interaction between forest and herbivores: the role of controlled grazing experiments. Forestry 73, 381-391.

Hobbs, N.T., 1996. Modification of ecosystems by ungulates. Journal of Wildlife Management 60, 695-713.

Holloway, C., 1973. Swamp deer in Uttar Pradesh. Oryx 12, 41-48.

Jackson, P., 1997. The status of the tiger in 1997 and threats to its future. Cat News 27, 8-10.

Javed, S., 1996. Elephants in Dudhwa. Gajah 16 (July), 17-22.

Javed, S., Qureshi, Q., Rahmani, A.R., 1999. Conservation status and distribution of swamp francolin in India. Journal of the Bombay Natural History Society 96, 16-23.

Johnsingh, A.J.T., 1983. Large mammalian prey-predators in Bandipur. Journal of Bombay Natural History Society 80, 1-57.

Johnsingh, A.J.T., 2001. The story of Goral: A mountain Goat. Hornbill (October-December), 22-29.

Johnsingh, A.J.T., 2002. Establishment of Chilla-Motichur corridor for elephant and tiger movement. Wildlife Institute of India Newsletter (Winter 2001& Spring 2002), 1-3.

Johnsingh, A.J.T., Joshua, J., 1994. Conserving Rajaji and Corbett National Parks-the elephant as a flagship species. Oryx 28, 135-140.

Johnsingh, A.J.T., Negi, A.S., 2003. Status of tiger and leopard in Rajaji–Corbett Conservation Unit, northern India**.** Biological Conservation 111, 385-393.

Johnsingh, A.J.T., Negi, A.S., 1998. Only disturbance-free well-managed habitats can save the tiger. Cat News 28, 4.

Johnsingh, A.J.T., Ramesh, K., Ashish David, K. Rajapandian, K., Dhananjai Mohan. *In press*. Enabling tigers survive in Haryana and Himachal Pradesh. In: A look at threatened species. Proceedings of the Journal Centenary Seminar, 12-15 November, 2003, Bombay Natural History Society, Mumbai.

Johnsingh, A.J.T., Ramesh, K., Dhananjai Mohan, Qamar Qureshi, Goyal, S.P., Rawat, G.S., Samir Sinha, Rajapandian, K., 2003. Saving the tiger in the extreme north-west of its range. Cat News 38,11-13. IUCN Cat Specialist Group, Bougy, Switzerland.

Johnsingh, A.J.T., Prasad, S.N., Goyal, S.P., 1990. Conservation status of Chilla-Motichur corridor for elephant movement in Rajaji-Corbett National Parks. Biological Conservation 51, 125-138.

Joshi, A. R., Garshelis, D.L., Smith, J.L.D., 1995. Home ranges of sloth bears in Nepal: Implications for conservation. Journal of Wildlife Management 59, 204-214.

Joshi, A. R., Garshelis, D.L., Smith, J.L.D., 1997. Seasonal and habitat-related diets of sloth bears in Nepal. Journal of Mammology 78, 584-597.

Joshi, A. R., Smith, J.L.D., Garshelis, D.L., 1999. Sociobiology of the myrmecophagus sloth bear in Nepal. Canadian Journal of Zoology 77, 1690-1704.

Joshi, A.P, Sundriyal, R.C., Negi, S.S., 1986. Association in between different tree species of Siwalik forest (Garhwal Himalaya). Journal of Tree Sciences 5, 65-66.

Joshua, J., Johnsingh, A.J.T., 1995. Ranging patterns of elephants in Rajaji National Park: Implications for reserve design. In: Daniel, J.C., Datye, H.S. (Eds.), A week with elephants. Proceedings of the International seminar on the Conservation of Asian Elephant held in Mudumalai Wildlife Sanctuary, South India, 13-15 June 1993, pp. 256-260

Karanth, K.U., Stith, B.M., 1999. Prey depletion as a critical determinant of tiger population viability. In: Seidensticker, J., Christie, S., Jackson, P. (Eds.), Riding the Tiger, Tiger conservation in human dominated landscapes. The Zoological Society of London, Cambridge University Press, Cambridge, pp.100-113.

Karanth, K.U., Sunquist, M.E., 1992. Population structure, density and biomass of large herbivores in the tropical forests of Nagarhole, India. Journal of Tropical Ecology 8, 21-35.

Karanth, K.U., Sunquist, M.E., 1995. Prey selection by tiger, leopard and dhole in tropical forests. Journal of Animal Ecology 64, 439-450.

Karanth, K.U., Sunquist, M., Chinnappa, K.M., 1999. Long-term monitoring of tigers: lessons from Nagarhole. In: Seidensticker, J., Christie, S., Jackson, P. (Eds.), Riding the Tiger, Tiger conservation in human dominated landscapes. The Zoological Society of London, Cambridge University Press, Cambridge, pp.114-122.

Karanth, K. U., Nichols, J.D., Seidenstricker, J., Dinerstein, E., Smith, D., Mcdougal, C., Johnsingh, A.J.T., Chundawat, R.S., Thapar, V. 2003. Science deficiency in conservation practice: the monitoring of tiger populations in India. Animal Conservation, 6 (2), pp. 141 – 146.

Khati, D.V.S., 1993. Problems in paradise: *Gujjars* in conflict with Rajaji. Sanctuary 8, 16-22.

Kumar, H., Mathur, P.K., Lehmkuhl, J.F., Khati, D.S., De, R., Longwah, W., 2002. Management of forests in India for biological diversity and forest productivity, a new perspective. Volume VI – Terai conservation area. WII-USDA Forest Service collaborative project report, Wildlife Institute of India, Dehradun.

Laurie, A., Seidensticker, J., 1977. Behavioural ecology of the sloth bear (*Melursus ursinus*). Journal Zoology 182, 187-204.

Laws, J.W., Laws, V.H.J., 1984. Social interactions among adult male langurs (*Presbytis entellus*) at Rajaji Wildlife Sanctuary. International Journal of Primatology 5, 31-50.

Lawton, J.H., 1995. Population dynamic principles. In: Lawton, J.H., May, R.M. (Eds.), Extinction rates. Oxford University Press, Oxford, pp. 147-163.

Lindburg, D.G., 1977. Feeding behaviour and diet of rhesus monkeys (*Macaca mulatta*) in a Siwalik forest in north India. In: Clutton-Brock (Ed), Primate Ecology: studies of feeding and ranging behaviour in lemurs, monkeys and apes, Academic Press, London, pp. 223 – 249.

Makwana, S. C., 1979. Field ecology and behaviour of the rhesus macaque, *Macaca mulatta*. II. Food, feeding and drinking in Dehra Dun forests. Indian Journal of Forestry 2, 242-253.

McGarigal, K., Masks, B.J., 1995. Fragstats: Spatial pattern analysis program for quantifying landscape structure. Gen. Tech Report PNW-GTR-351, USDA Forest Science Pacific Northwest Research Station, Portland.

Mishra, G.C., 1989. Rhino rehabilitation in Dudhwa National Park. Van Vigyan 27, 60-64.

Mishra, H.R., Wemmer, C., 1987. The comparative breeding ecology of four cervids in Royal Chitwan National Park. In: Wemmer, C. (Ed.), Biology and management of the Cervidae. Smithsonian Institution Press, Washington, D. C, pp.259-271

Moe, S. R., Wegge, P., 1994. Spacing behaviour and habitat use of axis deer (*Axis axis*) in lowland Nepal. Canadian Journal Zoology 72, 1735-1744.

Moe, S. R., Wegge, P., 1997. The effects of cutting and burning on grass quality and axis deer (*Axis axis*) use of grassland in lowland Nepal. Journal of Tropical Ecology 13, 279-292.

Naoroji, R., 1997a. Contamination in egg shells of Himalayan grey headed fishing eagle *Ichthyophaga nana plumbea* in Corbett National Park, India. Journal of the Bombay Natural History Society 94, 398-400.

Naoroji, R., 1997b. First breeding record of the collared falconet *Microhierax caerulescens* for the Indian subcontinent in Corbett National Park, Uttar Pradesh. Journal of the Bombay Natural History Society 94, 267-272.

Naoroji, R., 1999. Status of diurnal raptors of Corbett National Park with notes on their ecology and conservation. Journal of the Bombay Natural History Society 96, 387-398.

Opdam, P., Verboom, J., Pouwels, R., 2003. Landscape Cohesion; an index for the conservation potential of landscapes for biodiversity. Landscape Ecology 18, 113-136.

Pandey, S., Joshua, J., Rai, N.D., Mohan, D., Rawat, G.S., Sankar, K., Katti, M.V., Khati, D.V.S., Johnsingh, A.J.T., 1994. Birds of Rajaji National Park, India. Forktail 10, 105-114.

Pant, A., Chavan, S.G., 2000. Vegetation type and land use mapping in Corbett National Park using satellite data. Environmental Ecology 18, 976-983.

Panwar, H.S., 1985. The Planning and Management of Protected Areas in the Indo-Malayan Realm. In: Thorsell, J.W. (Ed.), A study of management requirements in Corbett National Park. Conserving Asia's Natural Heritage, pp.169-176.

Pendharkar, A.P., Goyal, S.P., 1995. Group size and composition of gray goral in Simbalbara sanctuary and Darpur reserved forest, India. Journal of Mammalogy 76, 906-911

Pirta, R.S., Prakash, P., Singh, M., 1980. A population study of two species of non-human primates: *Macaca mulatta* and *Macaca radiata.* Journal of the Bombay Natural History Society 77, 429-434.

Rahmani, A.R., Narayan, G., Sankaran, R., Rosalind, L., 1988. The Bengal Florican. Annual Report 3. Bombay Natural History Society, Bombay.

Rahmani, A.R., Narayan, G., Posalind, L., Sankaran, R., Ganguli, U., 1989. Status of the Bengal Florican, *Houbaropsis bengalensis* in India. Journal of the Bombay Natural History Society 88, 349-375.

Rajvanshi, A., Mathur, V.B., Teleki, G., Mukherjee, S.K., 2001. Roads, Sensitive Habitats and Wildlife: Environmental Guidelines for India and South Asia. Wildlife Institute of India and Canadian Environmental Collaborative limited Publication.

Randhawa, M.S., 1986. A history of agriculture in India, volume IV (1947 – 1981). Indian Council of Agricultural Research, New Delhi.

Rawat, G.S., Goyal, S. P., Johnsingh, A.J.T., 1997. Ecological Observations on the grasslands of Corbett Tiger Reserve, India. Indian Forester 123, 958-963.

Rodgers W.A., Rawat, G.S., Srivastava, J.L., 1990. The vegetation of western Rajaji National Park: floristic and community analysis. Wildlife Institute of India, Dehradun.

Rodgers, W.A., Panwar, H.S., 1988. Planning wildlife Protected Area network in India, volume II. Wildlife Institute of India, Dehradun.

Rookmaaker, K., 1999. The rhinoceros of Kotdwara. Hornbill (July-September), 9.

Sale, J.B., 1986. Rhinos reestablished in Uttar Pradesh. Indian Forester 112, 945-948.

Sale, J.B., Singh, S., 1987. Reintroduction of greater Indian rhinoceros into Dudhwa National Park. Oryx 21, 81-84.

Sankaran, R., 1990. Status of Swamp deer *Cervus duvauceli duvauceli* in the Dudhwa National Park, Uttar Pradesh. Journal of the Bombay Natural History Society 87, 251-259.

Schaaf, C.D., 1978a. Population size and structure and habitat relations of the barasingha (*Cervus duvauceli duvauceli*) in Sukla Phanta Wildlife Reserve, Nepal. MS. Diss. Michigan State University.

Schaaf, C.D., 1978b. Some aspects of the ecology of the swamp deer or barasingha (*Cervus duvauceli duvauceli*) in Nepal. Proc. IUCN Deer Specialist Group, Longview Washington State.

Schaaf, C.D., Singh, A., 1976. Barasingha in the Dudhwa Sanctuary. Oryx 13, 495-498.

Schaller, G.B., 1967. The deer and the tiger: a study of wildlife in India. University of Chicago Press, Chicago.

Seidensticker, J. 1976a. Ungulate population in Chitwan valley, Nepal. Biological Conservation 10, 183-210.

Seidensticker, J. 1976b. On the ecological separation between tigers and leopards. Biotropica 8, 225-34.

Seidensticker, J., Sunquist, M. E., McDougal, C., 1990. Leopards living at the edge of the Royal Chitwan National Park, Nepal. In: Daniel, J.C., Serrao, J.S. (Eds.), Conservation in developing countries: Problems and prospects. Oxford University Press, Bombay, India, pp.415-423.

Seidensticker, J., Christie, S., Jackson, P. (Eds.), 1999. Riding the tiger: tiger conservation in human dominated landscapes. Cambridge University Press, Cambridge.

Seidensticker, J., Christie, S., Jackson, P., 1999. Tiger ecology: understanding and encouraging landscape patterns and conditions where tigers can persist. In: Seidensticker, J., Christie, S., Jackson, P. (Eds.), Riding the tiger: tiger conservation in human dominated landscapes. The Zoological Society of London, Cambridge University Press, Cambridge, pp.55-60.

Sharma, K.K., 1995. Parks, policy and people: a case study of Rajaji National Park. Administrator 60, 183-200.

Singh, A., Reddy, V.S., Singh, J.S., 1995. Analysis of woody vegetation of Corbett National Park India. Vegetatio 120, 69-79.

Singh, A., 1971. The tiger of the *terai* with special reference to the Kheri forests of Uttar Pradesh, India. IUCN Publications. New Series 18, 55-56.

Singh, A., 1973. Tiger haven. (Ed. John Moorehead.) Harper and Row Publishers, New York.

Singh, A., 1978. The Status of the swamp deer *Cervus duvauceli duvauceli* in the Dudhwa National Park. Peter Scott, Chairman. Threatened Deer. IUCN, Morges, Switzerland.

Singh, A., 1981. Tara: a tigress. (Ed. John Moorehead.) Quartet Books, London.

Singh, A., 1982. Prince of cats. B.I. Publications, New Delhi.

Singh, A., 1984. Tiger Tiger. Jonathan Cape, London.

Singh, A., 1993. The Legend of the Man-eater. Ravi Dayal Publisher, New Delhi.

Singh, K.K., 1982. Studies on the grasses of Kheri district, Uttar Pradesh. Journal of the Bombay Natural History Society 79, 515-521.

Singh, K.S., 1994. The Scheduled Tribes. Oxford University Press, New Delhi.

Singh, V.B., 1969a. The elephant (Elephas maximus Linn.) in Uttar Pradesh, India. Journal of the Bombay Natural History Society 66, 239-250.

Singh, V.B., 1969b. The tiger in Uttar Pradesh. Cheetal 12, 106-113.

Singh, V.B., 1978. The elephant in UP (India) – a resurvey of its status after 10 years. Journal of the Bombay Natural History Society 75, 71-82.

Singh, V. B., 1989. The elephant in UP (India) – the change in status in two decades. Cheetal 28, 39-43.

Sinha, S.P., 2003. Assessment of corridor viability and habitat restoration between Dudhwa National Park and Katerniaghat Wildlife Sanctuary and its management in Western Terai Rhino Conservation Unit, Kheri District, Uttar Pradesh, India.

Smith, J.L.D., 1993. The role of dispersal in structuring the Chitwan tiger population. Behaviour 124, 165-195.

Smith, J.L.D., McDougal, C., Sunquist, M.E., 1987. Female land tenure system in tigers. In: Tilson, R.L., Seal, U.S., (Eds.), Tigers of the World: The biology, biopolitics, management and conservation of an endangered species. Noyes Publications, Park Ridge NJ, USA, pp.97-109

Smith, J.L.D., Ahearn, S.C., McDougal, C., 1998. Landscape analysis of tiger distribution and habitat quality in Nepal. Conservation Biology 12, 1338-1346.

Stoen, O.G., Wegge, P., 1996. Prey selection and prey removal by tiger (*Panthera tigris*) during the dry season in lowland Nepal. Mammalia 60, 363-373.

Sunderraj, S.F.W., Mishra, B.K., Johnsingh, A.J.T., 1995. Elephant use of Rajaji-Corbett Forest Corridor, North West India. In: Daniel, J.C., Datye, H.S. (Eds.), A week with elephants. Proceedings of the International seminar on the Conservation of Asian Elephant held in Mudumalai Wildlife Sanctuary, South India, 13-15 June 1993, pp.256-260.

Sunquist, M.E., 1977. Notes on the early maternal behaviour of the leopard. Mammalia 41, 112-113.

Sunquist, M.E., 1983. Dispersal of three radiotagged leopards. Journal of Mammalogy 64, 337-341.

Sunquist, M., Karanth, K.U., Sunquist, F., 1999. Ecology, behaviour and resilience of the tiger and its conservation needs. In: Seidensticker, J., Christie, S. and Jackson, P. (Eds.), Riding the Tiger, Tiger Conservation in human dominated landscapes. The Zoological Society of London, Cambridge University Press, Cambridge, pp.5-18.

Sunquist, F., Sunquist, M., 1988. Tiger Moon. University of Chicago Press, Chicago.

Sunquist, M.E., 1981. The social organization of tigers (*Panthera tigris*) in Royal Chitawan National Park, Nepal. Smithsonian Institute Press, City of Washington.

Tak, P.C., Lamba, B.S., 1981. Some observations on hog deer (*Axis porcinus*) at Dhikala, Corbett National Park. Indian Journal of Forestry 4, 209-305.

Thapar, V., 1999. The tragedy of the Indian tiger: starting from the scratch. In: Seidensticker, J., Christie, S., Jackson, P. (Eds.), Riding the Tiger: Tiger Conservation in human dominated landscapes. The Zoological Society of London, Cambridge University Press, Cambridge, pp. 296-306.

Tilak, R., Sinha, N.K., 1987. Some of the problems of management of Dudhwa National Park. Cheetal 28, 41-44.

Tiwari, P.C., Johsi, B., 1997. Wildlife in the Himalayan foothills: Conservation and Management. Indus Publishing Company, New Delhi.

Toovey, J. (Ed.), 1987. Tigers of the raj. Pages from the Shikar diaries-1894 to 1949 of Colonel Burton, sportsman and conservationist. Alan Sutton.

Tucker, R., 1998. Non-Timber forest products policy in the Western Himalaya. In: Grove, R.H., Damodaran, V., Satpal, S. (Eds.), Nature and the Orient: The environmental history of South and Southeast Asia. Oxford University Press, New Delhi, pp. 459-483.

Wemmer, C. (Ed.), 1998. Deer Status Survey and Conservation Action Plan. IUCN/SSC Deer Specialist Group. IUCN, Gland, Switzerland and Cambridge, U.K.

Wikramanayake, E., Dinerstein, E., Robinson, J.G., Karanth, U., Robinowitz, A., Olson, D., Mathew, T., Hedao, P., Conner, M., Hemley, G., Bolze, D., 1998. An ecology based method for defining priorities for large mammal conservation: the tiger as case study. Conservation Biology 12, 865-878.

Wikramanayake, E., Dinerstein, E., Loucks, C., Olson, D., Morrison, J., Lamoreux, J., McKnight, M., Hedao, P., 2001. Terrestrial ecoregions of the Indo-Pacific: a conservation assessment. Island Press, Washington, DC.

Wildlife Protection Society of India, 2003. < www.wpsi-india.org >

Williams, A.C., Johnsingh, A.J.T., Krausman, P.R., 2001. Elephant - human conflicts in Rajaji National Park, Northwestern India. Wildlife Society Bulletin 29, 1097-1104.

WWF, 2000. Tiger Landscape profiles. WWF Global Tiger Conservation Strategy Workshop, Anyer, Java, Indonesia.

WWF Nepal Program, 2003. Terai Arc Landscape (TAL) – Nepal. Annual Technical Progress Report: July 2002 – June 2003.

Appendix I: States, districts and tehsils that cover the study area

STATE	DISTRICT	TEHSIL
HIMACHAL PRADESH		
	1. Sirmaur	Paonta Sahib
HARYANA		
	2. Yamunanagar	Chhachhrauli & Jagadhri
UTTARANCHAL		
	3. Dehradun	Vikasnagar, Dehradun & Rishikesh
	4. Haridwar	Roorkee & Hardwar
	5.Tehri Garhwal	Narendranagar
	6. Pauri Garhwal	Kotdwara, Lansdowne & Dhoomakot
	7. Nainital	Haldwani
	8. Udham Singh Nagar	Kashipur, Kichha, Sitarganj & Khatima
	9. Champawat	Champawat
UTTAR PRADESH		
	10. Saharanpur	Behat
	11. Bijnor	Najibabad & Nagina
	12. Pilibhit	Pilibhit, Puranpur & Bisalpur
	13. Shahjahanpur	Powayan
	14. Kheri	Nighasan, Gola, Mohammadi, Dhaurahara & Lakhimpur
	15. Bahraich	Nanpara
	16. Shrawasti	Bhinga
	17. Balrampur	Balrampur & Tulsipur
	18. Siddharthnagar – No terai forest exist in this district	Shohratgarh & Naugarh
	19. Maharajganj	Pharenda, Nataunwa, Maharajganj & Nichlaul
	20. Kushinagar	Padrauna
BIHAR		
	21. Pashchim Champaran	Sidhaw, Ramnagar, Gaunaha & Mainatanr – Blocks

Appendix II: Management units and Tiger Habitat Blocks within Indian portion of TAL

Block No.	Tiger Habitat Block (THB)	Protected Areas and Forest Divisions
I	Simbalbara WLS – west bank of Ganges	Simbalbara WLS Kalesar WLS Kalsi FD Shivalik FD Dehradun FD Narendranagar FD Western portion of Rajaji NP
II	East bank of Ganges – west bank of Gola river	Eastern portion of Rajaji NP Haridwar FD Lansdowne FD Bijnor FD (Plantation) Bijnor FD Corbett TR Ramnagar FD Terai West FD Terai Central FD
III	East bank of Gola river – Tanakpur: Khatima Highway	Terai East FD Haldwani FD Champawat FD
IV	Surai Range (Pilibhit FD) – South Kheri FD	Pilibhit FD Shahjahanpur FD Kishanpur WLS Part of North Kheri FD South Kheri FD
V	Dudhwa National Park	Dudhwa NP Part of North Kheri FD
VI	Katerniaghat Wildlife Division	Katerniaghat WLD Part of North Kheri FD
VII	Suhelwa Wildlife Sancturay	Suhelwa WLS
VIII	Sohagibarwa west	Western portion of Sohagibarwa WLS
IX	Sohagibarwa east – Valmiki Tiger Reserve	Eastern portion of Sohagibarwa WLS Valmiki TR
X	Tiger absent	Bahraich FD Shrawasti FD

Appendix III: Data sheet for recording tiger, prey species and disturbance status

Date: **Place:** **Survey Route:** **Observer:**
GPS Location (start point): **GPS Location (end point):**
Time (start): **Time (end):** **Total dist. (km):**

Segment (km)	Indirect evidences (pug marks, track, signs and dung or pellet groups)																						Direct counts	
	Tiger	Leopard	Sambar		Chital		Nilgai		Barking deer		Wild pig		Swamp deer		Hog deer		Goral		Cattle		Dog	Lopping	Species, *gujjar* dera and people	No.
			T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	D				
0 - 0.25																							Tiger	
0.25 - 0.5																							Leopard	
0.5 - 0.75																							Sambar	
0.75 - 1.0																							Chital	
1.0 - 1.25																							Nilgai	
1.25 - 1.5																							Braking deer	
1.5 - 1.75																							Elephant	
1.75 - 2.0																							Goral	
2.0 - 2.25																							Wild pig	
2.25 - 2.50																							Rhesus	
2.50 - 2.75																							Langur	
2.75 - 3.0																							Cattle	
3.0 - 3.25																							Domestic dog	
3.25 - 3.5																								
3.5 - 3.75																								
3.75 - 4.0																								
4.0 - 4.25																							People	
4.25 - 4.5																							*Gujjar*	
4.5 - 4.75																							*dera*	
4.75 - 5.0																								

T – Track P – Pellets D – Dung Absent – 0 Present – 1 Common – C (>5) Abundant – A (>10)

Appendix IV: Data sheet for vegetation sampling and monitoring

Date:	**Toposheet / Grid ID** **Plot No:**
Forest Division:	**Latitude:**
Range:	**Longitude:**
Block:	**Major Landmarks:**
Habitat type:	**Transect Name:**

10 m radius plot (Tree layer)					**5 m radius plot (Shrub layer)**		
Species	**GBH class**	**Lop**	**Cut**	**Notes**	**Species**	**Cut**	**Notes**

Canopy cover		**1 m radius plot (Ground layer)**	
No. of cattle dung		**Cover Category**	**Percentage**
Wild ungulate pellets		**Bare ground**	
		Herb	
		Grass	
		Weeds	

Appendix V: Data sheet for vegetation sampling (Relevé plot)

Date:	**Toposheet / Grid ID** **Plot No:**
Forest Division:	**Latitude:**
Range:	**Longitude:**
Block:	**Quantified by:**
Habitat type:	

10 m radius plot (Tree layer)					**5 m radius plot (Shrub layer)**			
Species	**Dominance Rank / No**	**GBH class**	**Lop**	**Cut**	**Species**	**Dominance Rank / No**	**GBH class**	**Cut**
1					**1**			
2					**2**			
3					**3**			
4					**4**			
5					**5**			

No. of cattle dung		**Tree cover**	
Wild ungulate pellets		**Shrub cover**	

Appendix VI: Champion and Seth (1968) forest types, corresponding to TAL vegetation

S.No.	Forest Type		Distribution	Vegetation Characteristics	Soil Characteristics
1	Moist Shiwalik sal	3C/2a	Shiwalik hills; Saharanpur Division	Typical associates include *Anogeissus latifolia*, *Terminalia alata*	On Nahan sandstone with light soil.
2	Moist bhabar sal – Bhabar-dun sal forest	3C/C2/2b(i)	Dun and gentle Bhabar slopes Dehradun and Kumoan.	*Lagerstroemia parviflora*, *Terminalia alata*	Gravelly, underlain by gravels and boulders fairy close to the surface.
3	Moist bhabar sal – Damar sal forest	3C/C2/2b(ii)	On high alluvial terraces or damars (high river bank) jutting out in the terai and plains; North Kheri Division	*Haldina cordifolia*, *Syzygium cumini*, *Schleichera oleosa*	Good loamy soils without pebbles.
4	Moist tarai sal forest	3C/C2/2c	Haldwani Division	*Syzygium cumini, Trewia nudiflora, Ardisia solanacea, Calamus tenuis*	Grey clayey alluvium with wet subsoil
5	Moist plains sal forest - Western light alluvial plains sal	3C/C2/2d(i)	North Kheri and South Kheri Division	*Terminalia alata, Terminalia bellirica, Lagerstroemia parviflora*	Sandy alluvium with dry subsoil
6	Moist plains sal forest - Chander sal	3C/C2/2d	Low lying chanders of the sub-Himalayan tract; Pilibhit	*Syzygium cerasoides*	Light to heavy alluvium on a dry subsoil
7	Moist plains sal forest - Eastern heavy alluvium plains sal	3C/C2/2d	Gorakhpur Division	*Terminalia alata, Dillenia pentagyna, Lagerstroemia parviflora*	On yellow clayey alluvium
8	Moist mixed deciduous forest – Western Gangetic moist deciduous forest	3C/C3/3a	Scattered freely through the hills occupied by moist sal type and more locally in the plains	*Albizzia procera, Haldina cordifolia, Terminalia alata, Terminalia bellirica, Toona ciliata, Garuga pinnata*; local variation Bauhinia forest with *Bauhinia retusa, B.variegata* and *B.vahlii*; on moister, higher riverain alluvium – *Trewia*, *Putranjiva*, *Aphanamixis*, *Bischofia*, *Alangium salvifolium* also occur	

9	Terminalia alata forest	3C/E1	Throughout the sal region	*Shorea robusta, Bombax ceiba, Syzygium cumini*	On heavy wet soils and on clayey alluvial patches.
10	Low alluvium savannah woodland	3C/1S1	Throughout the Gangetic plains	*Themeda*, *Erianthus*, *Saccharum*, with scattered trees of *Bombax* ceiba, *Albizzia procera*	Alluvial, mainly sandy with local clay patches, seasonal inundation.
11	Cane breaks	E1	Locally in moist deciduous forests	*Calamus* spp. (*C.tenuis* in moist sal forests) and other associates which vary with locality	Soil is permanently wet and usually fine clay, rich in humus
12	Sub-montane hill valley swamp forest	4C/FS2	Along sub-montane tract; Dehradun and Haldwani Division	Low-crowned evergreen trees, dense Calamus; *Ficus glomerata*, *Terwia nudiflora, Syzygium cumini, Pterospermum acerifolium, Toona ciliata, Bischofia javanica, Diospyros peregrina, Carallia brachiata, Putranjiva roxburghii, Phoebe lanceolata, Machilus gamblei, Salix tetrasperma, Achronychia pedunculata, Ardisia solanacea, Desmodium caudatum;* Ferns no grass	Soil is wet, stream beds gravelly and rich in humus
13	Barringtonia swamp forest	4D/SS2	Swampy areas in the Gangetic flood plains; South Kheri Division	*Barringtonia acutangula, Syzygium cumini, Salix tetrasperma, Calamus tenuis*	Prolonged annual summer flood. Soil rich in humus, heavy and poor in aeration.
14	Syzygium cumini swamp low forest	4D/SS3	Along stream banks in Gangetic alluvium; typically seen in eastern U.P.	Almost pure stands, occasionally *Barringtonia* or *Trewia nudiflora*.	Seasonally flooded, along banks of sluggish streams
15	Easter seasonal low swamp forest	4D/SS4	Gangetic valley from Pilibhit eastwards, south Kheri division	*Syzygium cumini, Cephelanthus occidentalis*	Swampy depressions in sal zone, with deep black heavy waterlogged soil.
16	Eastern wet alluvial grassland	4D/2S2	Gangetic flood plains	*Vetiveria zizanioides, Erianthus arundinaceus, E.munja, Phragmites karka, Themeda arundinacea, Arundo donax, Saccharum spontaneum, Imperata cylindrica,*	Alluvial deposits which dry out completely after the floods recede.

17	Riparian fringing forest	4E/RS1	Along banks of large streams in the hilly regions	*Bischofia javanica, Mangifera indica, Lagerstroemia speciosa*	Soil coarse and non-retentive, sandy or siltey, well drained.
18	Dry sal bearing forest - Dry Shiwalik sal forest	5B/C1/1a	Shiwalik hills	*Anogeissus latifolia, Buchanania lanzan*	Rock and conglomerates, shallow sandy and is completely drained
19	Dry sal bearing forest - Dry plains sal forest	5B/C1/1b	Flat areas in UP; Ramnagar, Haldwani and Bahraich	*Terminalia alata, Terminalia bellirica, Pterocarpus marsupium, Madhuca indica, Acacia catechu*,	Top soil clayey, surface drainage sluggish
20	Northern dry mixed deciduous forest	5B/C2	Shiwaliks, Bhabar plains	*Anogeissus latifolia, Boswellia serrata, Acacia catechu, Shorea robusta, Terminalia alata, Stereospermum suaveolens, Lannea coramandelica*	
21	Dry deciduous scrub	5/DS1	Dry Shiwalik hills	*Acacia catechu, Butea monosperma, Randia dumentorum, Carissa opaca*	
22	Dry savannah forest	5/DS2	Throughout dry deciduous forests, following severe anthropogenic pressures	Trees standing singly or in small groups with heavy undergrowth of fire and grazing resistant species.	
23	Aegle forest	5/E6	Drier regions of Gonda, Bahraich	*Aegle marmelos* forming nearly pure consociations,	
24	Dry tropical riverain forest	5/1S1	Narrow strips along hilly sections of larger streams	Trees larger than the surrounding dry deciduous forest, more or less evergreen.	Light sandy soil
25	Khair-sissoo forest	5/1S2	Along all larger rivers of N.India	*Acacia catechu, Dalbergia sissoo, Holopteliaintegrifolia, Cannabis sativa, Grewia oppositifolia*	Sandy or gravelly alluvium, devoid of humus
26	Inundation babul forest	5/1S3	Bahraich Division	*Acacia nilotica*, thick grass cover	Flooded for a few weeks.
27	Lower or Shiwalik chir pine forest	8B/C1/1a	Shiwalik hills	*Pinus roxburghii* singly or with *Shorea robusta, Terminalia alata, Anogeissus latifolia*	

Appendix VII: Habitat characteristics in Forest Divisions and Protected Areas within TAL (values are mean ± standard deviation)

Forest Divisions/PAs	Canopy cover (%)	Tree density	Tree richness	Shrub density	Shrub richness	Sapling density	Sapling richness	Lopping	Cattle dung density	Wild herbivore pellets	Dominant trees	Dominant shrubs
Kalesar WLS	23.6 ± 6.3	20 ± 7.3	3.1 ± 0.7	10.7 ± 7.4	1.4 ± 0.8	11.4 ± 7.7	2.1 ± 0.7	0.6 ± 1.0	1.9 ± 1.5	0 ± 0	*Tectona grandis, Mallotus philippinensis, Eucalyptus*	*Lantana camara, Aerva scandens, Dendrocalamus strictus*
Shivalik	20.4 ± 10.6	6.4 ± 4.1	2.3 ± 1.3	17.2 ± 11.2	2.2 ± 1.2	5.5 ± 7.5	1.2 ± 1.2	0.7 ± 1.4	1.3 ± 1.7	0.1 ± 0.3	*Acacia catechu, Tectona grandis, Diospyros melanoxylon*	*Lantana camara, Adhatoda vasica, Murraya paniculata*
Rajaji NP	23.4 ± 12.3	8 ± 4.4	3.3 ± 1.2	17.1 ± 12.1	2.2 ± 1.2	4.8 ± 5.3	1.3 ± 1.4	1.5 ± 2.4	1.3 ± 1.6	2.4 ± 3	*Mallotus philippinensis, Holarrhena antidysenlerica, Anogeissus latifolia*	*Lantana camara, Murraya paniculata, Helicteres isora*
Dehradun	21.6 ± 17.6	5.3 ± 3.6	2.3 ± 1.1	18.8 ± 6.8	2.1 ± 1	3.1 ± 4.8	0.8 ± 0.9	0.1 ± 0.3	2.7 ± 3.2	3.7 ± 2.1	*Tectona grandis, Trewia nudiflora, Eucalyptus*	*Adhatoda vasica, Murraya paniculata, Clerodendron viscosum,*
Narendranagar	13.8 ± 2.5	5 ± 0.8	2 ± 0	20.3 ± 7.1	2 ± 0.8	10.5 ± 13.4	1.3 ± 1.3	0.0 ± 0.0	2.5 ± 3.0	0.3 ± 0.5	*Holoptelia integrifolia, Tectona grandis, Aegle marmelos*	*Murraya paniculata, Adhatoda vasica,*
Haridwar	25.4 ± 15.1	4.8 ± 2.9	2.5 ± 1.4	11.8 ± 6.4	2.1 ± 0.8	1.4 ± 2.3	0.4 ± 0.5	1.8 ± 1.1	0.5 ± 0.7	1.2 ± 1.5	*Holoptelia integrifolia, Acacia catechu, Zizyphus mauritiana*	*Lantana camara, Adhatoda vasica, Helicteres isora*
Lansdowne	14.7 ± 9.0	6.5 ± 3.7	2.9 ± 1.4	15.2 ± 11.5	2 ± 0.8	4.9 ± 3.0	4.9 ± 3.0	0.8 ± 1.3	3.9 ± 3.0	2.5 ± 2.4	*Mallotus philippinensis, Shorea robusta, Acacia catechu,*	*Murraya paniculata, Lantana camara, Colebrookia oppositifolia*
Sonanadi WLS	19.1 ± 4.0	8.6 ± 2.2	5.4 ± 1.2	37.4 ± 14.4	3 ± 1.1	6.5 ± 5.3	1.8 ± 1.0	0.1 ± 0.5	0.2 ± 0.4	1.3 ± 1.2	*Aegle marmelos, Ehretia laevis, Mallotus philippinensis*	*Helicteres isora, Murraya paniculata, Desmodium spp.,*
Corbett TR	21.6 ± 12.3	7 ± 5.7	3 ± .3	23.6 ± 18.3	1.9 ± 1	5.2 ± 5.6	1.1 ± 0.9	0.0 ± 0.1	0.2 ± 0.6	1.3 ± 1.6	*Shorea robusta, Mallotus philippinensis, Syzygium cumini*	*Murraya paniculata, Clerodendron viscosum, Helicteres isora*
Ramnagar	24.5 ± 10.1	9.4 ± 4.2	2.9 ± 1.2	26.4 ± 21.4	2.3 ± 1.6	8.7 ± 8.4	1.5 ± 1.2	0.1 ± 0.4	1.0 ± 1.2	0.5 ± 0.8	*Shorea robusta, Mallotus philippinensis, Tectona grandis*	*Murraya paniculata, Lantana camara, Clerodendron viscosum*
Terai West	21.1 ± 5.6	13.8 ± 4.1	4.2 ± 1.5	37.3 ± 23.1	3.2 ± 1.3	8.3 ± 8.0	1.5 ± 1.1	0.1 ± 0.5	0.4 ± 0.8	0.3 ± 0.6	*Mallotus philippinensis, Eucalyptus, Acacia catechu,*	*Glycosmis pentaphylla, Murraya paniculata, Lantana camara*
Terai Central	30.8 ± 16.7	13.8 ± 6.2	3.9 ± 1.3	25.5 ± 20.1	2.2 ± 1.2	5.9 ± 5.8	1.5 ± 1.3	0.9 ± 1.8	1.2 ± 1.2	0.9 ± 1.2	*Mallotus philippinensis, Tectona grandis, Acacia catechu,*	*Murraya paniculata, Lantana camara, Clerodendron viscosum*
Terai East	20.8 ± 12.6	7.7 ± 5.9	3 ± 2	18.9 ± 19.4	2.1 ± 1.4	6.7 ± 7.7	1.8 ± 1.8	0.7 ± 1.2	1.9 ± 2.0	0.2 ± 0.5	*Shorea robusta, Acacia catechu, Trewia nudiflora*	*Lantana camara, Murraya paniculata, Clerodendron viscosum*

Haldwani	30.6 ± 12.6	11.2 ± 4.8	3.8 ± 1.8	16.9 ± 14.6	2 ± 1.3	15.0 ± 12.7	2.6 ± 1.8	0.7 ± 1.4	0.8 ± 1.2	0.3 ± 0.8	*Shorea robusta, Mallotus philippinensis, Tectona grandis*	*Clerodendron viscosum, Murraya paniculata, Millettia auriculata*
Champawat	21.1 ± 8.9	7.3 ± 3.3	2.8 ± 1.9	5.6 ± 7.5	1.2 ± 1.1	5.4 ± 4.6	1.7 ± 1.2	1.0 ± 1.2	0.1 ± 0.3	0.1 ± 0.3	*Shorea robusta, Mallotus philippinensis, Holoptelia integrifolia*	*Murraya paniculata, Lantana camara, Pogostemon parviflorus*
Pilibhit	21.7 ± 11.0	7.7 ± 4.1	2.4 ± 1.4	8.5 ± 8.5	1.1 ± 1	14.3 ± 10.6	2.3 ± 1.3	0.4 ± 0.9	1.0 ± 1.9	0.4 ± 0.9	*Shorea robusta, Mallotus philippinensis, Syzygium cumini*	*Millettia auriculata, Clerodendron viscosum, Helicteres isora*
Shahjahanpur	22.5 ± 4.6	7.3 ± 1.7	2.3 ± 0.7	-	-	3.6 ± 2.7	2.0 ± 1.1	0.3 ± 0.5	0.0 ± 0.0	0.1 ± 0.4	*Shorea robusta, Terminalia alata, Miliusa velutina*	No shrub in the sampled area
Kishanpur WLS	25.7 ± 13.9	9.2 ± 5.5	3.6 ± 1.8	7.9 ± 11.7	1 ± 1.1	9.7 ± 11.1	1.8 ± 1.4	0.6 ± 1.2	0.5 ± 1.2	0.9 ± 1.1	*Shorea robusta, Mallotus philippinensis, Syzygium cumini*	*Helicteres isora, Clerodendron viscosum, Glycosmis pentaphylla*
South Kheri	28.2 ± 9.9	10.8 ± 3.9	3.8 ± 1.5	5.2 ± 7	0.6 ± 0.7	14.1 ± 14.0	2.5 ± 1.5	0.5 ± 0.9	1.1 ± 1.7	0.4 ± 0.7	*Shorea robusta, Mallotus philippinensis, Syzygium cumini*	*Clerodendron viscosum, Glycosmis pentaphylla, Desmodium spp.*
Dudhwa NP	26.4 ± 10.8	8.1 ± 4.7	2.9 ± 1.3	7.3 ± 9.3	0.9 ± 0.8	8.6 ± 11.2	1.5 ± 1.3	0.3 ± 0.7	0.4 ± 1.0	0.6 ± 1	*Shorea robusta, Syzygium cumini, Mallotus philippinensis*	*Murraya paniculata, Clerodendron viscosum, Tiliacora acuminata*
North Kheri	14.6 ± 9.0	4.7 ± 3.2	2.1 ± 1.2	8 ± 8.4	1.3 ± 1.3	3.6 ± 4.1	0.9 ± 0.9	0.5 ± 1.1	3.1 ± 1.9	0.3 ± 0.7	*Acacia catechu, Dalbergia sissoo, Trewia nudiflora,*	*Murraya paniculata, Glycosmis pentaphylla, Solanum spp.*
Katerniaghat WLS	26.3 ± 10.9	8.8 ± 5.1	3.5 ± 1.4	11.8 ± 9.5	1.4 ± 0.9	9.2 ± 7.1	1.5 ± 0.9	1.0 ± 1.5	1.5 ± 2.0	0.7 ± 1.1	*Mallotus philippinensis, Shorea robusta, Acacia catechu*	*Glycosmis pentaphylla, Murraya paniculata, Clerodendron viscosum*
Shrawasti	20.7 ± 7.6	6.6 ± 3.1	2.9 ± 1.2	10.5 ± 8.5	1.2 ± 0.7	5.2 ± 4.5	1.1 ± 0.8	0.2 ± 1.0	1.1 ± 1.8	0.2 ± 0.6	*Tectona grandis, Mallotus philippinensis, Shorea robusta*	*Murraya paniculata, Glycosmis pentaphylla, Carissa opaca,*
Suhelwa WLS	24.6 ± 10.0	8.8 ± 3.7	3.8 ± 1.4	13.1 ± 10.1	1.5 ± 0.9	7.8 ± 6.6	1.8 ± 1.2	0.8 ± 1.3	7.0 ± 1.4	0.2 ± 0.5	*Mallotus philippinensis, Holoptelia integrifolia, Acacia catechu*	*Murraya paniculata, Clerodendron viscosum, Glycosmis pentaphylla*
Sohagibarwa WLS	28.8 ± 12.4	8.6 ± 5	2.7 ± 1.6	3.6 ± 5.5	0.6 ± 0.9	12.7 ± 12.0	2.3 ± 1.4	1.1 ± 1.6	1.6 ± 3.0	0.2 ± 1	*Shorea robusta, Syzygium cumini, Tectona grandis*	*Clerodendron viscosum, Carissa opaca, Millettia auriculata*
Valmiki TR	19.8 ± 8.3	5.2 ± 2.1	3.1 ± 1.3	8.8 ± 8.2	1.3 ± 0.9	5.1 ± 4.8	1.4 ± 1.2	0.2 ± 0.6	1.5 ± 1.9	0.5 ± 1.3	*Shorea robusta, Acacia catechu, Syzygium cumini*	*Clerodendron viscosum, Lantana camara, Pogostemon parviflorus*

Appendix VIII: Transects details, evidence of tiger and other wildlife species in TAL

Division / PA	Range	Transect name	Transect ID	Transect start point		Transect end point		Distance (km)	Tiger PMER (no./km)	Leopard PMER (no./km)	Frequency of occurrence (%)										
				Latitude	Longitude	Latitude	Longitude				Tiger	Leopard	Sambar	Chital	Nilgai	Barking deer	Wild pig	Hog deer	Swamp deer	Elephant	Sloth bear
Bijnor-Plantation	Jaffarabhat	Malan river	1	29.70358	78.42087	29.7317	78.43719	3.5	0	0.86	0	36	0	71	100	0	36	0	0	71	0
Bijnor-Plantation	Jaffarabhat	Riwady rau	2	29.69972	78.43139	29.74333	78.41000	5	0	0.6	0	30	20	5	65	0	10	0	0	50	0
Bijnor-Plantation	Kodia	Railway Station sot	3	29.67694	78.44528	29.71583	78.47444	3.8	0	0.53	0	13	0	67	73	20	73	0	0	67	0
Bijnor	Amargarh	Kotri rau	4	29.38667	78.88750	29.40861	78.90028	3.5	0.86	0.29	29	14	79	100	50	0	64	0	0	7	0
Bijnor	Badhapur	Dholkhand rau	5	29.54444	78.61944	29.53750	78.59889	1.5	0.67	0	17	0	0	100	100	0	0	0	0	67	0
Champawat	Boom	Batnagad upstream	6	29.12361	80.16222	29.14417	80.14861	3	0.33	0.33	20	10	0	0	0	0	0	0	0	0	0
Champawat	Boom	Kaligad upstream	7	29.11028	80.13500	29.13583	80.11917	3.5	0	0.29	0	14	0	0	0	0	0	0	0	0	0
Champawat	Boom	Jhuligad upstream	8	29.14056	80.17833	29.14750	80.17889	1.5	0.67	0	17	0	50	0	0	17	0	0	0	0	0
Champawat	Boom	Babligad	9	29.13361	80.18639	29.10972	80.16111	1.5	0.67	0	17	0	67	0	0	17	0	0	0	0	0
Champawat	Boom	Bhawanigad	10	29.12528	80.21500	29.12750	80.21167	1.5	0	0	0	0	17	0	0	17	50	0	0	0	0
Champawat	Boom	Gojigad	11	29.12694	80.22139	29.13000	80.22361	1	0	0	0	0	0	0	0	25	0	0	0	0	0
Champawat	Dugari	Sajgad nala	12	29.08944	80.01750	29.11500	80.01278	2.9	1.03	0.34	17	25	83	67	0	0	8	0	0	8	0
Corbett TR	Paterpani	Paterpani sot	13	29.52250	78.77806	29.52333	78.80583	5	1.2	0	35	0	100	95	0	10	20	0	0	80	0
Corbett TR	Jhirna	Dhara sot	14	29.46448	78.84829	29.48527	78.87007	5	1	0	25	0	90	90	0	0	0	0	0	20	5
Corbett TR	Jhirna	Kotri rau	15	29.44361	78.91972	29.45556	78.92778	4	1.25	0	31	0	100	88	0	6	31	0	0	81	0
Corbett TR	Jhirna	Jirna sot	16	29.45306	78.89472	29.48194	78.89472	4.8	1.04	0.42	74	11	84	47	0	47	47	0	0	68	0
Dehradun	Azaroori	Suk rau	17	30.28250	77.92000	30.24806	77.93472	4.7	0	0	0	0	5	74	0	21	89	0	0	0	0
Dehradun	Bharkot	Lalpani rau	18	30.16639	78.24000	30.14889	78.23500	2	0	0	0	0	88	100	0	13	0	0	0	13	0
Dehradun	Bharkot	Soni sot	19	30.09611	78.21111	30.08194	78.21556	2	0	1	0	50	100	100	0	0	0	0	0	25	0
Dehradun	Bharkot	Sandrabhaga river	20	30.12111	78.28000	30.16417	78.25611	6.4	0	0.31	0	15	35	50	0	0	0	0	0	81	0
Dehradun	Ramghar	Azaroogi rau	21	30.24444	77.97472	30.23722	77.96278	1.9	0	0.53	0	25	88	75	0	50	88	0	0	0	0

Dudhwa NP	Satiyana /Dudhwa	Forest road	22	28.53694	80.58278	28.50667	80.62194	5	0.4	0	80	0	50	100	0	0	75	0	0	0	0
Dudhwa NP	Gouriphanta	Forest road	23	28.64722	80.54417	28.62944	80.58472	5	0.2	0	5	0	0	0	55	0	95	0	0	0	0
Dudhwa NP	Dudhwa /Bankatti	Forest road	24	28.57167	80.59778	28.5875	80.63111	3.5	0.29	0	14	0	0	86	0	36	93	0	0	0	7
Dudhwa NP	Sonaripur	Forest road	25	28.42111	80.70000	28.46861	80.70500	5.3	0.38	0	76	0	81	100	0	0	67	0	0	0	38
Dudhwa NP	South Sonaripur	Forest road	26	28.46278	80.74000	28.50694	80.72111	5	0.4	0	5	0	0	90	55	0	55	10	0	0	0
Dudhwa NP	Belrayan	Forest road	27	28.42722	80.91000	28.39861	80.91833	3.9	0.51	0	81	0	25	100	19	0	100	0	0	0	0
Dudhwa NP	Belrayan	Forest road	28	28.37111	80.78722	28.41333	80.77889	5	0.2	0.2	10	10	25	100	10	0	75	35	0	0	25
Dudhwa NP	Belrayan	Forest road	29	28.40889	80.86694	28.42611	80.82444	5.2	0.38	0	10	0	0	100	14	0	100	10	0	0	5
Haldwani	Nandaur	Nandaur river	30	29.15667	79.71389	29.11611	79.71556	5	0	0	0	0	65	80	0	0	40	0	0	20	5
Haldwani	Nandaur	Nandaur ghati	31	29.16000	79.71583	29.16333	79.74583	5	0	0.2	0	5	20	0	0	0	0	0	0	25	0
Haldwani	Nandaur	Asni nala	32	29.15889	79.66250	29.1375	79.64611	5	0.2	0.2	20	15	90	75	20	10	0	0	0	70	0
Haldwani	Jualasal	Bhargot rau	33	29.05694	79.88194	29.09278	79.89472	5	0.2	0.6	5	30	90	30	15	10	30	0	0	0	0
Haldwani	Jaulasal	Lebar nala	34	29.06000	79.92556	29.08056	79.91667	3	0.67	0.33	33	42	92	8	0	25	17	0	0	0	0
Haldwani	Jualasal	Kachham nala	35	29.09056	79.74722	29.12111	79.75000	4.5	0	0.67	0	17	50	83	0	0	0	0	0	0	0
Haldwani	Jualasal	Raila nala	36	29.07444	79.80306	29.10028	79.79611	4.3	0	0.47	0	29	82	41	0	0	24	0	0	0	12
Haldwani	Sarda	Kalonia rau	37	29.08583	80.08944	29.05500	80.04139	4.3	0.23	0.47	6	35	24	24	59	0	24	0	0	65	6
Haldwani	Sarda	Bhumiyagar nala	38	29.08694	80.05639	29.06167	80.07861	4	1	0.25	38	6	75	69	6	0	0	0	0	19	0
Haldwani	Sarda	Kirora rau	39	29.09444	80.11389	29.12111	80.08056	4.8	0	0.21	0	5	53	16	26	0	11	0	0	0	0
Haldwani	Sarda	Dulagarh nala	40	29.05056	79.97139	29.06417	79.99167	3	2	0.33	27	8	92	8	0	25	25	0	0	42	0
Haldwani	Chakata	Parla sot	41	29.19972	79.59528	29.18472	79.60111	3	0	0.33	0	42	50	67	0	50	33	0	0	17	0
Haldwani	Chakata	Porjia nala	42	29.16500	79.64528	29.18639	79.66111	5	0.4	0.4	15	15	90	75	0	20	0	0	0	25	10
Haldwani	Chakata	Seljam nala	43	29.17778	79.62806	29.21222	79.6525	5	0.2	0.4	5	10	100	45	0	5	5	0	0	60	50
Haldwani	Sarda	Jagpur-downstream	44	28.97667	80.05667	28.95139	80.08611	2	0	0.5	0	13	0	0	0	0	0	0	0	0	0
Haldwani	Sarda	Jagpur-upstream	45	28.97667	80.05667	29.00083	80.05806	3	0	0	0	0	0	0	25	0	83	0	0	0	0
Haldwani	Sarda	Sarda islands-downstream	46	29.03583	80.11972	28.99611	80.11361	4	0	0.25	0	6	0	6	0	6	25	0	0	0	0

Haldwani	Sarda	Sarda islands-upstream	47	29.03583	80.11972	29.08611	80.11944	4	0	0	0	0	0	0	0	6	19	0	0	0	0
Haridwar	Haripur	Rhaghati sot	48	30.08213	77.92384	30.04280	77.90758	5	0	0.4	0	15	35	40	95	15	95	0	0	35	0
Haridwar	Shampur	Mundal sot	49	29.88194	78.18778	29.87611	78.18056	1.6	0	1.25	0	29	29	71	71	0	100	0	0	86	0
Haridwar	Shampur	Simbal sot	50	29.86722	78.19000	29.88500	78.22167	4.4	0	0.68	0	67	50	61	22	0	44	0	0	50	0
Haridwar	Shampur	Paperi sot	51	29.85583	78.18750	29.87444	78.22472	5	0	0.8	0	25	25	85	30	0	0	0	0	80	0
Haridwar	Shampur	Sidh sot	52	29.90611	78.17750	29.91028	78.21306	5	0	0.4	0	20	80	90	10	5	40	0	0	30	0
Haridwar	Shampur	Ravasan sot	53	29.8104	78.24162	29.82974	78.22514	4	0	0.75	0	25	0	69	88	0	63	0	0	56	0
Haridwar	Shampur	Chandi nala	54	29.94611	78.17444	29.93250	78.20528	4	0	0.25	0	13	100	100	0	6	100	0	0	88	0
Kalagarh	Sonanadi	Dholkhand rau	55	29.56083	78.62056	29.5375	78.59889	3	1	0.67	25	33	83	100	100	0	67	0	0	92	8
Kalagarh	Sonanadi	Morgatti sot	56	29.55583	78.62917	29.54056	78.61278	2	0	1	0	63	75	100	38	0	0	0	0	63	0
Kalesar WLS	Kalesar	Barakhol rau	57	30.33583	77.57250	30.34639	77.55611	3	0	1	0	25	100	8	0	50	75	0	0	0	0
Kalesar WLS	Chhachrauli	Chikenkhol rau	58	30.38389	77.49500	30.39611	77.50944	2.9	0	0	0	0	83	83	8	75	0	0	0	0	0
Kalesar WLS	Kalesar	Sukh rau	59	30.37528	77.56556	30.38750	77.53889	3	0	0.67	0	17	100	100	92	0	50	0	0	0	0
Katerniaghat WLS	Katerniaghat	Forest road	60	28.28056	81.03833	28.27389	81.04444	1.4	0	0	0	0	0	0	67	0	83	0	0	0	0
Katerniaghat WLS	Murtiah	Forest road	61	28.11472	81.31250	28.15778	81.29194	5	0.2	0.2	5	5	0	65	10	0	50	0	0	0	0
Katerniaghat WLS	Kakraha	Forest road	62	28.09972	81.31944	28.11000	81.30000	2	0	0	0	0	0	88	88	0	88	13	0	0	0
Katerniaghat WLS	Motipur	Forest road	63	28.05556	81.34528	28.03889	81.32361	3	0.33	0	8	0	0	92	58	0	92	0	0	0	0
Katerniaghat WLS	Dharmapur	Forest road	64	28.21139	81.24500	28.22167	81.29417	5	0	0	0	0	0	60	30	0	50	0	0	0	0
Katerniaghat WLS	Katerniaghat	Forest road	65	28.34417	81.12083	28.35500	81.08472	4.5	0.22	0	6	0	0	0	0	0	0	89	0	89	0
Katerniaghat WLS	Nishangara	Forest road	66	28.26167	81.20972	28.26861	81.17639	5	0.2	0	50	0	0	90	0	0	100	0	0	0	0
Katerniaghat WLS	Nishangara	Forest road	67	28.26167	81.20972	28.28167	81.22972	3.5	0	0	0	0	0	36	14	0	21	0	0	0	0
Katerniaghat WLS	Katerniaghat	Gaura river	68	28.33972	81.19111	28.34944	81.18750	1.3	2.31	0	40	0	40	100	0	0	100	0	0	60	0
Kishanpur WLS	Mailani	Forest road	69	28.33361	80.36639	28.37861	80.35028	5	0.2	0	15	0	0	55	45	0	80	0	0	0	0
Kishanpur WLS	Kishanpur	Forest road	70	28.43861	80.34056	28.39444	80.38056	5	0.4	0	30	0	0	100	100	0	100	0	0	0	0
Kishanpur WLS	Kishanpur	Sarda river-downstream	71	28.40639	80.43861	28.37750	80.47250	5	0.8	0	70	0	0	75	0	0	85	0	0	0	0

Kishanpur WLS	Kishanpur	Sarda-upstream	72	28.43861	80.4075	28.45139	80.41667	5	0.8	0	70	0	0	100	0	0	100	95	100	0	0
Kishanpur WLS	Kishanpur	Forest road	73	28.33444	80.44861	28.36667	80.43972	3.6	0.28	0	7	0	0	100	100	0	93	0	0	0	0
Kishanpur WLS	Kishanpur	Forest road	74	28.36667	80.43972	28.37528	80.4275	1.5	0	0	0	0	0	50	67	0	50	0	0	0	0
Lansdowne	Kotri	Nimbu sot	75	29.70139	78.57083	29.69139	78.60389	5	0.8	0.2	65	5	100	75	0	0	90	0	0	100	0
Lansdowne	Kotri	Khewgard rau	76	29.71194	78.58556	29.72917	78.59056	2.2	0.91	0	22	0	100	100	0	0	0	0	0	89	0
Lansdowne	Kotri	Labbar sot	77	29.70139	78.57083	29.68222	78.56861	4.9	0.82	0.41	100	11	84	84	0	0	84	0	0	84	0
Lansdowne	Dugadda	Kho river	78	29.75639	78.54306	29.78361	78.57611	5	0	0.2	0	20	80	0	0	80	65	0	0	80	0
Lansdowne	Kotri	Sarkada sot	79	29.64250	78.53722	29.65111	78.54861	3.5	0	0.29	0	21	79	0	0	36	0	0	0	93	0
Lansdowne	Kotri	Saneh Nadi	80	29.69361	78.52861	29.71250	78.55361	5	0.2	0.2	5	5	100	5	0	85	40	0	0	100	0
Lansdowne	Kotdwar	Gujjar sot	81	29.61472	78.55889	29.62056	78.57194	4.5	0.22	0.22	17	6	89	72	0	33	0	0	0	89	0
Lansdowne	Kotri	Pakhrao	82	29.59500	78.57250	29.61694	78.59111	5	0.2	0.2	10	25	90	45	5	80	5	0	0	85	0
Lansdowne	Kotdwar	Giwain sot	83	29.75806	78.52750	29.78444	78.53444	4.8	0.21	0	5	0	42	0	0	5	11	0	0	21	0
Lansdowne	Kotdwar	Suka rau	84	29.76361	78.50139	29.77889	78.52583	5	0.2	0.2	15	10	50	0	0	25	5	0	0	40	0
Lansdowne	Laldhang	Ravasan river	85	29.85722	78.31861	29.85889	78.34583	4.3	0.23	0.23	6	12	12	18	0	0	0	0	0	24	0
Lansdowne	Laldhang	Maili sot	86	29.80417	78.35278	29.82361	78.36889	4	0.25	0.25	6	38	6	6	0	0	0	0	0	75	0
Lansdowne	Laldhang	Chawariya sot	87	29.81528	78.33083	29.83694	78.34361	4.3	0	0.23	0	35	0	0	18	0	47	0	0	12	0
Lansdowne	Kotdwar	Malan river	88	29.79389	78.45972	29.81056	78.46139	3.8	0	0	0	0	0	0	0	0	0	0	0	0	0
Lansdowne	Laldhang	Nalgaddi sot	89	29.80083	78.35389	29.80694	78.38611	4.5	0	0.22	0	28	0	17	0	11	0	0	0	50	0
North Kheri	Palyia	Sarda-upstream	90	28.43611	80.44972	28.46278	80.41000	5	0.8	0	15	0	0	0	15	0	60	0	0	0	0
North Kheri	Palyia	Sarda-downstream	91	28.43389	80.44917	28.39583	80.46528	5	1	0	60	0	75	85	20	0	50	0	0	0	0
North Kheri	Palyia	Sarda-upstream	92	28.46778	80.40528	28.48667	80.36333	5	0.4	0	10	0	40	45	75	0	30	0	0	0	0
North Kheri	Palyia	Paraspur-FR	93	28.47278	80.44806	28.48722	80.45111	4.3	0	0.23	0	11	0	39	44	0	72	0	0	0	0
North Kheri	Sampurnanagar	Sarda-downstream	94	28.76333	80.20694	28.76611	80.17167	2	1	0.5	38	13	0	63	88	0	100	0	0	0	0
North Kheri	Sampurnanagar	Sarda-downstream	95	28.74667	80.22194	28.70583	80.21917	7.5	0.53	0	37	0	0	87	13	0	87	0	0	0	0
North Kheri	Sampurnanagar	Sarda-downstream	96	28.70778	80.23833	28.69083	80.28028	5	0	0	0	0	0	40	80	0	95	0	0	0	0

North Kheri	North Nighasan	Forest road	97	28.36889	80.86972	28.36806	80.8225	5	0.4	0	5	0	0	70	65	0	90	0	0	0	5
North Kheri	North Nighasan	Batuwa-FR	98	28.29167	80.98833	28.28000	80.97667	1.8	0	0.56	0	14	0	71	71	0	29	0	0	0	0
North Kheri	North Nighasan	Latua-FR	99	28.30000	81.00722	28.29250	80.99167	2	0	0	0	0	0	38	100	0	13	0	0	0	0
North Kheri	North Nighasan	Majra-FR	100	28.28361	81.02583	28.28056	81.03833	1.6	0	0	0	0	0	0	14	0	86	0	0	0	0
North Kheri	North Nighasan	Bahira-FR	101	28.26278	80.99583	28.26056	81.02028	3.2	0	0	0	0	0	69	69	0	23	0	0	0	0
Narendra Nagar	Bhageerathi	Kara sot	102	30.14139	78.29694	30.14889	78.30000	2.7	0	0.37	0	9	9	27	0	0	0	0	0	0	0
Pilibhit	Barahi	Sarda river	103	28.81444	80.11472	28.84639	80.12194	4	0.25	0.25	13	31	75	63	81	0	88	0	0	56	0
Pilibhit	Barahi	Sarda river	104	28.81472	80.11417	28.77361	80.13889	5	0	0.2	0	30	0	5	0	0	25	0	0	20	0
Pilibhit	Mahof	Forest road	105	28.69028	80.06750	28.69444	80.02028	5	0.4	0	35	0	0	85	95	0	90	0	0	0	0
Pilibhit	Mahof	Forest road	106	28.70083	79.99500	28.70917	79.96500	3	0.33	0	8	0	8	100	67	0	100	0	0	0	0
Pilibhit	Mahof	Forest road	107	28.71389	79.95833	28.69444	79.94444	9.1	0.33	0	33	0	0	100	86	44	100	0	0	0	0
Pilibhit	Mala	Forest road	108	28.66250	79.94278	28.62306	79.93111	4.3	0.23	0	6	0	0	100	100	0	76	0	0	0	18
Pilibhit	Mala	Forest road	109	28.62500	79.93861	28.59917	79.92889	2.7	0	0	0	0	0	64	100	0	82	0	0	0	18
Pilibhit	Mala	Forest road	110	28.58806	79.93389	28.55500	79.97278	5	0.2	0	10	0	10	95	45	0	95	0	0	0	10
Pilibhit	Barahi	Forest road	111	28.68139	80.13444	28.64361	80.16722	5.7	0.35	0	26	0	0	100	100	0	100	0	0	0	0
Pilibhit	Mahof	Forest road	112	28.74833	80.08639	28.72917	80.07083	2.6	1.15	0	36	0	9	100	27	9	73	0	9	0	9
Pilibhit	Mahof	Forest road	113	28.72917	80.07083	28.77389	80.05917	5	0.4	0	20	0	0	95	35	0	90	5	0	0	0
Pilibhit	Barahi	Forest road	114	28.68306	80.13278	28.70583	80.15194	3	0.33	0	17	0	0	100	0	0	100	0	0	0	0
Pilibhit	Barahi	Forest road	115	28.64500	80.16861	28.66806	80.19139	3.1	0.65	0.32	15	8	0	85	8	0	92	0	0	0	0
Pilibhit	Deoria	Forest road	116	28.34889	79.97528	28.36556	79.94278	3.6	0	0	0	0	0	7	80	0	27	13	0	0	0
Pilibhit	Deoria	Forest road	117	28.33472	79.97167	28.30750	79.96111	3.3	0	0	0	0	0	85	85	8	62	0	0	0	0
Pilibhit	Deoria	Forest road	118	28.43528	79.99778	28.39000	79.97833	5	0	0	0	0	0	25	100	0	95	0	0	0	0
Pilibhit	Deoria	Forest road	119	28.48944	79.99806	28.49528	80.03556	4.3	0	0	0	0	0	71	100	0	100	0	0	0	0
Pilibhit	Haripur	Forest road	120	28.50806	80.29083	28.50500	80.2575	3.3	0.91	0	31	0	0	100	100	0	100	0	0	0	0
Pilibhit	Barahi	Forest road	121	28.57111	80.23278	28.57917	80.20722	5	0.2	0	5	0	0	80	95	0	100	0	0	0	0

Pilibhit	Haripur	Forest road	122	28.56722	80.25056	28.56694	80.29000	3.7	0	0	0	0	0	100	47	0	100	0	0	0	0
Pilibhit	Haripur	Forest road	123	28.46861	80.28667	28.46639	80.30778	2	0	0	0	0	0	50	75	0	63	0	0	0	0
Pilibhit	Haripur	Forest road	124	28.46639	80.30778	28.49611	80.3075	3.1	0.32	0	8	0	0	100	85	0	100	0	0	0	0
Ramnagar	Fatepur	Bhakra-upstream	125	29.26806	79.42222	29.23917	79.41722	3.7	0.27	0	7	0	13	40	67	0	0	0	0	7	0
Ramnagar	Fatepur	Bhakra-downstream	126	29.27306	79.42194	29.29667	79.42972	3.2	0	0.31	0	15	85	54	23	0	54	0	0	0	0
Ramnagar	Fatepur	Machhiyagat sot	127	29.26417	79.45778	29.27333	79.48194	3.5	0	0.29	0	7	93	0	0	50	7	0	0	0	0
Ramnagar	Fatepur	Nihal Nadi	128	29.27583	79.39944	29.30139	79.40333	3	1	0.33	42	8	83	100	67	17	17	0	0	0	0
Ramnagar	Kaladungi	Gumiyapani river	129	29.30222	79.37028	29.31833	79.36694	2.5	1.2	0	30	0	90	0	0	0	0	0	0	10	0
Ramnagar	Kaladungi /Dechurie	Baur river	130	29.24972	79.32083	29.22167	79.30194	4	0.5	0.25	38	19	50	50	44	13	25	0	0	0	0
Ramnagar	Kaladungi	Bour river	131	29.30694	79.33833	29.33500	79.33472	5	0.4	0.2	20	15	95	50	0	0	55	0	0	30	0
Ramnagar	Koshi	Koshi river	132	29.55361	79.14083	29.54389	79.11222	3	0.67	0	25	0	75	83	0	0	33	0	0	0	0
Ramnagar	Koshi	Koshi river	133	29.51444	79.11778	29.54444	79.11167	5	0.8	0	15	0	95	95	10	0	95	0	0	0	0
Ramnagar	Koshi	Koshi river	134	29.41722	79.13222	29.45389	79.14944	5	0.8	0	35	0	70	90	80	0	25	0	0	10	0
Ramnagar	Kota	Bangajala nala	135	29.4725	79.16389	29.46111	79.19972	5	0.6	0.2	45	5	95	95	20	30	20	0	0	10	0
Ramnagar	Kota	Kolygard sot	136	29.41611	79.21806	29.43028	79.24833	4	1	0.5	50	13	100	100	0	0	94	0	0	0	0
Ramnagar	Kota	Chahal sot	137	29.40833	79.22861	29.41722	79.26222	5	0.6	0.2	25	5	100	100	0	45	45	0	0	0	0
Ramnagar	Dechewrie	Dhapka river	138	29.37222	79.24806	29.40194	79.28028	5	0	0.8	0	40	85	35	0	0	40	0	0	0	0
Ramnagar	Dechewrie	Katcharpani sot	139	29.34278	79.23861	29.36444	79.26111	4.5	0	0.22	0	6	83	11	0	56	67	0	0	0	0
Ramnagar	Dechewrie	Timalia nala	140	29.36722	79.22111	29.37806	79.23167	2	0	0.5	0	13	75	38	0	0	0	0	0	0	0
Rajaji NP	Dholkhand	Sambawali sot	141	30.09866	77.98703	30.10856	78.02581	5	0.6	0.4	20	20	95	100	0	0	0	0	0	20	0
Rajaji NP	Dholkhand	Guleria sot	142	30.10417	77.99028	30.11750	78.02694	5	0.4	0.4	25	25	90	100	0	25	30	0	0	35	0
Rajaji NP	Dholkhand	Dholkhand sot	143	30.09878	77.98663	30.12642	78.02097	5	0.8	0.2	25	5	95	100	0	5	0	0	0	25	0
Rajaji NP	Motichur	Ganges-Motichur	144	30.00083	78.21306	30.03111	78.24750	2.6	0	0.38	0	20	60	60	0	0	60	0	0	0	0
Rajaji NP	Kansrau	Kansa rau	145	30.08833	78.14444	30.07250	78.16694	3.3	0	0.61	0	46	85	92	0	0	92	0	0	0	0
Rajaji NP	Chilla	Ganges-temple	146	29.98389	78.22111	30.02306	78.25167	5.9	0	0.85	0	50	79	92	0	0	21	0	0	13	0

Rajaji NP	Kotri	Binj rau	147	30.03250	78.27611	30.00528	78.29389	3.8	0.53	0.79	27	27	100	100	7	7	33	0	0	47	0
Rajaji NP	Chilla	Dhogudda sot	148	30.03750	78.13944	30.05278	78.28056	4.5	0.44	0.22	11	17	94	100	6	0	61	0	0	39	0
Rajaji NP	Mohand	Thanda sot	149	30.21444	77.93806	30.20639	77.90972	3	0	1	0	92	83	25	0	33	83	0	0	8	0
Rajaji NP	Haridwar	Ranipur-choki rau	150	29.97000	78.10806	29.98139	78.11667	3.3	0	0.61	0	38	100	100	0	0	38	0	0	0	0
Rajaji NP	Haridwar	Ranipur rau	151	29.96333	78.10528	29.96222	78.13639	5	0	0.4	0	25	95	85	15	15	25	0	0	55	0
Rajaji NP	Chilla	Ghara sot	152	29.9525	78.26556	29.66389	78.44389	3.5	0.57	1.14	14	57	93	93	0	0	86	0	0	93	0
Rajaji NP	Chilla	Amgadi sot	153	29.94194	78.27611	29.95528	78.31472	5	0.6	0.4	65	40	95	95	0	0	55	0	0	100	0
Rajaji NP	Chilla	Jabhar dhaba	154	29.96889	78.24611	29.96944	78.28194	3.9	0	0.26	0	6	100	100	0	0	38	0	0	19	0
Rajaji NP	Chilla	Mundal sot	155	29.9725	78.22278	29.95500	78.26000	5	0.2	0.6	20	45	85	100	45	0	50	0	0	90	0
Rajaji NP	Haridwar	Bhag rau	156	29.97278	78.16167	29.99639	78.13528	3.5	0	0.29	0	21	100	86	0	0	0	0	0	100	0
South Kheri	Mailani	Forest road	157	28.42472	80.41000	28.40278	80.42222	5.3	0.19	0	5	0	43	100	100	0	100	0	0	0	0
South Kheri	Mailani	Forest road	158	28.33833	80.32250	28.13056	80.30639	5	0.2	0	10	0	0	55	100	0	20	0	0	0	0
South Kheri	Mailani	Forest road	159	28.18722	80.33528	28.21667	80.36556	4.3	0	0	0	0	0	56	94	0	94	0	0	0	0
South Kheri	Bhira	Forest road	160	28.18722	80.33528	28.20778	80.51861	5	0.6	0	10	0	0	75	100	0	100	0	0	0	0
South Kheri	Bhira	Forest road	161	28.25778	80.47694	28.30056	80.45917	5	0.2	0	25	0	0	20	100	0	95	0	0	0	0
South Kheri	Gola	Forest road	162	28.32833	80.49417	28.32833	80.49278	3.3	0	0	0	0	0	0	100	0	0	0	0	0	0
South Kheri	Gola	Forest road	163	28.14083	80.50833	28.15167	80.52667	3	0	0.33	0	8	0	8	100	0	83	0	0	0	0
Shahjhanpur	Khuttar	Forest road	164	28.39083	80.33889	28.41	80.33444	5	0	0	0	0	0	25	100	0	30	0	0	0	0
Shahjhanpur	Khuttar	Forest road	165	28.37167	80.33278	28.33833	80.34694	4.2	0	0	0	0	0	59	100	0	65	0	0	0	0
Shivalik	Mohand	Lallukhoda nala	166	30.17667	77.88972	30.19556	77.89972	3.3	0	0.61	0	15	85	38	0	0	0	0	0	8	0
Shivalik	Mohand	Hathini sot	167	30.18889	77.84361	30.21083	77.85556	3.7	0.27	0.54	14	21	71	71	14	0	14	0	0	7	0
Shivalik	Barakala	Sanshara rau	168	30.23556	77.75361	30.26972	77.77111	3.5	0	0.86	0	29	86	79	0	0	29	0	0	0	0
Shivalik	Barakala	Khotri rau	169	30.22667	77.76861	30.24694	77.79889	5	0.2	0.4	15	35	90	70	0	30	45	0	0	0	0
Shivalik	Barakala	Barbla rau	170	30.26306	77.69694	30.28194	77.73222	5	0	0.6	0	60	55	40	5	5	10	0	0	40	0
Shivalik	Barakala	Chapri sot	171	30.30639	77.64861	30.31250	77.67639	5	0.6	0.4	15	30	65	60	0	5	30	0	0	65	0

Shivalik	Barakala	Karoandi rau	172	30.37361	77.60833	30.37583	77.64417	5	0.4	0.6	5	65	100	50	0	60	95	0	0	0	0
Shrawasti	Bhinga	Forest road	173	27.75825	81.99368	27.74211	81.98714	2	0	0	0	0	0	0	63	0	25	0	0	0	0
Shrawasti	Bhinga /Kakardhari	Forest road	174	27.77583	81.90292	27.77538	81.93882	2	0	0.5	0	13	0	0	0	0	38	0	0	0	0
Shrawasti	Bhinga	Forest road	175	27.72062	81.90891	27.72586	81.98065	2	0	0.5	0	13	0	0	25	0	38	0	0	0	0
Sohagibarwa WLS	North Chauk	Payas-downstream	176	27.34028	83.55306	27.32667	83.52889	5	0	0	0	0	15	65	70	0	100	0	0	0	0
Sohagibarwa WLS	Madhuvalia	Payas-upstream	177	27.33444	83.57694	27.36194	83.60000	5	0.4	0	20	0	25	85	80	0	0	50	0	0	0
Sohagibarwa WLS	North chauk	Forest road	178	27.36556	83.55389	27.37389	83.51611	4.2	0	0	0	0	0	53	59	0	82	0	0	0	0
Sohagibarwa WLS	Nicahlaul	Forest road	179	27.27278	83.79278	27.24889	83.7625	4.8	0	0	0	0	0	15	70	0	85	0	0	0	0
Sohagibarwa WLS	Nicahlaul	Little Gandek	180	27.31972	83.77417	27.28389	83.74639	5	0	0	0	0	0	55	95	0	0	0	0	0	0
Sohagibarwa WLS	Nicahlaul	Gandek-downstream	181	27.32139	83.84194	27.28444	83.82889	5	0.2	0.2	10	20	5	70	70	5	40	5	0	0	0
Sohagibarwa WLS	Pakri	Rihai nala-upstream	182	27.13639	83.45444	27.15806	83.46389	5	0	0.2	0	10	0	35	60	0	95	0	0	0	0
Sohagibarwa WLS	Pakri	Rihai nala-downstream	183	27.13528	83.45083	27.11944	83.42389	5	0	0	0	0	0	0	75	0	0	0	0	0	0
Sohagibarwa WLS	Lakshmipur	Rohini/Payas	184	27.25139	83.49056	27.23139	83.47306	4.5	0	0	0	0	17	39	28	0	0	0	0	0	0
Sohagibarwa WLS	Shivpur	FR/trail	185	27.30211	83.93102	27.27221	83.91628	4.2	0	0	0	0	0	6	0	0	0	0	0	0	0
Suhelwa WLS	Suhelwa-west	Bhavuva nala	186	27.87472	82.04722	27.90889	82.06306	5	0	0.2	0	20	15	65	15	0	100	0	0	0	0
Suhelwa WLS	Suhelwa-west/east	Baisahi nala	187	27.84944	82.08361	27.88250	82.11139	5.5	0	0.18	0	5	36	86	5	0	64	0	0	0	0
Suhelwa WLS	Suhelwa-west	Gongri nala	188	27.90722	81.96750	27.92222	81.97722	3.5	0	0.29	0	14	64	29	21	0	29	0	0	0	0
Suhelwa WLS	Suhelwa-east	Sonpathiri nala	189	27.8175	82.13083	27.84750	82.14500	5	0.2	0.2	10	5	45	65	40	0	80	0	0	0	0
Suhelwa WLS	Suhelwa-east	Hathikunda nala	190	27.78722	82.17972	27.80111	82.19972	5	0.8	0.2	25	5	20	95	20	0	95	0	0	0	0
Suhelwa WLS	Banketwa	Hingaha nala	191	27.76306	82.20833	27.79000	82.23500	5	0.2	0	5	0	5	10	25	5	90	0	0	0	0
Suhelwa WLS	Barahwa	Amha nala	192	27.71944	82.30917	27.75417	82.32222	5	0	0.2	0	20	85	60	60	0	25	0	0	0	0
Suhelwa WLS	Tulsipur	Gauraw nala	193	27.64722	82.43417	27.68528	82.44556	5	0.2	0.4	5	10	70	85	10	15	35	0	0	0	0
Suhelwa WLS	Tulsipur	Siriya nala	194	27.67000	82.39000	27.71250	82.39139	5.5	0	0.55	0	18	5	14	86	0	18	0	0	0	0
Suhelwa WLS	Banketwa	Jamdhara nala	195	27.72583	82.26667	27.75500	82.26833	5	0	0.2	0	10	15	25	5	0	90	0	0	0	0
Suhelwa WLS	Bhambhar	Barava nala	196	27.71000	82.67528	27.67417	82.69083	6	0.17	0	8	0	29	42	0	63	67	0	0	0	0

Suhelwa WLS	Rampur	Musi nala	197	27.65000	82.57306	27.67278	82.57778	4.2	0.48	0	12	0	47	18	18	0	35	0	0	0	0
Suhelwa WLS	Rampur	Dhara nala	198	27.68806	82.52722	27.64861	82.53417	5	0.2	0	5	0	10	35	85	15	70	0	0	0	0
Terai Central	Gadgadia	Nihal rau	199	29.21500	79.35222	29.17778	79.34056	4.5	0.89	0.44	44	11	100	78	22	6	50	0	0	0	0
Terai Central	Gadgadia	Bhakra rau	200	29.22722	79.40611	29.19250	79.38611	5	0	0.4	0	10	0	15	95	0	5	0	0	10	0
Terai Central	Bahrani	Baur river	201	29.21889	79.29833	29.18361	79.27028	5	0.2	0	5	0	5	40	70	0	0	0	0	0	0
Terai Central	Gadgadia	Bhakra rau	202	29.15528	79.37806	29.18861	79.38417	5	0.2	0.2	5	15	0	20	100	0	0	0	0	0	0
Terai Central	Bahrani	Baur river	203	29.24972	79.32083	29.22167	79.30194	4	0.5	0.25	38	19	38	56	50	19	25	0	0	0	0
Terai Central	Pipelparao	Bhakra rau	204	29.15417	79.36556	29.12083	79.35389	3.9	0	0.51	0	13	81	6	88	0	88	0	0	0	0
Terai Central	Pipelparao	10 no.nala	205	29.08778	79.39556	29.10222	79.41306	3.5	0	0	0	0	0	0	100	0	93	0	0	0	0
Terai Central	Thanda	Ganga patia	206	29.03472	79.50778	29.03028	79.50778	2.5	0	0.4	0	10	0	0	90	0	0	0	0	10	0
Terai Central	Haldwani	Fireline	207	29.11139	79.46694	29.08583	79.44361	4.9	0.2	0.2	5	5	0	75	85	0	0	0	0	0	0
Terai Central	Bahrani	Gadappu nala	208	29.24000	79.27500	29.22583	79.24333	5.1	0	0	0	0	0	0	100	0	75	0	0	0	0
Terai East	Surai	Forest road	209	28.79528	80.01278	28.83139	80.01139	5	0.2	0.2	30	10	0	60	0	30	60	0	0	0	0
Terai East	Surai	Fire line	210	28.80750	79.98056	28.80583	79.93722	5	0	0.2	0	5	0	75	45	0	75	0	0	0	0
Terai East	Surai	40-Choraha	211	28.79639	80.01083	28.74972	80.03028	4.1	0.49	0.24	29	6	24	24	76	0	94	0	0	0	0
Terai East	Kishanpur	Katna nala	212	29.07028	79.61778	29.05722	79.62861	2.2	0	0	0	0	100	0	0	0	89	0	0	0	0
Terai East	Doli	Forest road	213	29.07250	79.59028	29.07472	79.61083	5	0	0	0	0	0	40	15	0	0	0	0	0	0
Terai East	Ransali	Dedwa rau	214	29.06056	79.74556	29.04250	79.76278	3.5	0	0	0	0	29	100	100	0	100	0	0	0	0
Terai East	Kishanpur	Sukhi Nadi	215	29.06972	79.64889	29.10722	79.65139	5	0.6	0.2	25	15	10	100	95	25	40	0	0	0	0
Terai East	Katima	Jagpura rau	216	28.96556	80.06000	28.93167	80.06806	5	0	0.6	0	45	0	25	45	0	60	0	0	0	0
Terai East	Kilpura	Lohia nala	217	29.01417	79.99417	29.04083	80.00444	4.1	0.73	0.24	41	6	76	82	0	12	24	0	0	41	0
Terai East	Kilpura	East Kilpura	218	29.00806	80.01472	29.01806	80.05	4.3	0.23	0.47	6	24	76	82	29	0	6	0	0	41	0
Terai East	Jaulasal-south	Bhargath nala	219	29.07194	79.78444	29.03861	79.77667	5	0	0.2	0	0	0	0	0	0	0	0	0	0	0
Terai East	Ransali	Hatgad nala	220	29.06444	79.70361	29.04111	79.70472	5	0	0	0	0	20	45	5	205	0	0	0	20	0
Terai East	Ransali	Kailash river	221	29.05417	79.88056	29.03028	79.87	5	0	0	0	25	0	0	0	0	5	0	0	0	0

Terai West	Belparao	Karkat nala	222	29.33694	79.23111	29.31083	79.21361	4	0.75	0.25	25	25	63	75	0	69	75	0	0	0	6
Terai West	Belparao	Dhapka river	223	29.35139	79.16333	29.35833	79.19556	3	0.33	1	8	25	58	100	75	0	92	0	0	0	0
Terai West	Belparao	Chumakhan nala	224	29.29528	79.25472	29.31306	79.27972	5	0.4	0	15	0	85	90	40	0	25	0	0	0	0
Terai West	Bannabhera	Gadappu nala	225	29.24111	79.27583	29.27250	79.30111	5	0	0.2	0	5	0	5	100	0	75	0	0	0	0
Terai West	Ampokra	Dhela rau	226	29.34750	79.00750	29.39667	79.01528	5	0.4	0.2	15	5	65	75	55	0	65	0	0	0	0
Terai West	North Jaspur	Pikha pathi	227	29.38917	78.90306	29.39361	78.90583	1	1	1	25	25	0	100	100	0	75	0	0	0	0
Terai West	Ampokra	Patharuva nala	228	29.36139	78.97556	29.39417	78.97556	4.7	0.21	0.43	11	32	42	84	74	0	53	0	0	37	0
Valmiki TR	Manguraha	FR/trails	229	27.31526	84.5426	27.33837	84.55674	4.5	0.22	0.44	6	17	56	67	0	0	0	0	0	0	0
Valmiki TR	Manguraha	Pandai river	230	27.33431	84.60908	27.32863	84.57514	5	0	0.2	0	5	10	0	15	0	45	0	0	0	0
Valmiki TR	Manguraha	FR/trails	231	27.27017	84.62654	27.26311	84.64967	5	0	0	0	0	0	0	10	0	50	0	0	0	0
Valmiki TR	Manguraha	FR/trails	232	27.26295	84.66951	27.25034	84.65525	2	0	0.5	0	13	0	100	13	0	0	0	0	0	13
Valmiki TR	Manguraha /Govardhana	Gidahi	233	27.32090	84.47874	27.34138	84.46012	5	0	0.2	0	5	65	35	10	15	0	0	0	0	10
Valmiki TR	Govardhana	Pathygar rau	234	27.31141	84.41609	27.32554	84.4165	3	0	0.33	0	8	83	83	25	0	25	0	0	0	0
Valmiki TR	Manguraha	Ammoha Nadi	235	27.30835	84.51558	27.31961	84.4958	4	0	0	0	0	25	0	19	75	0	0	0	0	56
Valmiki TR	Govardhana	Sukada nala	236	27.3184	84.34507	27.32912	84.34602	1.5	0.67	0	17	0	67	67	17	0	0	0	0	0	17
Valmiki TR	Raghia	Bhakna Nadi	237	27.32969	84.27427	27.3545	84.27562	3.6	0.28	0	57	0	86	7	0	50	0	0	0	0	57
Valmiki TR	Raghia	Bichuri river	238	27.38956	84.19798	27.40806	84.20172	3	0	0.33	0	8	17	0	0	67	42	0	0	0	0
Valmiki TR	Govardhana	Balooha rau	239	27.45370	84.16180	27.44012	84.16163	4	0	0.25	0	6	81	56	0	0	38	0	0	0	0
Valmiki TR	Govardhana /Raghia	Singaha nala	240	27.33154	84.30538	27.34813	84.31204	2	0.5	0	25	0	13	0	13	0	100	0	0	0	0
Valmiki TR	Chutaha	Bhapsa Nadi	241	27.36266	84.06990	27.34042	84.04522	5	0	0	0	0	0	0	0	5	25	0	0	0	0
Valmiki TR	Chutaha	Kirwania sot	242	27.27813	84.18684	27.30339	84.1863	4	0	0	0	0	0	0	0	63	0	0	0	0	6
Valmiki TR	Hanatarn	Kosil rau	243	27.29502	84.10886	27.32164	84.12123	4.3	0	0.7	0	11	50	67	39	0	100	0	0	0	0
Valmiki TR	Ganoli	Pachmol rau	244	27.44248	83.95484	27.44404	83.99904	5	0.4	0.4	10	10	70	40	0	0	55	0	0	0	0
Kalsi	Timili	Mundiawala rau	245	30.24209	77.60540	30.40528	77.61168	3.1	0	0.32	0	15	46	23	8	0	31	0	0	0	0
Kalsi	Timili	Binol rau	246	30.40304	77.58527	30.39956	77.60259	3	0	0	0	0	83	25	0	0	25	0	0	0	0

Appendix IX: Status of corridors identified in TAL

1. Yamuna river corridor

The tiger habitats on the banks of Yamuna river vary in size and conservation status. The forests on the left bank of the river are in Shivalik FD (332km^2), Uttar Pradesh and Kalsi FD (293km^2), Uttaranchal. These forests are contiguous with Dehradun FD (510km^2), Narendranagar FD (part, 150km^2) and the western portion of Rajaji NP (west of Ganga river), which together constitute a single block of ca. 1800km^2. The tiger habitat on the right bank of Yamuna river is limited to the Kalesar forests (ca. 150km^2, Kalesar WLS, Haryana) and Simbalbara forests (ca. 50 km^2, Simbalbara WLS, Himachal Pradesh). Surveys in December 2002 and January 2003 indicated that one or two tigers range from Badshahibagh Range of Shivalik FD to Kalesar and Simbalbara WLSs.

There are five *rau*s in Badshahibagh Range that flow into the Yamuna river (left bank) through aqueducts built under the Yamuna canal (Ghara canal). Of these, the Karaundi and Bari Lui *rau*s are 10-30m wide, while the rest are about 5m wide. There is a *gujjar* camp near the aqueduct of Binaul *rau*, and a grass-cutters' camp near the exit of the Karaundi *rau* aqueduct. Other *rau*s or *nallah*s are free from human settlements. Tigers can move along any of the *rau*s, come to the Yamuna riverbed via the aqueducts, walk west diagonally across the riverbed into Kalesar WLS between Bohra village (Majra Range, Paonta FD, Himachal Pradesh) and Mamduwas village of Kalesar WLS, from where they can move into Simbalbara WLS. Earlier observations by staff of the Himachal Pradesh Forest Department indicate that the tigers move back to Shivalik FD at the end of winter. Unfortunately, the entire riverbed along the Bohra–Mamduwas–Hathnikund stretch, a distance of 9km, is highly disturbed by boulder collection in the riverbed. The following need to be done immediately if the tigers are to continue to range between Shivalik FD and forests, west of Yamuna river:

The *gujjar* camp near the Binaul *rau* aqueduct should be shifted, at least a kilometer inside the forest.

The grass-cutters' camp near the exit of Karaundi *rau* aqueduct should be shifted away.

The other smaller *rau*s and their aqueducts need to be kept free from human disturbance.

Boulder collection between Bohra and Mamduwas village (this stretch belongs to Himachal Pradesh) and between Mamduwas and Hathnikund (this stretch belongs to Haryana) should be banned.

Anthropogenic pressures from the villages on the eastern and southern boundaries of Kalesar WLS should be contained, so that at least 50km^2 of Kalesar WLS will remain a disturbance-free core area.

The stretch of ca. 7km between Kaludeo *rau* and Barudev *nalla* of Simbalbara WLS should be kept free from human disturbance, as a mini-core. Presently, *gujjar*s and villagers move with their livestock from Sudanwala to Haryana via Simbalbara, disturbing this proposed mini-core.

It is important to provide a special status to these forests (like establishing Rajaji-Shivalik Tiger Reserve), with satellite cores in Kalesar WLS and Simbalbara WLS (Johnsingh *et al* in press). This conservation programme would require commitment and coordination between the State Governments of Uttaranchal, Uttar Pradesh, Haryana and Himachal Pradesh, and the Government of India. This initiative along wth *gujjar* relocation, control of boulder collection and other anthropogenic pressures would enable revival of the tiger population in its northwestern range on both the banks of Yamuna river.

2. Kansrau–Barkote corridor

A 2km stretch of forests between Lal Thapar and Chiddarwala village on the Dehra Dun–Haridwar Highway connects Kansrau Range of Rajaji NP and Barkote Range of Dehra Dun FD. This corridor stretch and Barkote Range itself are subjected to high disturbance arising from wood cutting and grazing. At present, prey availability in the Barkote Range is extremely poor, and therefore tiger use of this Range and corridor is low. The proposed 4-lane (Delhi-Haridwar-Dehra Dun) highway further threatens the viability of this corridor. Regulation of vehicular speed and minimization of hazards to wild animals attempting to cross the highway are required to be put in place. Eventually, it may be desirable to use the portions of Barkote Range closer to Rishikesh for resettling villages such as Gangabhogpur Talla and Malla and Kunaun *goth*, which can cause enormous problems to the tiger habitat on the east bank of Ganges. Tigers and other wildlife may increasingly use this corridor if anthropogenic disturbances to Dehra Dun FD, Rajaji NP and the corridor stretch are brought under control.

3. Chilla–Motichur corridor

As late as the 1950s, the summer concentration of elephants as presently seen on the banks of Ramganga river in Dhikala in Corbett TR was an annual wildlife spectacle even on the banks of Ganga river (Singh 1978, 1989). This assembly does not occur any more, and the forest connectivity between Chilla and Motichur portions of Rajaji National Park has been severely hampered, ever since the land between Rishikesh and Haridwar was subjected to enormous changes over the last 40 years. Specifically, (i) expansion of Haridwar and Rishikesh townships and Raiwala village, (ii) establishment of Raiwala Army Camp with the ammunition dump, and the Hindustan Antibiotic Factory, (iii) establishment of Khand *Gaon* settlements (I, II and III) on the west bank, for the Tehri dam evacuees and (iv) construction of the 14km long Rishikesh-Chilla power channel on the east bank have contributed to disruption in the habitat connectivity.

At present, movement of elephant bulls and other wildlife such as sambar, chital, wild pig and nilgai, is restricted to the forests along Motichur (between Motichur *rau* and Raiwala village) on the west bank and Chilla/Gauri Range (between Suni *sot* and Dogudda *rau*) on the east bank. Wildlife Institute of

India identified this crucial stretch as the Chilla–Motichur Corridor, way back in 1980s. The islands on the Ganga river in this corridor are critical for safe passage of large mammals. Also, it is pertinent to note that the Binj *rau* corridor identified by Uttar Pradesh Forest Department is no longer viable, as the west bank of Ganga river, opposite Binj *rau*, is under human occupation and agriculture. Even in 1988, when WII studied this corridor, there were very few elephant signs in the Binj *rau* area (Johnsingh *et al.* 1990). This brings forth the criticality of the Chilla–Motichur corridor in enabling movement of large mammals between the forests on the west and east bank of Ganges. This corridor is extremely crucial for charismatic species like elephant and tiger, as their population to the west of the Ganga river represents the northwestern limit of their distribution range. When we strive to envisage and implement a concept like Terai Arc Tiger Conservation Landscape, extending from Yamuna river to Bhagmati river in Nepal, this corridor is of great consequence. The elephant and tiger habitat west of Ganga river (ca. 1800 $km^{2)}$ will become isolated from the adjoining habitats east of Ganga river if a permanent breakage is allowed to develop along this corridor. Establishment and reinforcement of this corridor require immediate action on the following:

- **Relocation of Khand Gaon (settlement):** The 30 or so households of the Khand *Gaon* III should be shifted to the relocation site already identified by the Uttaranchal Forest Department near Rishikesh in the Dehra Dun FD. This will create a 600m wide corridor between the Motichur forests and the Army Camp. The relocation site is not of great consequence for wildlife values as it is situated at the extreme western end of the highly disturbed elephant range, and elephant use of this area is negligible. However, its proximity to the Haridwar–Rishikesh road and a perennial spring should make the relocation site attractive to the Khand Gaon III villagers. The present location of the village is away from the road with inadequate water provision and educational facilities for children. Once the village is relocated, the wall built to prevent crop depredation between Motichur *rau* and Khand Gaon III village, should be pulled down.
- **Shifting the army ammunition dump:** The army ammunition dump should be shifted out of the corridor area. There is sufficient land near the Army Camp to build this dump and the Army could take a lead in this conservation programme by vacating the area at the earliest. This request is being made since 1990 (Johnsingh *et al.* 1990).
- Disturbances originating from Raiwala (including Khand Gaon II village and the Army Camp) and Haridwar township into the corridor area should be contained. This could be achieved by (i) building a wall south of Khand Gaon II, from Haridwar-Raiwala road to the west bank of Ganga river (given the Army ammunition dump is shifted), (ii) placing two 'Corridor Guards' to prevent woodcutting by people of Haridwar township and (iii) planting a belt of trees such as *Polyalthia longifolia* along the right bank of Motichur *rau* (so that the *rau* remains dark at night). This 60-80m broad *rau* is very

important for large mammal movement, including elephants, between Motichur forests and Ganga river. The road and rail bridge over this *rau* is high enough to permit even large elephant bulls to pass under.

- No further development should be allowed around the place of worship, on the west bank between the Army Camp and the river. There is an unpaved road from Haridwar to the place of worship, which needs to be blocked to prevent vehicular traffic. On no account should this road be upgraded to an all weather road.
- The islands on the Ganga river need total protection from any form of human use such as cattle grazing, camping and wood cutting.
- Daytime traffic on the power channel road on the east bank between Chilla and Rishikesh is largely between the *ashrams* on the left bank of Ganges. Such traffic can be and should be considerably reduced if a bridge is built across the river near Lakshman *jhula* at Rishikesh. Night traffic on the existing road should be stopped.
- **Relocation of Gangabhogpur villages and Kunaun goth:** Gangabhogpur, a village of about 30 households on the east bank of Ganga river between the river and the channel, should eventually be resettled. This village was settled at its present location in the early 1960's when the original village in the nearby Outer Himalayan range began to sink as a result of the unsettled nature of the fragile Himalaya. Unfortunately, this village is situated close to ca. 2km riverine forest, the only patch of forest that is still being used by tiger and elephant along the entire length of the Ganges (ca. 2500km) and if this village is not shifted, the resource demands arising from this village will eventually destroy this unique riverine forest. After the translocation of this village, a few rhino, barasingha and hog deer, which must have ranged here in the past, can be released into the marshy area between the canal and the river within an enclosure protected by electric fence. This will add to the wildlife values of this area.

  Translocation of Gangabhagpur Malla village with about 150 households and Kunaun *goth* with about 70 households is also desirable. Sufficient land for the relocation of these villages could be found in Barkote Range, Dehra Dun FD that is increasingly losing values for large mammal conservation as a result of pressures arising from firewood collection and sale into Rishikesh town. The narrow bridge across the Chilla power channel in front of Kunaun *goth* should be either closed or dismantled so as to protect the Bidasani forest block of ca.15-20km^2, an excellent tiger breeding site given its hilly terrain and dense vegetation.
- **Flyover between Haridwar and Raiwala:** Heavy vehicular traffic along the Haridwar–Raiwala road and rail traffic between Dehradun and Haridwar are preventing the daytime crossing over of

large mammals across Chilla-Motichur corridor. The proposed plans to widen the road will only exacerbate the situation and should be dropped. Instead, the Uttaranchal Forest Department, Ministry of Environment and Forests, Government of India, and conservationists need to take a firm and unanimous stand on the construction of a flyover between Haridwar and Raiwala, which allows large mammals to move unhindered below the flyover. However, impacts associated with the construction phase of a flyover are expected to be significant. These would largely result from clearing of the area, man and material movement, disposal of debris and the ensuing physical disturbance during the construction phase. Some of these impacts can be minimized by careful planning of the construction operations, ensuring use of pre-fabricated structural elements and completion in the shortest possible time. Further, habitat restoration may be required to compensate for the likely habitat degradation during construction (Rajvanshi *et al.* 2001). The underpass that would be created by the construction of the flyover will have to be kept free from human use through access control. Till such time that the flyover is built, there should be adequate regulation of the traffic along the Haridwar–Raiwala highway at night (between 2200 and 0400 hours) from February to June (dry season), when more animals move to the Ganga river. The traffic should either be allowed to move only at intervals of 60 minutes or speed breakers should be put in place, to allow animals more time to cross and avoid road kills. Earlier recommendation of Johnsingh (2002) to have a tunnel between Haridwar and Raiwala should be discarded.

- Relocation of *gujjars* from the entire Rajaji NP should be completed at the earliest, which will lead to significant decline in disturbance levels, the consequent recovery of prey populations and enhanced breeding of tigers on both the banks of river Ganges. With an increase in the population, tigers will start using the corridor once it is established.

Establishing the Chilla–Motichur corridor, which we have been demanding for the last two decades, is an acid test for Indian conservation efforts.

4. Rajaji–Corbett corridor

The forest ranges in Lansdowne FD, Laldhang Range (94km^2) to the west and Kotdwar Range (92km^2) to the east form the corridor between Rajaji NP and Corbett TR. In the past, there was a continuous stretch of forests south of the hilly tract between the eastern end of Rajaji NP (Rawason river, west of Laldhang village) and Khoh river (northeast of Kotdwar town). Over the years, these foothill forests in Kotdwar Range and the eastern part of Laldhang Range were lost to human settlements and agricultural frontier expansion, confining habitat connectivity to the hills. This narrow hilly corridor and the adjacent forests have come under immense anthropogenic pressures from *gujjar* and *bhotia dera*s (settlements) and villages situated on the northern and southern boundary. In 2002, Laldhang Range had

34 *gujjar dera*s with 203 *gujjar*s and 330 buffaloes, and 4 *bhotia dera*s with 17 persons, 800 sheep and 250 goats. There were 50 villages within a 5km belt along the southern boundary of this corridor. These villages had about 4000 households with a human population ranging between 20,000 and 30,000. There were 40 trails leading into the 27km long boundary of this corridor between Laldhang and Kotdwar. These trails were being used for fodder and fuel wood collection and livestock grazing. *Gujjar*s from this area should be resettled on a priority basis, and *bhotia*s should not be given permission to use this area. Similarly, along the hilly northern boundary of the corridor, 36 villages were enumerated with about 3,000 families consisting of 15,000-20,000 people in a 3km wide stretch.

The corridor patches between Rajaji NP and Khoh river (west of Corbett TR) need immediate attention, and the anthropogenic disturbances emanating from the villages and Kotdwar township need to be controlled. As of now, tiger use of this corridor is extremely low (Johnsingh and Negi 2003). Appropriate ecodevelopment measures for the villages along the northern boundary should address fodder and fuel requirements, to minimize impact on the corridor forests. There are five streams in this corridor: Rawasan, Malan and Khoh (perennial), and Maili and Sigaddi (these two have water up to the boundary of the forest till the end of March). Rawasan supplies water to Laldhang village and Khoh to Kotdwar town. The crucial role of this forest patch in regulating water availability could form the cornerstone in developing a conservation ethic amongst people of the villages benefiting from these streams. Measures including conservation education, ecodevelopment and anti-poaching programmes would go a long way in making this corridor suitable for tiger and other large mammals.

5 Kalagarh corridor

The construction of a reservoir across the Ramganga river, and Kalagarh township on the southwestern boundary of Corbett TR in the early 1970s, have curtailed the movement of tigers across the Ramganga river, south of the reservoir, from Corbett NP to Sonanadi WLS. Occasionally, tigers come down from the Reserve along the *Sukha sot,* east of Kalagarh–Saddle Dam road, to the Ramganga river and cross over into Sonanadi WLS. The *Sukha sot* area needs total protection from disturbances such as wood cutting arising from Bikkhawala village with about 1200 people.

The Kalagarh project and township was built on 90km^2 of forest land, and according to an agreement between the Irrigation and Forest Departments, 3.5km^2 of this area should have been vacated and returned to the Forest Department soon after the completion of the construction of the reservoir. After much persuasion, 3.1km^2 were returned by the Irrigation Department. The remaining area has colonies with about 4000-5000 encroachers. Subsequently, the Forest Department, supported by NGOs, has filed cases in the court of the Sub-Divisional Magistrate, Kotdwar for eviction against 724 individuals and their families. The encroachers in the Kalagarh colony should be evicted, which will be

possible only when the Government of India, the Government of Uttaranchal and NGOs interested in the conservation of Corbett TR, work together.

6 Kosi river corridor

The Kosi river flows between Corbett TR and Ramnagar FD, and although there are human habitations along the river, forest connectivity is available in four places: for a stretch of 5km between Mohan and Kumaria; 1.5km between Dhangari gate and Sunder Khal; 100m between the two blocks of Sunder Khal; and 6km between Infinity Resorts and Bijrani. In 1974, about 400 people, prompted by *Parvati Shilpkar Samiti – Sunder khal* (beautiful home), encroached into the western Kunkhet Beat, Dhulwa Block 5, 9 and 11, an area of 73.84 ha. This area was once famous for abundant wild pig and was hence called *Suer khal*, and is located in the Kosi Range of Ramnagar FD. The encroachment destroyed a teak plantation, which was raised by the Forest Department in 1971. The Forest Department filed cases in the Kashipur Court to evict these encroachers: 24 cases in 1974-75, 114 in 1989 and 131 in 1990, a total of 269. The Kashipur Court in 1992 gave a verdict that 172 families should leave, but no directives were given for the other 97 families. The 172 families refused to leave as they were not given resettlement sites at a single place. As per the 1999 census, 300 families with 1500 individuals lived there, most with voting rights. There were ca. 100 houses and 200 temporary huts. The growing problems of Sunder Khal, an encroachment since 1974, now 3.5 km long, along the right bank of Kosi river, is the major threat to this corridor. The people depend on the adjacent areas of Corbett TR for fuel, fodder and small timber. This dependency, which will only grow in the years to come, will be severely detrimental to the Reserve. The 3.5km long encroachment is also an impediment to animals moving from the Reserve to Kosi river for water.

The forests between Mohan and Kumaria villages should be made disturbance-free, by shifting the Indian Medicines Pharmaceutical Corporation Limited to a location closer to Ramnagar town. Most of this company's 200 or so employees come from this town, which is ca. 15km away from the present location of the factory. Another commercial unit Gargia Chemicals, where less than 10 people are employed, should be immediately closed. There is a colony of 15-20 huts, ca. 75m north of Mohan, on the way to Kumaria. The people in this colony earn their livelihood by cutting firewood and selling it in Ramnagar. Immediate attention is needed to address this problem. The encroachers at Sunder Khal could be resettled in Gabua forest patch (13km^2), between Ramnagar and Kaladhungi, in Terai West Forest Division. Gabua is surrounded by human habitation, and may eventually be encroached by the people or alternatively be used by the Government for some other purpose. The connectivity between Infinity Resorts and Bijrani can be improved if the two small villages, Ringora and Amdanda, are resettled. Similarly, shifting of Tedha forest village on the left bank of Kosi river (Ramnagar FD) would go a long

way in strengthening this corridor. All these three villages originated as cattle camps, and together have about 80 families.

Habitat restoration measures are immediately needed in the corridor patches identified between Kumaria–Mohan, Dhangari and the western block of Sunder Khal, and between Infinity Resorts and Bijrani. Planting of teak and other plants that provide cover (e.g. bamboo *Bambusa arundinacea* and *Dendrocalamus strictus* and browse (e.g. *Zizyphus mauritiana*) would be useful. The survival of the planted species could be improved by planting saplings (of 3-4 years) in the beginning of rainy season. Provision of cover in these teak plantations would facilitate large mammal use of this area.

7 Boar river corridor

This forest patch provides connectivity around Kaladhungi, the winter home of Jim Corbett, in Ramnagar FD. Boar river corridor needs total protection from infrastructure development and excess tourism. The buildings of Sterling Resorts, the construction of which was stopped by the Supreme Court, should be dismantled and taken away from the forest area. The Uttaranchal Government should acquire other private holdings in this corridor area in order to keep the area relatively disturbance free.

8 Nihal–Bhakhra corridor

The 4km wide Nihal–Bhakhra corridor is between Boar river and Gola river, and connects Ramnagar FD with Terai Central FD. Within the corridor area, there are seven villages – Bedrampur, Pratappur, Kharakpur, Lachchampur, Rampur, Sakatpur and Sherpur with a human and cattle population of 4000 and 3000, respectively. However, the major threat to this corridor is from clear felling for agriculture, besides legal and illegal commercial felling. The Nihal–Bhakhra corridor area needs intense management input in the form of ecodevelopment measures in the surrounding villages to arrest disturbances to the corridor area. The connectivity between Ramnagar FD and Central Terai FD if lost will in turn jeopardize any opportunity to revive the Gola river corridor.

9 Gola river corridor

Growth of Haldwani town and Lal Kuan industrial complex, on the southern periphery Haldwani has caused a major break in the tiger range. Heavy day and night time traffic along Haldwani–Lal Kuan road, and large-scale boulder mining involving hundreds of labourers along the Gola river from October to June, have also contributed to this fragmentation. The firewood demands of these labourers, camping in the riverbed, are decimating the Doli Range of Terai East FD and Tanda Range of Terai Central FD. There is a possibility of restoring the continuity between Terai East and Terai Central FDs by translocating the timber depot of the Uttaranchal Government north of Lal Kuan to a location east of the

Haldwani–Lal Kuan road and west of Gola river. This area is sparsely populated by illegal settlers of boulder collectors in Gola river. It will be crucial to ban sand and boulder mining in the entire stretch of Gola river and declare this stretch as an '**ecologically sensitive zone**'. Intensive regeneration of forests on either side of this corridor, particularly of Doli Range, by planting of suitable fodder tree species and bamboo, and protection from grazing and cutting should also be carried out.

10 Kilpura–Khatima–Surai corridor

Encroachments and infrastructure development have caused a distinct break in the tiger habitat in the Khatima Forest Range, between Kilpura and Surai Ranges of Terai East FD. Khatima Range (Terai East FD) is surrounded by Nepal to the northeast (Kanchanpur tehsil and Mahendra Nagar district), Sharda Range of Haldwani FD to the north, Kilpura Range to the northwest, Khatima township to the southwest, Surai Range to the south, and by cultivation to the southeast. Major landmarks in this corridor are Jagbora river (28º 58′ 31.6N, 80º 03′ 24.4E), Sannia *nallah* (28º 58′ 09.2N, 80º 01′ 52.2E) and Lal Kothi (28º 56′ 30.5N, 80º 01′ 10.9E). The forests of Khatima Range are a vital link in the chain of connectivity between Haldwani FD, Pilibhit FD and the forests in Nepal, and can serve as a corridor for several large mammal species, including tigers and a population of ca. 30-40 elephants that are currently confined to Haldwani FD and part of Terai East FD. Terai East FD faces severe encroachment problems as exemplified by Khatima Range (92km^2), of which, at least 6km^2 is under encroachment by about 800 families. The forests of Khatima are highly disturbed from settlements (Pachoria, Ghosi Kuan, Amanwa, Burahi) along the right bank of the Sharda Canal. As a result, the movement of large mammals between Kilpura and Surai ranges has almost come to an end. A few elephants occasionally cross the Sharda Canal and move into the Nepal forests across the Jagbora river, but this movement is limited by settlements (e.g. Banbasa and Devipura Majgain) along the left bank of the canal. There is a need to establish a 7km long and 3-4km wide corridor between Kilpura Range and Surai Range to maintain connectivity in this part of TAL.

Another problem to this corridor emanates from five *goth*s or settlements at Panthagoth, Jhamnabari, Rajana, Jungla and Berigot, with a total of 50 households, along the west (right) bank of Jagbora river, in Kilpura Range. The Colonial Administration encouraged these settlements, to maintain labour for forestry operations. Any effort to establish the Kilpura–Khatima–Surai corridor should include the resettlement of these *goth*s. Encroachments in this area, as a result of settlements such as Pachoria, Ghosi Kuan, Amanwa, Bhurai and Devipura Majgain need to be evicted on a priority basis. Lal Kothi bridge should be closed to woodcutters, so that Khatima forests between Sharda Canal and Jagbora river (Chhini Compartment 13 & 14) can be protected and revived. The Government of Nepal should be requested to initiate special ecodevelopment measures for the villagers on the banks of Jhagbora river on the Nepal side, in order to reduce their dependency on Khatima forests. Besides encroachment, Khatima

Range has suffered due to establishment of NAPIERS, an Army camp, in the year 1966-67 which led to the loss of 3.39km^2 forest areas. Further, Banbasa Hydel Project in 1952-54 and, Sharada Sagar and Sharda Main Canal in 1955-56 to 1959-60 have led to a loss of 0.25km^2 and 1.30km^2 forest areas respectively. Encroachment related habitat loss has been exacerbated by the linear breakages in the forests resulting from the alignments of the canal and road (Tanakpur-Khatima Highway).

11 Lagga Bagga–Sukhlaphanta–Tatarganj corridor

Lagga Bagga (5.9km^2) is part of Barahi Range of Pilibhit FD and is situated on the northern (left) bank of Sharda river. It is contiguous with Shuklaphanta Wildlife Reserve (WLR, 305km^2) to the north and northeast. Tatarganj forest block represents the northernmost forest patch of Sampurna Nagar Range of North Kheri FD. This narrow stretch of forest, along the north (left) bank of Sharda, provides connectivity between Shuklaphanta WLR and Haripur Range of Philibhit FD across Sharda river. There are large settlements (Gorakh Dipi) of over 100 households between Lagga Bagga and Tatarganj, which has led to habitat loss between Lagga Bagga and Tatarganj. Habitat connectivity is available only along Lagga Bagga, Sukhlaphanta WLR, Tatarganj and Haripur Range, which in turn is connected to Kishanpur WLS. Lagga Bagga is dominated by tall grasslands, which are interspersed with *Acacia catechu*, *Dalbergia sissoo* and *Bombax ceiba* trees. This grassland habitat supports several large mammal species including swamp deer, chital, hog deer, barking deer and nilgai. Tiger, elephant and a few rhinos frequent Lagga Bagga from Sukhlaphanta WLR, and some of them are reported to cross the Sharda occasionally. Encroachment by nearly 2000 *Bengali* settlers began in August-September 1996, was subsequently removed from the core area of Lagga Bagga. However, in spite of relocating these villagers across Sharda river in Ramnagar and Maharajpur villages, they continue to extensively use the forests of Lagga Bagga, for collecting firewood and cattle grazing.

The Tatarganj corridor (28º 44′ 42.9N, 80º 14′ 23.1E) is a narrow stretch of forest (1-3km wide and 20km long) along the north bank of Sharda, and consists of four major forest blocks; (from southeast to northwest) these are Hazara, Behla, Tila No.4 and Tatarganj. The vegetation here largely resembles that of Lagga Bagga, but supports a high density of *Acacia catechu*. However, the connectivities between these blocks are weak and are subjected to anthropogenic pressures from the villages to the north: Tatarganj, an Indian village with 60-70 households and Bewa, Jilmila and Goudi–Jilmila (villages in Nepal) with about 350 households adjacent to Sukhlaphanta WLR. Other than these villages, there is no major human habitation in this area. If these villages are translocated, large mammal movement between Sukhlaphanta WLR and Pilibhit FD along Tatarganj corridor would be facilitated. The villagers, ca. 420 households, may be willing to move out as their habitations are cut off during the rainy season. Resettling of Gorakh–Dipi on the south bank of Sharda would strengthen the connectivity between Lagga Bagga and Tatarganj. Periodically, the floodwaters of Sharda, flowing south of these blocks, alter

their shape and size. The Hazara forest (28º 34′ 33.1N, 80º 17′ 59.0E), for example, became an island in the year 1994, but it provides connectivity to Haripur Range of Pilibhit FD. Tatarganj forest block is connected to Sukhlaphanta WLR through patches of grasslands. Tiger, elephant, chital and wild pig use these forest patches. It is also possible for elephant and tiger to move between Sukhlaphanta WLR and Haripur Range along the Tatarganj corridor. Poaching and agricultural expansion are other problems.

12 Kishanpur-Dudhwa corridor

Increasing human habitations and vehicular traffic, particularly along the Paliya-Sampurnanagar road, have decisively disrupted the connectivity between Kishanpur WLS and Dudhwa NP. Local people report that tigers seldom move between the WLS and the NP through the sugarcane fields. This, however, needs to be confirmed. Establishing corridor here would be critical for two reasons: one is to enable gene flow between the populations and the other would be to avoid tiger-human conflict that is likely to occur here. Because, both Kishanpur WLS and Dudhwa NP function as source populations, and since there is no adjacent natural habitat for emigration, there is a likelihood of tigers getting into conflict with people while moving through sugarcane fields. In the current scenario, the area between Kishanpur WLS and Dudhwa NP can only be deemed as a potential corridor. Additional information and enormous efforts will be required to establish this corridor, which will be extremely expensive.

13 Dudhwa–Katerniaghat corridor

Dudhwa NP (Kheri District) and Katerniaghat WLD (Bahraich District) are in the western part of Uttar Pradesh. Isolated forest patches of varying sizes in North Nighasan Range (North Kheri FD), though in the midst of human habitations and agriculture, provide potential connectivity between Belrayan Range of Dudhwa NP and Katerniaghat Range of Katerniaghat WLD, along two corridors (northern and southern). Twenty-one villages in this corridor belt have encroached nearly 16km^2 of forest. The northern corridor includes six forest patches, west to east, these patches are (i) Belaparsua (1.37km^2), (ii) Ragunagar (2.45km^2), (iii) Kishannagar (2.09km^2), (iv) Deepnagar (1.88km^2), (v) Ganganagar (0.28km^2) and (vi) Khairatya (4.57km^2). Khairatya, being in the drawdown area of Ghagra reservoir, is largely swampy and under encroachment. It, however, provides connectivity with the southern corridor along Majra forest patch (8.23km^2). Large mammals such as tiger, elephant, chital, nilgai, hog deer and wild pig use the first four of the six patches. Recently elephants coming from Nepal were reported to use Khairatya patch before moving to Dudhwa. The southern corridor includes forest patches of Ramnagarh (9.25km^2), Batuwa (8.89km^2), Latuwa–Mortia (4.78km^2), Behria (4.80km^2) and Majra (ca. 8km^2). Ramnagarh forest patch, contiguous with Dudhwa NP, has miscellaneous forests, and had signs of tiger and sloth bear use. There is a gap of 6-7km between Ramnagarh and the other forest patches close to Katerniaghat. The gap is dominated by agricultural areas, largely sugarcane and wheat,

and habitations belonging to indigenous people including *tharu*s and punjabi settlers. Batuwa, Latuwa–Mortia and Behria form two isolated clusters northwest of Majra village; Batuwa and Latuwa–Mortia being in one unit and Behria being the other. *Acacia catechu* and *Dalbergia sissoo*, interspersed with small patches of short grasslands dominate the forests here. Prey species are scarce, and tigers stray here only occasionally. All these patches, however, are close to Majra patch, which is contiguous with Katerniaghat Range. As a result, evidence of tiger use of the Majra patch was relatively higher. According to Sinha (2003), the possibility of strengthening the northern corridor is greater than the southern corridor, but the cost involved in removing encroachments and restoring the area is going to be substantial. During the last eight years (1996-2003), only 1.71km^2 encroached area has been evicted and afforested at a cost of Rs.34,00,000 (US$ 69,800). According to Sinha (2003), the total estimated cost for the removal of encroachments and restoration of the area is ca. Rs.1,50,00,000 (US$ 3,07,945). There is also a very narrow stretch of forest patches, primarily dominated by *Acacia catechu*, along the Suheli river southwest of the southern corridor. This stretch has a tenuous link with Sonaripur Range of Dudhwa NP in the west, but does not provide connectivity to Katerniaghat WLD. Recently, a male rhino that escaped from the enclosure in Sonaripur used this stretch of forest, and from Ramnagarh patch, moved through sugarcane fields and reached Latuwa, injuring a few and reportedly killing two people on the way. It is reported to have reached Katerniaghat WLS. The southern ranges of Dudhwa NP (Sonaripur and Belrayan) are richer in large mammal abundance, and consequently straying of animals from these ranges along the Suheli river is possible. The forests along the Suheli river therefore need continued protection.

Katerniaghat WLD extends east of Geruwa branch of Ghagra/Karnali river but also to the west of Geruwa, up to the Kaudiala branch of Ghagra/Karnali. The northern boundary of these forests between Geruwa and Kaudiala is at the Indo-Nepal border, in an east-west orientation. The area north of this, is the Nepalese part between the Kaudiala and Geruwa, and is devoid of forests except for some small, degraded patches, with much of the area being essentially under agriculture. Bardia NP lies east of Geruwa on the Nepalese side. The southern boundary of Bardia NP, along the Geruwa river, is about 12km from the northern boundary of Katerniaghat WLD. Geruwa is a large river and its riverine forests may enable movement of rhinos between these two protected areas. In addition to this riverine forest, elephants moving between these two PAs may also use patches of degraded forests interspersed within the larger agricultural matrix. Possibility of some connectivity between Dudhwa NP and Katerniaghat WLD on the north, in the form of an arc from Belrayan Range through Basantha forests, Churia hills, Bardia NP and the northeastern part of Katerniaghat Range may exist. The gap between Belrayan Range and Basantha forests is less than a kilometer. Establishing a functional corridor here is relatively easier, and is also crucial as Dudhwa NP is otherwise an isolated habitat.

Appendix X: Poaching in TAL

The magnitude of the threat posed by illegal removal of wild species from Protected Areas and Reserve Forests is demonstrated by the fact that even relatively well-protected areas, such as Corbett TR and Rajaji NP, have reported instances of poaching (Wildlife Protection Society of India 2003). Perhaps the most highlighted instances of poaching come from the organized operators feeding the international demand for animal parts and products. Poaching for meat, plants and plant parts, animal parts and products derived thereof are responsible for jeopardizing the future of many wildlife species. The demand for trophies, animal parts such as tiger bones and ivory, along with the urge for the thrill and adventure associated with s*hikar* (hunting) continues to pose severe challenges for PA managers. In the long run, all these types of poaching can seriously deplete the abundance of large mammals, which has already happened in most parts of TAL.

People of the TAL, regardless of their social status, are fond of eating meat and naturally, poaching is widely prevalent in the entire Landscape. This is likely to be a major reason for low abundance of large mammals in most of the forests, particularly the ungulates. Three instances typify the general trend. (i) On 15th November 2002, acting on a tip off from a local, a team of forest staff guided by Mr. Ramakant Tiwari (Range Officer, Belparo Range of Terai West FD) apprehended poachers from Rudrapur and confiscated their car, rifle and a double-barrel shotgun. The poachers were caught in the act of cooking a chital that was shot in the nearby forest. This instance of poaching is typical of the intent of the poachers seeking adventure, the thrill of *shikar* and wild meat. (ii) Another group of people who poach for meat are the daily wage labourers engaged in sand and boulder mining, road repair and other works related to Forest Department. Snare-lines kept by daily wage labourers for junglefowl (*Gallus gallus*), kalij (*Lophura leucomelanos*) and peafowl (*Pavo cristatus*) were found barely 50m from Dholkhand Range office in Rajaji NP. Also local craftsmen like the *kanjars*, who are blacksmiths by tradition, provide the expertise for making traps; their poverty has driven them to poach and assist in poaching. (iii) During the survey, the project team encountered a poaching party of *rai sikhs* (Jaulasal Range of Haldwani FD) with hunting dogs, returning from the jungle carrying a sambar cut into large pieces. It is pertinent to note that such violation of laws is possible largely due to insufficient personnel for protecting the forests and wildlife. It could also be attributed to the lack of motivation, training and awareness among the people. In Nandaur Valley (Haldwani FD), the *chowkidar* of the Durgapeepal Forest Rest House, who has been serving there for the last 25 years, stated that the major reason for the depleted status of large mammals in the Valley is due to regular poaching by *rai sikhs*. The poachers usually camp in the Valley, after the monsoon (July – August) rains have damaged the only road into the Valley, and continue their illegal activities without any fear till December-January, when the roads are

repaired, leading to frequent visits by the staff. Poaching is done with dogs, snares, spears and guns. This practice by people is difficult to control, as the local people know the terrain and behaviour of animals very well.

PA management has to regard poaching as a serious problem, and demonstrate their will power to control poaching (Kumar and Wright 1999). Johnsingh and Negi (2003) suggested measures, such as replacing the guns around the tiger habitat with specially made guns that cannot be used for poaching, giving substantial rewards to persons who apprehend poachers and recruiting and training staff for protection. The involvement of local people, through conservation education and conservation programmes, is critical in bringing about their transformation, from providers of expertise and logistical assistance to poachers, to protectors of wildlife. Special programmes are needed to provide employment opportunities to *kanjars*, and persuade *rai sikhs* to give up poaching.

Appendix XI: Encroachments in TAL

Over the decades the forests in the Terai Arc Landscape have suffered as a result of encroachment. This has lead to loss of habitat, encroachers and their livestock place continuous and increasing pressures on the resources, which are important for the survival of wildlife. Further, encroachments gradually grow in size over years, often leading to habitat fragmentation. Parts of the Landscape falling in the State of Uttaranchal have suffered the most as a result of large scale State encouraged encroachment. Government encouraged the locals since there was large scale aggressive encroachment by the Punjabis and resettling of Bengalis displaced from erstwhile East Pakistan by Government of India. Two examples of State sponsored encroachment are Sunder Khal in the Kosi river corridor area and the other is in the Terai East FD. In 1974, about 400 people, prompted by *Parvati Shilpkar Samiti – Sunderkhal* (beautiful home), encroached western Kunkhet Beat, Dhulwa Block 5, 9 and 11, an area of 73.84ha. This encroached area within Kosi Range of Ramnagar FD was previously known for abundant wild pig and was hence called *Suerkhal*. The encroachment destroyed a teak plantation, which was raised by the Forest Department in 1971. The Forest Department filed cases in the Kashipur Court to evict these encroachers: 24 cases in 1974-75, 114 in 1989 and 131 in 1990, a total of 269. The Kashipur Court gave a verdict in 1992 that 172 families should leave, but no decision was made on the other 97 families. The 172 families refused to leave, as they were not given resettlement sites at a single place. In 1999, 300 families with 1500 individuals were reported from here, most with voting rights. There are 100 houses and 200 temporary huts. The population gets its fuel, fodder and small timber from the Corbett TR. This impact, which will only grow in the years to come, will be disastrous for the Reserve. The 3.5km long encroachment is also an impediment to animals moving from the Reserve to the Kosi river for water. Resettlement of these people enmass should be a priority to secure the future of this premier Tiger Reserve of the country. Parts of Gabua forest patch (13 km^2), between Ramnagar and Kaladhungi, in Terai West FD may have to be traded-off for resettling these people. Gabua is surrounded by human habitations, and may eventually be encroached or used by Government for some other purpose. Before this happens, the encroachers could be resettled here, eradicating this growing scourge from the environs of Corbett TR.

The Terai East FD has an area of 820km^2, of which nearly 60km^2 is encroached. The ranges affected are: Barkoli (encroached area 22.40ha), Doli (138.44), Gaula (4312.63), Khatima (ca. 600), Kishanpur (84.10), Ranshali (250.71), South Jaulasal (159.570 and Surai (497). Hundreds of families live in these encroached areas. The worst affected Range in Terai East FD is Khatima Range (92km^2), with nearly 6km^2 under encroachment, supporting ca. 800 families. Besides encroachment, Khatima Range has suffered from establishment of NAPIERS (Army camp), Banbasa Hydel Project, Sharada

Sagar reservoir and Sharda Main Canal, leading to the loss of 4.94 km^2 forest area since 1952. As a result the habitat connectivity between the forests west of Tanakpur-Khatima Highway (e.g. Kilpura and South Jaulasal ranges of Terai East FD and Jaulasal Range of Haldwani FD) and Surai Range (Terai East FD) and Pilibhit FD is lost. Regretfully, the Forest Department does not have the requisite mechanisms in place to monitor the growth of encroachment. Similar information on encroachments in the entire TAL should be collected, as the information is not readily available with the Forest Department. There is a dire need to remove encroachments at least from some crucial areas to arrest the growing threat to wildlife habitats and to establish corridors. The study on encroachments should be taken up on a priority basis and the help of Central Empowered Committee should be sought to evict encroachers.

Appendix XII: Sand and boulder mining in TAL

Bhabar tract, characterized by boulders and a low water table, has numerous rivers and streams, locally called *raus* and remain dry in summer. These *raus* are the source for sand and boulders and have considerable commercial value as construction material. Extensive commercial mining for sand and boulders in these *raus* in many parts of this *bhabar* tract is underway, with the exclusion of PAs (Kalesar WLS, Simbalwara WLS, Rajaji NP and Corbett TR). Mining activities disturb wildlife habitats, further posing the danger of disrupting forest connectivities. In Uttaranchal alone, nearly 25,000 labourers from Bihar and eastern UP are employed for mining near the Reserve Forests. They mostly live in flimsy huts on the riverbeds, and their firewood needs, particularly in winter, are enormous. While one or two family members may be engaged in the mining related activities, others cut and sell firewood. Already, a large population of the resident population of Uttaranchal depends on the forests for their firewood needs, and the additional removal by these labourers only adds to the pressures. The hundreds of labourers staying in the Ganga riverbed, near Haridwar, for example, cut wood from Chandi Range of Haridwar FD and Chilla Range of Rajaji NP. Miners camping in the Rawason riverbed near Haridwar-Chidiapur Highway put enormous pressure on the 4km wide forest connectivity between Rajaji NP and Corbett TR, along Haridwar and Bijnor Plantation FD.

As late as the year 2000, tigers inhabited the islands on Sharda river between Tanakpur and Banbasa barrage, but boulder mining has driven them out now. Among the worst affected areas is Doli Range of Terai East FD, where hundreds of labourers camp in the Gola riverbed between Haldwani and Lalkuan. If such large-scale mining is allowed to continue, the foothill forests, tiger and elephant habitats, will degrade and disappear from most places within years, and the existing forest connectivities will be broken. For example, there is a possibility to create a corridor for tiger and elephant between Terai Central FD and Terai East FD across Gola river near Lalkuan timber depot, but the continued mining will preclude this opportunity forever. Another area where mining leads to habitat fragmentation in the western part of TAL, is the Yamuna river, which in winter is still being used by one or two tigers moving between the forests on the left bank (Shivalik FD) and right bank (Kalesar-Simbalwara WLSs). The area crucial for tiger and other large mammal crossing the Yamuna is along the 9km stretch between Bohra (Himachal Pradesh) – Mamduwas – Hathnikund (Haryana). This area is highly disturbed by the plying of numerous trucks and tractors in and out of the riverbed for boulder collection.

To control the ill effects of mining, the following measures need to be undertaken:

Gola river area should be declared an **ecologically sensitive zone**. Mining should be stopped between Haldwani and Lalkuan, and efforts should be made to establish the Gola river corridor

between Terai Central and Terai East FDs. If the Chilla-Motichur corridor (across the Ganga river) and Gola river corridor are established, and anthropogenic disturbances to Rajaji-Corbett corridor minimized, then these areas together will form a contiguous wildlife habitat of ca. 8,000km^2 for tiger and elephant populations between Yamuna river and Sharda river.

No labour camps should be allowed on the Ganga riverbed between Haridwar and Chandi Range. This is vital to curb the growing anthropogenic disturbances to Chilla and Chandi Ranges from the environs of Haridwar.

Mining should not be permitted in Rawason riverbed, so as to reduce disturbances to Rajaji-Corbett corridor along Haridwar and Bijnor Plantation Division.

No mining should be permitted on the islands of Sharda river, falling under Sharda Range of Haldwani FD.

In the Yamuna river, boulder collection between Bohra and Mamduwas village (this stretch belongs to Himachal Pradesh) should be totally banned. This two-kilometer stretch is extremely crucial for the movement of tigers. Efforts should also be made to ban boulder collection between Mamduwas and Hathnikund (this seven kilometer stretch belongs to Haryana), which will significantly strengthen the connectivity between the forests on both the banks of the Yamuna (Johnsingh *et al*. in press). Help of Uttar Pradesh Government will also be needed in this venture, as there is boulder mining adjacent to Shivalik FD.

Reports of illegal mining in the *bhabar* tract should be investigated and all unlicensed boulder-crushing factories should be closed down.

Ideally boulder mining should be banned in the western part of the TAL, between Sharda and Yamuna rivers, in 5km buffer areas adjacent to and between tiger habitats. Alternately, river stretches like Song river, north of Doiwala, can be identified for boulder mining. Help of Central Empowered Committee should be sought in this regard. The Uttaranchal Government faces the choice between either mining, which may fetch annual revenue of Rs. 30-50 crores, but will eventually destroy the tiger and elephant habitat, or a forested landscape with these charismatic species and other associated fauna. The latter option, in the long run, will be beneficial for Uttaranchal, which plans to steer a sustainable future based on ecotourism.

Appendix XIII: List of TAL Workshop (6-7 November, 2003) participants

1. Mr. S.S. Rasaily, DFO Terai West
2. Mr. G.S. Pande, DFO Terai East
3. Dr. P.S. Easa WTI
4. Mr. Vivek Menon, WTI
5. Dr. Sarla Khaling, WWF Nepal
6. Mr. G.D. Sarin, The Corbett Foundation
7. Mr. Ashok Kumar, WTI
8. Mr. Ramesh Chandra, DFO Lansdowne
9. Mr. Ashok K. Mohan, DFO Nainital
10. Dr. Eric Wikramanayake, WWF-US
11. Dr. David Ferguson, USFWS
12. Mr. Jai Raj, CF, Dehradun
13. Mr. A.S. Negi, Ex-CWLW, Uttaranchal
14. Dr. M.C. Porwal, IIRS, Dehradun
15. Dr. Nita Shah, Biologist
16. Mr. M.K.S. Pasha, WPSI
17. Mr. P.K. Sen, WWF-India
18. Mr. A.K. Gulati, CWLW HP
19. Mr. Deepak Kumar, DFO Shivalik
20. Mr. P.K. Singh, Deputy Director, DTR
21. Mr. Tariq Aziz, WWF-India
22. Dr. Harish Guleria, WWF-India
23. Mr. Manoj Kumar, DCF, Karnataka
24. Mr. H.K. Singh, DFO Haridwar
25. Mr. Dhananjai Mohan, IGNFA
26. Mr. Ramesh Pandey, DFO, Pilibhit
27. Mr. Rupak De, CF, Mirzapur, UP
28. Mr. Sunil Pandey, CF, Moradabad
29. Mr. Nav Prabhat, Minister of Forests and Environment, Uttaranchal
30. Mr. Samir Sinha, Director, Rajai NP
31. Mr. P. K. Ghosh, Friends of the Doon
32. Mr. N. S. Negi, Eye of The Tiger
33. Mr. Harshwardhan Varma, Film Maker
34. Dr. Barry Noon
35. Mr. S. Singsit, IFS, Director, WII
36. Dr. Atul K. Gupta, WII
37. Dr. Gopal S. Rawat, WII
38. Dr. S. P. Goyal, WII
39. Dr. Sanjay K. Shrivastwa, WII
40. Dr. Mehar Singh, WII
41. Dr. B.K. Mishra, WII
42. Dr. P.K. Mathur, WII
43. Dr. Asha Rajvanshi, WII
44. Dr. K. Sankar, WII
45. Dr. Vinod B. Mathur, WII
46. Dr. S.A. Hussain, WII
47. Dr. Ruchi Badola, WII
48. Ms. Bitapi Sinha, WII
49. Dr. B.S. Adhikari, WII
50. Dr. Parag Nigam, WII
51. Dr. Karthik Vasudevan, WII
52. Dr. S. P. Sinha, SOS Rhino
53. Mr. Anil K. Singh, WTI
54. Mr. A. K. Pathe, WII
55. Ms. K.V.R. Priyadarsini, WII
56. Mr. K. Yoganand, WII
57. Mr. Ashutosh Sharma, WII
58. Dr. Manoj Aggrawal, WII
59. Mr. Panna Lal, WII
60. Mr. Rajesh Thapa, WII
61. Mr. V. Sukumar, WII
62. Mr. Lekh Nath Sharma, WII
63. Mr. Pranab Pal, WII
64. Dr. A.J.T. Johnsingh, WII
65. Mr. Qamar Qureshi, WII
66. Dr. K. Ramesh, WII
67. Mr. K. Rajapandian, WII
68. Ms. Soumya Prasad, WII
69. Dr. Ashish David, WII
70. Mr. M.S. Chaitra, WII
71. Mr. Advait Edgaonkar, WII
72. Mr. Rashid Raza, WII
73. Ms. Bindu Raghavan, WII
74. Dr. N. M. Ishwar, WII
75. Mr. Gopi G.V., WII
76. Ms. Reeta Sharma, WII
77. Ms. Rina Singh, WII
78. Mr. Vivek Sehjpal, WII
79. Mr. Jeewan Singh Jalal, WII
80. Ms. R. Padmawate, WII

Officer Trainees, Post Graduate Diploma (XXV), WII
Officer Trainees: Certificate Course, WII

WILDLIFE INSTITUTE OF INDIA

Post Box No. 18, Chandrabani, Dehradun

EPABX (0135) 2640111 to 115; Fax : (0135) 2640117

e-mail : wii@wii.gov.in; Website : www.wii.gov.in