This report evaluates the current status of tigers, co-predators and their prey in India. It is the outcome of a country-wide effort to scientifically determine the occupancy, population limits, habitat condition and connectivity, so as to guide conservation planning for ensuring the survival of free ranging tigers. The study shifts the focus from tiger number and protected area oriented conservation practices to landscape level holistic conservation strategies.

The methodology consisted of a three phase approach to sample all forested habitats in tiger states. A double sampling approach was used to first estimate occupancy and relative abundance of tigers, co-predators, and prey through sign and encounter rates in all forested areas. A team of researchers then sampled a subset of these areas using robust statistical approaches like mark-recapture and distance sampling to estimate absolute densities of tigers and their prey. Covariate information was generated using remotely sensed data and attribute data using Geographic Information System. Indices (tiger signs, prey relative abundance indices, habitat characteristics) were then calibrated against absolute densities and the relationships used for extrapolation of tiger densities within a landscape. Tiger numbers were obtained for contiguous patches of occupied forests by using average densities for that population block. Numbers and densities are reported as adult tigers with a standard error range.

Tiger occupied forests in India have been classified into 6 landscape complexes; namely (a) Shivalik-Gangetic Plains, (b) Central Indian Landscape Complex (c) Eastern Ghats, (d) Western Ghats, (e) North-Eastern Hills and Bhramaputra Plains, and (f) Sunderbans. Tiger populations within these landscape complexes are likely to share a common gene pool, since tiger habitats within these landscape complexes were contiguous during the recent past. Each landscape complex consists of landscape units that still have contiguous tiger habitat and contain one to many breeding populations of tigers (source populations). Within each landscape unit there exists a potential to manage some of the tiger populations as meta-populations. This enhances the conservation potential of each of the single populations and the probability of their long-term persistence.

Occupancy of a forest patch by tigers was negatively correlated with human disturbance indices and positively correlated with prey availability, forest patch and core sizes. For establishing and maintaining high density source populations of tigers it is essential to set aside inviolate areas devoid of human presence within each landscape. These source populations should be connected through multiple use forests (buffers and corridors) where human land uses conducive to maintaining low density tiger occupancy are permitted and fostered by providing appropriate incentives to local communities.
F or designing, implementing, and evaluating the success of any conservation program for an endangered species, it is imperative to monitor the status, distribution, and trends in the populations of the target species. The monitoring program should be transparent in its approach, after the Sariska crisis, the Tiger Task Force recommended the implementation of this monitoring scheme for all tiger occupied landscapes. The Project Tiger Directorate (currently the National Tiger Conservation Authority) synergized this mammoth task by liaising with the State Forest Departments to generate the required field data in appropriate formats and the Wildlife Institute of India to impart training in field data collection, and for estimating tiger and prey densities for the Nation wide monitoring program. Dr. Pradip Dr. Govind Shesh, Director (Retd.), Ministry of Environment and Forests took personal interest in ensuring the success of the program in the true spirit of an independent scientific endeavor. We thank Ms. Meena Gupta, Secretary Ministry of Environment and Forests for her support. This exercise was facilitated by Shri R. P. S. Katwal, Additional DG (WL) (Retd.) and by Shri Vinod Rishi, in his capacity as Additional DG (WL) (Retd.), we acknowledge their support. Shri P. R. Sinha, Director and Dr. V. B. Mathur, Dean, Wildlife Institute of India provided the conditions for fostering the collection protocols in consultation with field managers and scientists. The monitoring program uses remote sensing, geographic information system, and global positioning system technology in combination with high resolution spatial data and field data, based on sign surveys, camera trapping, and distance sampling, to effectively monitor tiger and prey populations.

Preface
This report evaluates the current status of tigers, co-predators and their prey in India. It is the outcome of a country-wide effort to scientifically determine the occupancy, population limits, habitat condition and connectivity, so as to guide conservation planning for ensuring the survival of free ranging tigers.

The methodology consisted of a three phase approach to sample forested habitats in tiger states. A double sampling approach was used to first estimate occupancy and relative abundance of tiger populations. This enhances the conservation potential of each of the single populations and the probability of their long-term persistence. The research team (Appendix 1.1) of the Wildlife Institute of India accomplished this within the stipulated timeframe by sincere and untiring efforts.

Acknowledgments

We acknowledge their contribution with gratitude. Dr. K Sankar, Andrew Royle helped coordinate the logistics and recruitment of researchers at odd hours and short notices. Chief Wildlife Wardens and participating forest officials are acknowledged for successful implementation of the Phase I field data collection and compilation. Shri K. Nayak, Field Director Kanha Tiger Reserve is acknowledged in particular for galvanizing field managers and conducting training. The enthusiasm and sincerity of the frontline staff in collecting field data which is the backbone of this monitoring program is acknowledged.

Estimating absolute densities of tigers and prey with the needed accuracy and precision is by no means an easy task, the research team (Appendix 1.1) of the Wildlife Institute of India accomplished this within the stipulated timeframe by sincere and untiring efforts.

Andrew Royle is acknowledged for his assistance in occupancy modeling of tigers. We are grateful to the comments, criticisms, and suggestions by the National, International peers (Appendix 1.2), and others who communicated with us in helping improve this monitoring program. We thank Dr. Nita Shah for editing the landscape part of this report and Ms. Birupi Sinha for assistance in publication. The staff of the administration, finance, academic, and computer section of the Wildlife Institute of India are acknowledged. We acknowledge Nilanjana Roy, Babita, Parminda Bass, Vivek Budun, Vinay Shamsa, Virendra Sharma, Mauo Aggawal, and Rajesh Thapa for assistance in preparing this report. We thank translators for transcribing field guide into different regional languages. We thank our families, Nita, Rajeshwari, Harshini and Dhananjay for their understanding and support during the course of this project.

The Authors
Executive Summary

STATUS OF TIGERS, CO-PREDATORS AND PREY IN INDIA

Currently tigers occupy 21,435 km² of forests within the Western Ghats Landscape comprising 21% of the forested area. The current potential tiger habitat in the landscape complex is about 51,000 km². The population estimate for this landscape was 266 (297-434) tigers. The Western Ghats landscape complex consists of three landscape units; (a) Forested area from the district of Pune to Palghat in Kerala, and eastwards upto Bhramapuram in Tamil Nadu. This landscape has good potential for long term tiger survival due to its large extent of over 34,000 km² of contiguous forest, with several source populations of tigers that of Kaziranga that formed a part of a forest patch of 136,000 km², tiger occupancy of Kaziranga was only 766 km² but due to its potential for sustaining a high density population and forest continuity through the Karbi Anglong hills it serves as a major source for dispersing tigers. The Sunderbans landscape complex is the smallest isolated landscape that likely has a single population of tigers with a tiger occupancy in 1,586 km². Population number assessment for Sunderbans is ongoing as a separate exercise as the uniqueness of the habitat requires a different approach such as using radio-telemetry for estimating tiger numbers. The Sunderbans tiger population needs to be managed through International cooperation with Government of Bangladesh.

The current assessment has shown that though the tiger has lost much ground due to direct poaching, loss of quality habitat, and loss of its prey, there is still hope. Individual tiger populations...
that have high probability of long term persistence by strict protection to established source populations and manage themselves are only a few: Nagarhole-Madumalai-Bandipur-areas with restorative inputs by involving local communities in Waynad population, Corbett population, Kanha population, buffer and corridor areas by providing them with a direct stake and possibly Sunderban and Kaziranga-Karbi Anglong in conservation. Tigers are a conservation dependent species populations. Tiger populations that exist and can persist in a requiring large contiguous forests with fair interspersion of meta-population framework are Rajaji-Corbett, Dudhwa-undisturbed breeding areas. This leaves little choice other than Katarniaghat-Kishenpur (along with Bardia and Shuklaphanta to evolve strategies by mainstreaming conservation priorities in Nepal), Satpura-Melghat, Pench-Kanha, Bhadra-Kudremukh, Parambikulam-Indira Gandhi, and KMR-Pryej. The landscapes that have potential but are currently in need of conservation inputs are Struvium Nagarjun Sagar, Simlipal, Ranthambore-Kuno-Palpur, Indiragandhi, and KMTR-Priority areas identified in the landscape complexes. Such an approach would ensure that breeding tiger populations have a need of conservation inputs are Sirsailam Nagarjun Sagar, possibility to share genetic material and exist in a meta-population framework, thereby enhancing the possibility of Preiyar. The landscapes that have potential but are currently in approach would ensure that breeding tiger populations have a

<table>
<thead>
<tr>
<th>State</th>
<th>Tiger km</th>
<th>Leopard km</th>
<th>Dhole km</th>
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| Central Indian Landscape Complex and Eastern Ghats Landscape Complex

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INTRODUCTION 

& METHODS
The present report is the final outcome of the All India Tiger Monitoring exercise undertaken on the direction of the Ministry of Environment and Forests by the Wildlife Institute of India in association with National Tiger Conservation Authority, MoEF, Government of India, and the State Forest Departments. Tiger is not only a flag bearer of conservation but also an umbrella species for majority of eco-regions in the Indian subcontinent. Its role as a top predator is vital in regulating and perpetuating ecological processes and systems (Terborgh J. 1991, Sunquist et al. 1999). The tiger needs large undisturbed landscapes with ample prey to raise young and to maintain long term genetic and demographic viability (Seidensticker and McDougal 1993, Karanth and Sunquist 1995, Carbone et al. 1999).

Introduction

Unlike Africa, Latin America or South-East Asia, the forest boundaries in India appear to have stabilized while forest quality continues to deteriorate due to resource extraction (Ghumer 1979, Ganatilake and Chakravarty 2000, Lele et al. 2000). In the past 50 years, humans have changed these ecosystems largely to meet growing demands for food, fresh water, timber, fiber, and fuel (Millennium Ecosystem Assessment, 2005) more rapidly and extensively than in any other region in the world. These are essential steps towards assigning priorities and identifying crucial links. The tools used include assessment of tiger occurrence, remotely sensed data and attribute data, and density in these forests vary on account of several ecological and anthropogenic factors like forest cover, terrain, natural prey availability, presence of undisturbed habitat and the quality of land use planning that maintain connectivity between tiger source and corridor value for demographic and genetic viability of tiger populations. This becomes extremely crucial at the national level for evolving a road map to prevent the extinction of the tiger.

The current monitoring system for tigers, co-predators, prey and their habitat transcends beyond estimating mere numbers. It is a holistic approach which uses the tiger as an umbrella species to monitor some of the major components of forest systems where the tiger occurs in India. The data and inferences generated by the system would not only serve as a monitoring tool but also as an information base for decision making for land use planning. It provides an opportunity to incorporate conservation objectives supported with a sound database, on equal footing with economic, sociological, and other values in policy and decision making for the benefit of the society. After the Sariska debacle, this system with a few modifications was recommended as a monitoring tool for the entire country by the Tiger Task Force.

Individually identified tigers by visual inspection of the pugmark tracings/plaster casts, mapping tiger distribution at the local scale and inferring total numbers from the above information (Choudhury 1970, Panwar 1979, Sawarkar 1987 and Singh 1999). This methodology has come under severe criticism (Karanth et al., 2003). The major limitations of the above technique are that: 1. It relies on subjective (expert knowledge) identification of tigers based on their pugmarks. 2. The pugmarks of a tiger are likely to vary with substrate, tracings/casts and the tiger’s gait. 3. It is not possible to obtain pugmarks of tigers from all tiger occupied landscapes. 4. The method attempts a total count of all tigers (Karanth et al., 2013). An alternative proposed by tiger biologists is to use individually identified tigers by camera traps in a capture-recapture statistical framework to estimate tiger densities (Karanth 1995 and 1998, Karanth and Nichols 1998, 2000 and 2002, Karanth et al. 2004, Per Wegge et al. 2003). An alternative proposed by tiger biologists is to use individually identified tigers by camera traps in a capture-recapture statistical framework to estimate tiger densities (Karanth 1995 and 1998, Karanth and Nichols 1998, 2000 and 2002, Karanth et al. 2004, Per Wegge et al. 2003).
Methods

PHASE I: Spatial mapping and monitoring of tigers, prey and habitat

For estimating the distribution, extent and relative abundances of tigers, other carnivores, and ungulates data were collected in similar formats on carnivore signs and ungulate sightings in forested areas of the region within each forest beat. Data were also recorded on indices of human disturbance and habitat parameters. Over 88,000 copies of the field guide (Jhala, Qureshi & Gopal 2005) for data collection were printed in nine regional languages and given to beat guards of all beats. Six regional workshops were conducted to train field staff by subsequent workshops. These constituted the Phase I data and were collected by the State Forest Department between November 2005 to March 2006. A total effort of 491,648 man days was expended to sample 460,920 km of carnivore sign survey walks and 184,368 km of transect walks. This probably constitutes an unprecedented effort for any wildlife survey conducted in the world.

This stage consists of mapping (a) tiger presence and relative abundance (Karanth and Nichols 2002); (b) tiger prey presence and relative abundance and (c) habitat quality and anthropogenic pressures at a high spatial resolution of 15-20 km.

We consider a forest beat (an administrative unit, 15-20 sq km in average size, delineated primarily on natural boundaries) as the unit for sampling. Since each beat is allocated to a beat guard for patrolling and protection, the boundaries of a beat are well known. Beat boundaries are distributed in all beats of potential tiger occupied forests (tiger reserves, revenue and reserve forests). Thus, in effect, the entire landscape where tigers are likely to occur was sampled (beats were not stratified or randomly selected). This probably constitutes an unpresidented effort for any wildlife survey conducted in the world. 2002, Karanth and Nichols 2002).

The method was useful in determining tiger densities in small areas, within tiger reserves having high to medium density tiger populations. The method has a high potential for monitoring source population and smaller sample areas within tiger occupied landscapes. However, due to the technical nature of the method, high cost, security issues of the equipment and low performance in low density tiger populations this method has its limitations for a country-wide application for monitoring tigers (Carbone et al. 2001, Karanth 1995 and 1998, Karanth and Nichol 1998, 2000 and 2012, Karanth et al 2004 and Kawanshi and Sunquist 2004).

The other two potential methods that can be used in smaller sample areas for monitoring source tiger populations are the (a) tiger presence and relative abundance (Qureshi & Gopal 2005) for data collection were printed in nine regional languages and given to beat guards of all beats. Six regional workshops were conducted to train officials for field medium density tiger populations. The method has a high potential for monitoring source population and smaller sample areas within tiger occupied landscapes. However, due to the technical nature of the method, high cost, security issues of the equipment and low performance in low density tiger populations this method has its limitations for a country-wide application for monitoring tigers (Carbone et al. 2001, Karanth 1995 and 1998, Karanth and Nichol 1998, 2000 and 2012, Karanth et al 2004 and Kawanshi and Sunquist 2004). This probably constitutes an unpresidented effort for any wildlife survey conducted in the world. 2002, Karanth and Nichols 2002).

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Introduction & Methods

Robson, 1992, Williams

the double sampling approach of Pollock

ungulate densities within stratified sampling units. We used relevant ecological index to a more comprehensible concept of

deployed in each landscape complex for estimating tiger density abundance data), they should suffice the need for converting a

tigers and ungulates are there. Teams of researchers were proposed to be done through the site occupancy and relative

Phase 3 of the methodology answers the question of how many these estimates are not be used for monitoring trends (which is

PHASE III: Estimating the population of tigers and its prey

were used in the remaining states for determining the beat 1991). Based on the relationships development between tiger

digitized beat maps, hand held Global Positioning System units Pollock

Karnataka, and Tamil Nadu were used to spatially link the Phase

planning. traps to identify individual tigers based on stripe patterns,

linkages between occupied landscapes and conservation size (100-200 km).  We primarily depended on remote camera

distribution of tigers, potential habitats, threats t o crucial we estimated actual tiger density in 5 to 13 replicates of sufficient

AVHRR satellite data was used. Part of this component was We stratified each landscape into tiger sign abundance classes of

vegetation map. IRS (LISS III and AWiFS), LANDSAT and

Tiger Numbers

we stratified each landscape into tiger sign abundance classes of

high, medium, low and no tiger sign in the beat and larger spatial resolution (100 km²). In each of these strata, within a landscape we estimated actual tiger density in 5 to 13 replicates of sufficient

(100-200 km²). We primarily depended on remote camera transects to identify individual tigers based on stripe patterns, population estimates based on mark-recapture framework were done using CAPTURE, CARE 2 and Density 4 (Carbone et al. 2001, Chau-Yang 2003, Efrodi 2007, Karanth and Nichols 1999 1998, 2000 and 2002, Karanth and Nicholas 1998, 2000 and 2002, Karanth et al. 2004, Pollock et al. 1990, Per Wegge and Finlay 1991). Based on the relationships development between tiger density and indices/coordinates. These densities were then extrapolated for the areas under various density classes within the landscape to arrive at a tiger population estimate. We do realise tigers have high variances; but since these estimates are not be used for monitoring trends (which is proposed to be done through the site occupancy and relative abundance data), they should suffice the need for converting a relevant ecological index to a more comprehensible concept of number. The tiger population reported by us throughout the years above 1.5 years of age. We did not consider images of cubs and juveniles for population and density estimation as this age group is under represented in camera trap studies.

Tiger Prey

Phase 1 of the protocol would be reporting encounter rates on line transects (Brown et al. 1993); these would suffice for monitoring trends in ungulate population and site-specific occupancies as the same transects would be sampled during subsequent surveys. To convert encounter rates to density, an estimate of the effective strip width of these transects would be essential. The effective strip width of a transect primarily depends on the visibility (vegetation and terrain type), ability to detect ungulates by different observers and animal behaviour (Brown et al. 1993). We modeled effective strip widths in different vegetation types of a landscape using double sampling technique (Pollock et al. 2002), wherein a team of researchers sampled the beat transects in each habitat type using distance sampling technique (Pollock et al. 2002). Feller group counts on live animals would serve as an index to the presence and relative abundance of ungulates. The entire process from conceptualization to implementation (Phase I to Phase III) was transparent and open to scrutiny by independent National and International Professionals. A public debate with invited experts by the Tiger Task Force on the methodology which was also critiqued by International peers selected by the IUCN and the MoEF (Appendix 1.2). Independent National and International observers participated in field data collection and compilation. This process of review greatly refined the methodology and data collection procedure.

PHASE IV: Intensive monitoring of source populations

We propose that source populations of tigers (tigers in tiger reserves and protected areas) in each tiger landscape complex be monitored intensively. We propose the following methodology for this monitoring:

Photo registration of tigers: Pictures of individual tigers obtained by camera traps or by regular cameras should be maintained in the form of a photo identity album. Records should be kept on the location, condition (breeding status, injury, etc) and associated tigers whenever a tiger is sighted. This will provide crude data on ranging patterns, demography and mortality.

Tiger pugmark and other signs: Regular monitoring of tiger signs (pugmark hairstroking, plaster casts, etc) should be undertaken in every beat at a weekly interval with monthly compilation of data. With experience and exposure to the resident tigers and their pugmarks, the forest staff may be able to identify individual tigers from their track set characteristics (Patwari 1979, Smith et al. 1999 and Sharma 2001). Sign surveys and individual tiger monitoring should become a regular task for every guard as was the practice some years ago and is currently practised in some tiger reserves. The monthly data should be mapped and maintained to analyse trends.

Monitoring by telemetry in select areas: Use modern technology of VHF, GPS and satellite telemetry to study and monitor aspects of demography, metapopulation dynamics (dispersal, ranging patterns), mortality, predation ecology and behaviour. In all source populations, tiger abundance and density should be estimated using camera traps, digital images of pugmarks and/or DNA profile from non-invasive methods biannually. It was not possible to conduct a beat wise survey in all the forests of the North Eastern Hills Landscape and in the Sundarbans Landscape. For the North Eastern Hills spreads were conducted in expedition mode based on supervised knowledge of tiger presence. This approach permitted us to use the data for
Modeling Tiger Occupancy and Densities

The historical tiger distribution map was constructed for the past 150 years (before the commencement of Project Tiger) through a literature survey. A total of 140 records where mention of the tiger could be attributed to a geographical location (Appendix 1.4) were used for developing this map (Figure 1.1). Geographical locations mentioned in the literature were mapped to current districts in a GIS with a link to the referenced report.

Data was compiled on tiger presence reported at the tehsil level for the past 5-6 years (1999-2004) through a questionnaire addressed to the Chief Wildlife Wardens of all tiger-states by the Project Tiger Directorate. Though several states had data on tiger numbers in some tehsils (especially in protected areas), only the reported presence of tiger(s) in the past six years were used to score a tehsil as "occupied by tigers" or not. Since tigers were unlikely to live outside of forests, forest cover map was superimposed on the tehsils occupied by tigers, and non forested areas were eliminated from further analysis. The tiger occupied tehsils were further divided into three groups, tehsils that had reported tigers (a) only for 1 year, (b) for 2-3 years and (c) for more than 3 years between 1999-2004.

To compare the historical tiger distribution with the current tiger distribution, the information on current tiger distribution at the tehsil resolution was converted to the coarser scale of districts. The districts in which tigers have become locally extinct were marked (Figure 1.1). Tigers seem to have been preferentially exterminated from the Western and Northern population limits. The Western districts have dry thorn deciduous forests with low productivity, while the Gangetic Plains have been heavily exploited for intensive agriculture.

Relationships between verified tiger occupied forested beats, unoccupied beats and Phase-I data, and Phase-II data were developed to understand the underlying factors that make a habitat patch suitable for tigers. Several factors like prey encounter rates, wildlife dung index, canopy cover, anthropogenic disturbance indices like signs of lopping wood cutting, grass cutting, livestock trails, people seen on transects and livestock dung were significantly different between areas occupied by tigers and unoccupied forests. Phase II information like distance from roads, forest patch size, distance from night lights, and core area size attributes were significantly different between tiger occupied forests and unoccupied patches. This information was then used in a logistic regression framework to validate reported tiger occupancy. Grids with deviations were highlighted for further field verification.

Tiger densities (tigers >1.5 years) obtained from camera traps were used to develop predictive models for tiger density estimation in tiger occupied forests. Principle component analysis was used to extract parsimonious, independent information from Phase-I and II data. Tiger densities (as

Figure 1.1: Districts with tiger occupied forests and districts where tigers have become locally extinct within the past 100 years

Introduction & Methods
dependent variables) were modeled using Multiple Linear Regression with the Principle Component scores as the independent variables. The principle components that significantly contributed to explaining variation in tiger densities were primarily those containing information on tiger sign indices, prey indices, anthropogenic disturbances and wilderness values.

Tiger occupied landscapes and habitat potential

Entire India was divided into six landscape complexes (Figure 1.2) based on current tiger occupancy and potential for connectivity. A landscape complex is largely a unit comprised of several ecological landscapes, which are or were interconnected in the recent past and have a potential for exchanging genetic material between tiger populations inhabiting the complex. The six landscape complexes were (1) Shivaliks and the Gangetic Plain, (2) Central Indian Highlands, (3) Eastern Ghats, (4) Western Ghats and (5) Brahmaputra Flood Plains and North Eastern Hills and (6) the Sundarbans (Figure 1.2).

The overall spatial occupancy of tigers in a forest patch is based on the premise that small tiger populations can persist for long periods given sufficient prey and adequate protection (Karanth & Stith 1999, Mishra et al 1987, Panwar 1987, Wikramanayake et al 1999). A 10 km x 10 km grid was then superimposed on all forested habitats. Data from each grid on 22 different variables (Appendix 1.5) were extracted of which 14 were found to be significantly contributing to the tiger occupancy model. Occupancy of 10 km x 10 km forest patches by tigers was modeled, using variables defining landscape characteristics (patch size, core size, shape and connectivity of forests), climatological data and variables depicting human influences within each landscape complex (Appendix 1.6). The binary logistic model was used to model the potential tiger habitat within each landscape complex. The model fit was tested using Receiver Operator Characteristic (ROC) Curves. The area under ROC curves ranged between 98 to 99 percent for all landscape models indicating a good fit.

The conservation potential of a landscape was evaluated keeping in view the earlier works of Opdam et al (2003), Entire India was divided into six landscape complexes (Figure 1.2) based on current tiger occupancy and potential for connectivity. A landscape complex is largely a unit comprised of several ecological landscapes, which are or were interconnected in the recent past and have a potential for exchanging genetic material between tiger populations inhabiting the complex. The six landscape complexes were (1) Shivaliks and the Gangetic Plain, (2) Central Indian Highlands, (3) Eastern Ghats, (4) Western Ghats and (5) Brahmaputra Flood Plains and North Eastern Hills and (6) the Sundarbans (Figure 1.2).

Dinerstein et al (1999), Johnsingh et al (2004), Narain et al (2005) and Smith et al (1998). These studies suggest that tigers require large areas, with minimal human disturbance and abundant prey for persistence. Habitat connectivities between source populations are essential for long term viability in larger landscapes. Demographic viability and population persistence information was taken from Kenney et al (1995), Karanth and Stith (1999), Sunquist et al (1999), Seidensticker et al (1999), Eastern Hills and (6) the Sundarbans (Figure 1.2).

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STATUS OF TIGERS, CO-PREDATORS AND PREY IN INDIA

SHIVALIK-GANGETIC FLOOD PLAINS

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Jyotirmay Jena, Kunwar Sai, Manish Bhardwaj, Mohit Badyal, Narvani Das, Parshita Bave, Peer Muzamil Shams,
Prudhvi Raj G., Purnima Munra, Rajni Sharma and Ved Prakash Ola.
Also referred to as the Terai Arc Landscape, this landscape complex stretches from a little west of the Yamuna River through southern Nepal to forests of Bhutan in the east. It stretches across five Indian states with Valmiki Tiger Reserve in Bihar marking its eastern boundary within India. Since key connectivities of this landscape are in Nepal and Bhutan, an effective conservation strategy will be possible only with trans-boundary co-operation.

The Shivaliks, the adjoining bhabar areas and terai plains are in the form of narrow strips running parallel to the main Himalayas, 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 along the foothills to form a pebbly-boulder layer referred to as the bhabar, while the finer sediments or clay are 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. Altitude within the Shivaliks ranges from 750 to 1400 m. The bhabar zone exhibits an undulating topography with an altitude ranging between 300 and 400 m. Terai is relatively flat with a surface gradient, which is slightly higher near Shivaliks.

For tigers, the landscape holds some promise as the tiger zone exhibits an undulating topography with an altitude ranging between 300 and 400 m. Terai is relatively flat with a surface gradient, which is slightly higher near Shivaliks.

According to the recent classification proposed by Wikramanayake et al. (1999, 2002) that takes into consideration both biogeography and conservation values, the landscape corresponds to three ecoregions – (i) Upper Gangetic Plains moist deciduous forest, (ii) Terai-Duar savanna 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. The vegetation in the area comprises of a mosaic of dry and moist deciduous forests, scrub savanna and productive alluvial grasslands, which harbour a rich fauna including several endemic and globally endangered species. Prominent among such species are tiger, Asian elephant, one-horned rhinoceros and swamp deer. Other endemic and obligate species found in this landscape are hog deer (Axis porcinus), hispid hare (Caprolagus hispidus), Bengal florican (Houbaropsis bengalensis) and swamp francolin (Francolinus gularis). Many of these species, surviving in small populations, have their last home in this Landscape (Johnsingh et al. 2004).

For tigers, the landscape holds some promise as the tiger inhabited forests in the region are still somewhat connected (Figure 2.1). If key corridors can be maintained and a few more
b) Dudhwa Tiger Reserve and Sohagi Barwa in Uttar Pradesh and Valmiki Tiger Reserve in Bihar (2,600 km²) are connected through the Shivalik forests (Churia hills) of this landscape where it was historically recorded. Currently the tiger has become locally extinct in 29% of the districts of this landscape unit with an estimated population size of 297 (259 to 335) in six separate populations (Figure 2.2).

Tiger habitat in this landscape exists in two contiguous ‘relatively’ large patches (Figure 2.1), which consist of:

(a) Kalesar in Haryana to Kishanpur in Uttar Pradesh covering areas of Rajaji National Park and Corbett Tiger Reserve (21,500 km²). This landscape unit is most promising for long term tiger conservation.

(b) Dudhwa Tiger Reserve and Sohagi Barwa in Uttar Pradesh and Valmiki Tiger Reserve in Bihar (2,600 km²) are connected through the Shivalik forests (Churia hills) of Nepal. These forests in Nepal have protected areas like Sukla Phanta, Bardia, and Chitwan National Parks. This population size of 297 (259 to 335) in six separate populations of the Shivaliks-Gangetic Floodplain landscape (Figure 2.2).

Table 2.1: Landscape characteristics of the Shivaliks and the Gangetic Plain

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of forest patches</td>
<td>5660</td>
</tr>
<tr>
<td>Forest patch density per 1000 km²</td>
<td>3.5</td>
</tr>
<tr>
<td>Mean forest patch area (km²)</td>
<td>11.48</td>
</tr>
<tr>
<td>Mean forest perimeter to area ratio</td>
<td>33.8</td>
</tr>
<tr>
<td>Total forest core area (km²)</td>
<td>3337</td>
</tr>
<tr>
<td>Number of disjunct forest core areas</td>
<td>223</td>
</tr>
<tr>
<td>Mean forest core area (km²)</td>
<td>0.59</td>
</tr>
<tr>
<td>Median forest core area (km²)</td>
<td>9</td>
</tr>
<tr>
<td>Total forest core area in forest patches &gt;1000 km²</td>
<td>2796</td>
</tr>
</tbody>
</table>

The tiger has become locally extinct in 29% of the districts of this landscape where it was historically recorded. Currently the tiger occupies 5,080 km² of forested habitats with an estimated population size of 297 (259 to 335) in six separate populations (Figure 2.2).

Tiger habitat in this landscape exists in two contiguous ‘relatively’ large patches (Figure 2.1), which consist of:

(a) Kalesar in Haryana to Kishanpur in Uttar Pradesh covering areas of Rajaji National Park and Corbett Tiger Reserve (21,500 km²). This landscape unit is most promising for long term tiger conservation.

(b) Dudhwa Tiger Reserve and Sohagi Barwa in Uttar Pradesh and Valmiki Tiger Reserve in Bihar (2,600 km²) are connected through the Shivalik forests (Churia hills) of Nepal. These forests in Nepal have protected areas like Sukla Phanta, Bardia, and Chitwan National Parks. This landscape unit has high tiger conservation potential through transboundary conservation efforts and International cooperation and commitment. The tiger habitats within India by themselves have limited long term value, unless managed as a holistic landscape including connectivities and source populations in Nepal.

The most important tiger population within this landscape is Corbett having tiger presence in 1,524 km² with an estimated population of 164 (151-178). The landscape is characterized by having the ability of sustaining high density tiger populations e.g. Corbett 19.6 tigers per 100 km². Dudhwa, Kishanpur and Katamahat tiger density ranging between 4.5 to 6.5 tigers per 100 km². Thus, with good management and protection tiger reserves in this landscape can serve an important role for tiger conservation. Reserves and landscapes that need fostering to achieve their inherent potential are Rajaji (along with Shivalik, and Haridwar Forest Divisions) and Valmiki Tiger Reserve.
Landscape Occupancy of Co-predators and prey in Shivalik-Gangetic Flood Plains

Leopard occupancy was detected in 7,171 km² (Figure 2.3), Wild Dog occupancy was detected in 513 km² (Figure 2.4), Sloth bear occupancy was detected in 4,515 km² (Figure 2.5),

Figure 2.3: Leopard occupied forests, individual populations, their extents and habitat connectivity in Shivalik Gangetic Landscape Complex

Shivaliks Gangetic Flood Plains

Sloth bear occupancy was detected in 4,515 km² (Figure 2.5),

Figure 2.4: Wild Dog occupied forest, individual populations, their extents and habitat connectivity in Shivalik Gangetic Landscape Complex

Gangetic Flood Plains

Chital occupancy was detected in 8,274 km² (Figure 2.6),

Figure 2.6: Chital occupancy in Shivalik Gangetic Landscape Complex

Sambar occupancy was detected in 5,718 km² (Figure 2.7),

Figure 2.7: Sambar occupancy in Shivalik Gangetic Landscape Complex

Wild Pig occupancy was detected in 11,545 km² (Figure 2.8),

Figure 2.8: Wild Pig occupancy in Shivalik Gangetic Landscape Complex

Nilgai occupancy was detected in 9,291 km² (Figure 2.9) and

Elephant occupancy was detected in 579 km².

Figure 2.9: Nilgai occupancy in Shivalik Gangetic Landscape Complex

Sloth bear occupancy was detected in 4,515 km² (Figure 2.5),
Figure 2.5: Bear occupied forest, individual populations, their extents and habitat connectivity in Shivalik Gangetic Landscape Complex.

Figure 2.6: Chital occupied forest, individual populations, their extents and habitat connectivity in Shivalik Gangetic Landscape Complex.
Figure 2.7: Sambar occupied forest, individual populations, their extents and habitat connectivity in Shivalik Gangetic Landscape Complex.

Figure 2.8: Wild Pig occupied forest, individual populations, their extents and habitat connectivity in Shivalik Gangetic Landscape Complex.
Figure 2.9: Nilgai occupied forest, individual populations, their extents and habitat connectivity in Shivalik Gangaic Landscape Complex.
The forest cover of Uttarakhand is 24,536 km², comprising 46% of the geographic area of the State. Forests of Tiger Conservation Priority I & II are 13,000 km² in Uttarakhand. Currently tigers occupy 1,901 km² of these forests having tiger presence throughout the state and North western forests of Uttar Pradesh. It is currently the only demographically viable population in Northwestern India and responsible for maintaining genetic connectivity throughout the Northwestern tiger populations of the Terai Arc landscape. Since this population of tigers has the best chances of long term survival, it is essential to create an inviolate space of over a 1000 km² as the core area of Corbett Tiger Reserve. The well being and source value of this core can only be achieved by active management of the buffers in Landsdowne, Haldwani, Ramnagar, Terai East and Central forest divisions. These buffers not only ensure and enhance the source value of the core, but along with Haridwar forests provide habitat corridors for dispersing tigers to maintain demographic viability of Rajaji population and genetic linkages with the Pilibhit population.

(2) The smaller tiger population of Rajaji National Park having an occupancy of 390 km² with an estimated population of 14 (11-17) tigers is sustained by dispersing tigers from Corbett Tiger Reserve. Through, with recent management interventions of translocating resident Gujjar families from Chilla and Dhaulkhand these areas...
have the potential of sustaining small breeding populations of tigers. If such small breeding populations in mini cores are fostered in Rajaji by good management practices and protection there is a possibility of repopulating the Shivalik Forest Division (UP) with dispersing tigers from Rajaji. Forest contiguity exists from Corbett to Kalesar in Haryana and onwards in Southern Himachal Pradesh. Dispersing tigers occasionally traverse this intervening forests. Breeding tiger populations in Rajaji are essential to ensure tiger occupancy of these forests.

For enhancing tiger dispersal from Corbett towards the west the following linkages in the corridors are bottle necks for tiger movement and need conservation management inputs: a) Landsdowne: though there is sufficient cover but the area has low tiger prey densities due to human pressure, b) Ganga – Chilla-Motichur: due to the development of the townships of Haridwar and Rishikesh, development along the the highway connecting the two townships and the dependency of the increasing human population on forest resources is responsible for making the area permeable to wildlife, c) Yamuna River corridor: is crucial for maintaining connectivity with Kalesar. Major issues in this corridor are colonies of laborers settled along Yamuna river for boulder mining. Towards the East tiger dispersal would be facilitated by management of the a) Bou river b) Nehal-Bhakra,d) Gola River, e) Kilpur-Khatima-Surai corridors. (3) For enhancing tiger dispersal from Corbett towards the west the following linkages in the corridors are bottle necks for tiger movement and need conservation management inputs: a) Landsdowne: though there is sufficient cover but the area has low tiger prey densities due to human pressure, b) Ganga – Chilla-Motichur: due to the development of the townships of Haridwar and Rishikesh, development along the the highway connecting the two townships and the dependency of the increasing human population on forest resources is responsible for making the area permeable to wildlife, c) Yamuna River corridor: is crucial for maintaining connectivity with Kalesar. Major issues in this corridor are colonies of laborers settled along Yamuna river for boulder mining. Towards the East tiger dispersal would be facilitated by management of the a) Bou river b) Nehal-Bhakra,d) Gola River, e) Kilpur-Khatima-Surai corridors.
STATUS OF TIGERS, CO-PREDATORS AND PREY IN INDIA

The forest cover of Uttar Pradesh is 14,424 Km², constituting 8% of the land area. Of this forested habitat, 3,175 Km² constitutes Potential Tiger habitat of Priority I and II. Tigers were found to occupy 2,766 km² of forests with an estimated population of 109 (91-127) in Uttar Pradesh. Leopards occupancy was reported to be 1,889 km², while Sloth bears occupied 1,446 km² and Dhole 109 km² of forested habitats in Uttar Pradesh.

Within Uttar Pradesh tigers are distributed in one major population and three smaller populations. Sporadic occupancy is reported in Sonbhadra Forests. The major population is constituted by Dudhwa Tiger Reserve comprising of Dudhwa National Park, Kishenpur Wildlife Sanctuary, Katarraighat Wildlife Sanctuary and forests of Pilibhit, North and South Kheri forest divisions. The forested area with tiger occupancy constituted by this population is 1,916 km². This population is connected across the Nepal border via the forests of Pilibhit (Lagga-Bagga) to Sukla Phanta of Nepal and Katarniaghat is connected across the border to Bardia National Park in Nepal.

The smaller population in the West is in Bijnor forests covering an area in UP of 221 km², maintained by dispersing tigers from the Corbett Tiger Reserve. The two smaller Eastern populations are in Suhelwa Wildlife Sanctuary with a tiger occupancy of 490 km² and Sonabara Wildlife Sanctuary having a tiger occupancy in 139 km² in two separate blocks.

Suhelwa is connected with the forests of Mahadevpuri in Nepal (Figure 2.11).

Conservation Recommendation
1) Dudhwa Tiger population forms three distinct units comprising of Katarraighat, Dudhwa, and Kishenpur-Pilibhit that have intervening land between them under private ownership. The estimated tiger numbers in this population were 95 (80-110) having an occupancy of 1,833 km². Currently the land use matrix is primarily sugarcane and rice farming, and is not totally tiger hostile. No legal government owned corridor exists to connect these 3 units. For long term conservation of tigers in this population it is essential to procure and develop a government owned corridor system that could potentially be restored along water courses and remaining swamp lands by careful mapping and planning. The state needs to work in partnership with private land owners, so as to ensure that the intervening land use pattern remains tiger friendly. This could be achieved by economic incentives and subsides. To minimize backlash and hostilities towards tiger conservation the local communities needs to be compensated promptly at market rates for wildlife damage.

2) The Dudhwa population forms a part of the meta-population composed of Shuklaphanta and Bardia as the

Figure 2.11: Tiger occupied forest, individual populations, their extents and habitat connectivity in Uttar Pradesh.
other source populations in Nepal. This meta-population structure needs to be maintained through trans-boundary connectivity ensured through international cooperation for the long-term survival of tigers in Nepal (Suklaphanta and Bardia) and Dudhwa. Dudhwa - Pilibhit population has high conservation value since it represents the only tiger population having the ecological and behavioral adaptations of the tiger unique to the Terai habitat.

3) The Bijnor tiger occupancy can only be maintained as long as its connectivity with the Corbett Source remains intact.

4) The Suhelwa population is isolated on the Indian side with tiger occupancy in 475 km² and an estimated population of 6-10 tigers. It potentially has connectivity via the Shiralkill hills (Mahadevpuri-Lamahi Dovan corridor) of Nepal with Chitwan National Park and Valmiki Tiger Reserve, in Bihar. Sohagibawa has precarious stepping stone connectivity with Valmiki Tiger reserve and long term tiger persistence in this population is doubtful due to its small size and poor linkages. Tigers are likely to survive here as long as Valmiki and Chitwan sources produce substantial dispersing individuals. The estimated population is based on signage and index data reported during phase I. In the case of this population supervised knowledge of the field situation suggests that the estimate is on the higher side.

5) Sporadic tiger occurrences in the Sonbhadra forests of south eastern UP suggest a potential linkage with tiger occupied forests of Madhya Pradesh, Jharkhand and Chattisgarh. Forests of Sonbhadra are connected with forests of these three states.
The State of Bihar has a forest cover of 5,842 km², comprising 6% of the geographical area of the State. Tiger Conservation Priority I & II forests constituted 800 km². Tiger occupancy was reported to be 510 km² with an estimated tiger population of 10 (7-13) tigers. Leopard presence was reported from 551 km², Sloth bear presence in 534 km², Dhole presence in 323 km² of forests. Amongst prey species Chital occupied 576 km², sambar 321 km², nilgai 494 km², and wild pig 570 km² of forested habitats.

Tiger population in the state of Bihar occurs as single population in Valmiki Tiger Reserve. This population has a tiger occupancy of 510 km² within India and is contiguous with Chitwan National Park in Nepal (Figure 2.12).

Conservation Recommendations

The Valmiki population is contiguous with the Chitwan tiger population. For long term persistence of this population the connectivity with Chitwan is critical. Towards the south west this population is connected with the eastern block of Sohagibarwa, UP. This connectivity is essential for tiger persistence in Sohagibarwa. The value of Valmiki can be enhanced by protection from commercial and subsistence poaching of tiger and its prey. Reduction of human dependencies on the forest would enhance prey populations and in turn benefit tigers.

Southern forests of Bihar within the sanctuaries Kaimur and those bordering Jharkhand (Gautam Buddha, Koderma) have connectivity’s with Palamau Tiger Reserve and can potentially have tiger occupancy through dispersing tigers if Palamau source population is improved.
CENTRAL INDIAN & EASTERN GHATS LANDSCAPE

Principal Investigators
Y.V. JHALA, RAJESH GOPAL AND QAMAR QURESHI

Research Team Central India

Research Team Eastern Ghats
While much of the central Indian forests have been greatly disturbed by anthropogenic development, the zone does contain some of India’s finest forests, particularly in undivided Madhya Pradesh. The majority of the forests are of a deciduous nature, but there are regions of e.g. chital (Axis axis), sambar (Cervus unicolor), nilgai, greater diversity in the hill ranges. Relict populations of buffalo chowsingha (Tetraceros quadricornis). However, some species are more frequent than others, while a few species are restricted to moister areas, e.g. barking deer (Muntiacus muntjak) and gaur (Bos gaurus). Some species are restricted to drier, open environments, e.g. blackbuck (Antelope cervicapra) and chinkara (Gazella gazella), but still have a wide distribution. Species such as tiger, leopard, sloth bear (Melursus ursinus) and dhole (Cuon alpinus). However their ranges are increasingly fragmented as natural forest areas decrease in size (Rodgers and Panwar 1988). The better protected areas do provide examples of the levels of density and diversity that mature wildlife communities can attain, but these are few in number. Most of the tiger reserves in the landscape still have connectivity, with the potential of sustaining meta-populations. With protection of corridors, restorative ecology, and rejuvenation of prey outside protected areas the region has one of the best potential for long term tiger conservation (Table 3.1).

Table 3.1: Landscape Characteristics of the Central Indian Landscape Complex

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of forest patches</td>
<td>19405</td>
</tr>
<tr>
<td>Forest patch density per 1000km²</td>
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<tr>
<td>Mean forest patch area (km²)</td>
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</tr>
<tr>
<td>Mean forest perimeter to area ratio</td>
<td>34.2</td>
</tr>
<tr>
<td>Total forest core area (km²)</td>
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</tr>
<tr>
<td>Number of distinct forest core areas</td>
<td>1013</td>
</tr>
<tr>
<td>Mean forest core area (km²)</td>
<td>1.84</td>
</tr>
<tr>
<td>Median forest core area (km²)</td>
<td>9</td>
</tr>
<tr>
<td>Total forest core area in forest patches &gt;1000 km²</td>
<td>28313</td>
</tr>
</tbody>
</table>

Ganggetic Plains (Upper Gangetic Plains (7A) & Lower Gangetic Plains (7B) & 5. Coasts (East Coast (8A) & West Coast (8B))

Tiger Habitat status:

Districts from which tigers have become locally extinct within the recent historical past from the Central Indian Landscape was 30%. Forested area where tiger is currently reported was 48,610 km² (11.6 % of forests) with an estimated population of 548 (437 to 661) (Figure 3.2) in 17 populations. Potential habitat for tiger occupancy in the landscape complex was 156,548 km² (38.5% of forests).

Within Central Indian landscape complex potential meta-populations of tigers exist in four forest units (Figure 3.2).
Kanha-Pench Landscape: This is one of the best landscapes (16,000 km²) that exists today with two, source populations of forested landscapes (34,000 km²) in Central India. However, its current conservation value for tigers is poor due to anthropogenic pressures, insurgency and low prey populations. There is a paucity of any major source population of tigers. There is a potential for connectivity with Tadoba Tiger Reserve and Kanha-Pench landscape through “stepping stone” forest patches. Target forests to connect these source populations are in the tehsils of Gond, Pipri, and Sipar for Tadoba, and Dongargarh, Sulekasa, and Deori in the case of Kanha-Pench landscape. If the former connectivity is restored through the forest patches of Dongargarh, Sulekasa and Deori, two large landscapes of 34,000 and 16,000 km² areas would be connected. This landscape has the potential to support a meta-population and confirm one of the best tiger conservation areas in the world.

Sanjay-Palamau Landscape: The landscape (13,700 km²) is characterized by low tiger and prey population, with high biotic pressure. Target areas of concern are forests in Pratapur, Pal and Samri tehsils. These need to be protected and their habitat values enhanced to sustain prey and tiger populations. The Bandhavgarh Tiger Reserve can potentially be an important source for this landscape. Currently no contiguous forest patch exists between Bandhavgarh and Sanjay-Palamau landscape units. However, several small forest patches exist which could serve as “stepping stones” for the spill over population of tigers from Bandhavgarh. These forest patches (Priority II) need to be protected and enhanced in the tehsils of Beshari, Jasminthagar and Sehgar at the increase the conservation value of this landscape.

Kanha-Pench Landscape: This is one of the best landscapes (16,000 km²) that exists today with two, source populations of tigers connected as a potential meta-population. The weakest connectivity for this landscape exists at the forested border of Seoni and Wars Seoni tehsils, which needs to be managed with restorative inputs on a priority basis. This would ensure the linkage between the source populations and foster metapopulation existence.

Satpura-Melghat landscape: Though tiger densities in this landscape are medium to low (even in source populations), the landscape features (12,700 km²) are conducive for long term persistence of a meta-population. To boost up the conservation value of this landscape it may be pertinent to increase protection and prey populations. The weakest link in this landscape is in Itarsi tehsil which needs protection and restoration.

Sanjay-Palamau landscape: The landscape (13,700 km²) is characterized by low tiger and prey population, with high biotic pressure. Target areas of concern are forests in Pratapur, Pal and Samri tehsils. These need to be protected and their habitat values enhanced to sustain prey and tiger populations. The Bandhavgarh Tiger Reserve can potentially be an important source for this landscape. Currently no contiguous forest patch exists between Bandhavgarh and Sanjay-Palamau landscape units. However, several small forest patches exist which could serve as “stepping stones” for the spill over population of tigers from Bandhavgarh. These forest patches (Priority II) need to be protected and enhanced in the tehsils of Beshari, Jasminthagar and Sehgar at the increase the conservation value of this landscape.

Navegaon-Indravati landscape: This is one of the largest intact forested landscapes (34,000 km²) in Central India. However, its current conservation value for tigers is poor due to anthropogenic pressures, insurgency and low prey populations. There is a paucity of any major source population of tigers. There is a potential for connectivity with Tadoba Tiger Reserve and Kanha-Pench landscape through “stepping stone” forest patches. Target forests to connect these source populations are in the tehsils of Gond, Pipri, and Sipar for Tadoba, and Dongargarh, Sulekasa, and Deori in the case of Kanha-Pench landscape. If the former connectivity is restored through the forest patches of Dongargarh, Sulekasa and Deori, two large landscapes of 34,000 and 16,000 km² areas would be connected. This landscape has the potential to support a meta-population and confirm one of the best tiger conservation areas in the world.

Isolated Tiger Populations: Many small to medium size habitat blocks exist in Central India that support isolated tiger populations. Some of these populations have the potential to be connected to larger tiger bearing landscapes or to each other.

(a) Bandhavgarh Tiger Reserve: The forest block that includes Bandhavgarh is about 2000 km². It has fragmented forest patches towards its North East which has potential for some connectivity with Sanjay-Palamau landscape. To the south, there is potential for connectivity through more degraded patchy forests with the Kanha-Pench landscape.

(b) Panna: The forest patch that includes Panna is 3,500 km². Panna has lost all potential for connectivity with other tiger landscapes but due to its size, if properly protected and

Figure 3.1: Distribution of Protected Areas and various size of forest patches in the Central Indian Landscape
managed can sustain a sizable tiger population.

(c) Ranthambore–Kuno-Palpur–Madhav: Though Ranthambore forest patch (300 km²) is physically disjoint, it has the potential to be a source for Kuno-Palpur landscape (4000 km²). The connectivities through forest patches is poor, but the landscape is sparsely populated with ravines terrain which is conducive for movement of dispersing tigers. The possibility of tigers dispersing into Madhav-Shivpuri (660 km² forest patch) via stepping stone forest patches also exists.

(d) Tadoba Tiger Reserve: This is included in a forest patch of 2000 km², and has the potential to become an important source population for the Navegaon-Indravati landscape. It has the potential for sharing genetic material with Kanha-Pench landscape through restorative management of intervening areas ranging between 5-20 km² in size.

(e) Simlipal Tiger Reserve: It is a part of a forested patch of 3,800 km². The potential for connectivity with another tiger occupied landscape is poor. However, due to its large size Simlipal has the potential to sustain a sizable tiger population.

(f) Saranda National Park: The forest patch that includes the Saranda National Park is about 7,400 km². This forest has the potential for connectivities towards the South with forested districts of Sundargarh, Sambalpur, Denkanal, Puri, Phulbani and Ganjam, covering an area of about 15,000 km².
Tiger Habitat Status:

Currently the tiger occupies 7,772 km² of forested habitats with an estimated population size of 53 (49 to 57) in a single population. (Figure 4.2). Potential habitat for tiger occupancy in the landscape complex: 15837 km² (58.6% of forest).

The Eastern Ghats landscape complex consists primarily of three separate forest (Figure 4.2) blocks. 6000 km² area of Nagarjuna Sagar Tiger Reserve-Guddla Brahmeshwara proposed National Park, 3000 km² of forest comprising of Srisailam National Park and 700 km² forest patch in the tehsils of Kanigiri, Badaval, Udayagiri and Giddalur. The Nagarjuna Sagar forest block has the best potential for tiger conservation in this landscape followed by the Tirupati forest block. However the 3 forested blocks are isolated with low probability of sharing tiger gene pools through “stepping stone” forest patches. The Tirupati forest patch likely had good connectivity with the Western Ghats landscape during the recent past. Currently, only small forest patches dot the intervening landscape between the Eastern and Western ghats, which are unlikely to act as corridors for tiger movement.

Landscape occupancy of Co-predators and prey in Central India and Eastern Ghats Landscape:

Leopard distribution in the Central Indian Landscape is more contiguous in comparison to tigers and forms 9 occupied blocks of forested habitat with some intervening scattered presence. Total occupancy of leopards in central India and Eastern Ghats was 117,778 km² (Figure 3.3). Central India Madhya Pradesh likely has the largest population of Dhole. In Central India and Eastern Ghats Dhole distribution seems to be made up of 7 distinct populations and several scattered occurrences.

Cheetal was distributed in 109,873 km² of forested habitat (Figure 3.5). Chital was distributed in 109,873 km² of forested habitat (Figure 3.6). Sambar was distributed in 861,562 km² of forested habitat (Figure 3.7). Wild Pig was distributed in 711,322 km² of forested habitat (Figure 3.8) and Nilgai was distributed in 82,945 km² of forested habitat (Figure 3.9).
Figure 3.4: Wild Dog occupied forests, individual populations, their extents and habitat connectivity in Central Indian Landscape and Eastern Ghats Landscape Complex

Figure 3.5: Sloth Bear occupied forests, individual populations, their extents and habitat connectivity in Central Indian Landscape and Eastern Ghats Landscape Complex
Figure 3.6: Chital occupied forests, individual populations, their extents and habitat connectivity in Central Indian Landscape and Eastern Ghats Landscape Complex.

Figure 3.7: Sambar occupied forests, individual populations, their extents and habitat connectivity in Central Indian Landscape and Eastern Ghats Landscape Complex.
Figure 3.8: Wild Pig occupied forests, individual populations, their extents and habitat connectivity in Central Indian Landscape and Eastern Ghats Landscape Complex

Figure 3.9: Nilgai occupied forests, individual populations, their extents and habitat connectivity in Central Indian Landscape and Eastern Ghats Landscape Complex
RAJASTHAN

Rajasthan has a forest cover of 21,292 km² comprising 6% of the geographic area of the state. There is only a single tiger population in Rajasthan in the Ranthambore Tiger Reserve. The contiguous forest patch harbouring this population is 496 km² with a recorded tiger occupancy in 344 km². The population is geographically isolated with “stepping stone” connectivity through Kailadevi Sanctuary to Kuno Wildlife Sanctuary in Madhya Pradesh. This connectivity if revived can serve as a conduit for dispersing tigers to repopulate Kailadevi as well as Kuno. Ranthambore tigers have been reported to disperse through the narrow “ridge top” forest connectivity in the districts of Kota and Bundi towards the South-West. This corridor can potentially connect the forests of Chittorgarh and Mandau with the tiger source of Ranthambore.

Population Size: The total population of tigers in the state of Rajasthan was estimated to be 32 with a standard error range of 30-35 tigers.

Recommendations:
1. Consolidate the area covered by the tiger reserve, so as to increase the tiger occupancy throughout forested habitat in Sawai Mansingh and Kailadevi Sanctuaries. This would permit the tiger population to increase and tend towards becoming a self-sustaining viable unit.
2. Improve the potential habitat connectivity between Ranthambore, Kuno Wildlife sanctuary and reserve forests of Sheopur district to form a viable Arid zone western most tiger conservation unit in India (Figure 3.1).

Good potential tiger habitat exists in Sariska Tiger Reserve where tigers became locally extinct in late 2004. The landscape consists of over 700 km² of forests. Parts of this forest also have a good prey base. The possibility of natural colonization by tigers of this landscape unit is remote as the closest source population of Ranthambore has no habitat connectivity with Sariska. The area has potential for reintroduction through restorative measures and continued management of the introduced population by supplementation.

Figure 3.10: Tiger occupancy, population extent and potential habitat connectivity in Rajasthan
MADHYA PRADESH

Madhya Pradesh has a forest cover of 80,717 km², comprising 26% of the geographic area of the State. Madhya Pradesh reported tiger presence in 15,614 km², leopard presence in 24,736 km², dhole presence in 14,736 km², and Sloth bear presence in 24,960 km² of forested habitat. Amongst prey species, wild pig occupied 59,903 km², nilgai 40,704 km², gaur 5,577 km², chital 41,509 km², and sambar 33,550 km² of forested habitats. The relict population of Barasingha was restricted to a single landscape (Kanha 231 km²). Tigers were distributed in four major populations, namely the landscapes of:

a) Kanha having a recorded tiger presence in 3,162 km², supporting a population of 89 tigers (± 1 se range 73-105).

b) Pench having a recorded tiger presence in 718 km² and supporting a population of 33 tigers (± 1 se range 27-39). The Kanha-Pench landscape is still a contiguous forest patch of 16,000 km², having sporadic tiger presence recorded in the narrow corridor constituting about 7-12 tigers (± 1 se range).

c) Satpura landscape of 12,700 km² has its largest tiger population located in and around the Satpura Tiger Reserve with a tiger occupancy in 1,803 km² and supporting 39 tigers (± 1 se range 26-52) tigers. Five other smaller tiger populations occur, one towards the north-east of the tiger reserve and the other 4 between Satpura Tiger Reserve and Melghat Tiger reserve in Maharashtra. These populations harbour between 9-15 tigers.

d) Bandhavgarh landscape covers an area of 2000 km² and has a tiger occupancy in 1575 km². The major tiger population is in and around the Bandhavgarh Tiger reserve comprising 47 tigers (± 1 se range 37-57) tigers.

e) Panna landscape covers an area of 3500 km² and has 2 discrete tiger occupied areas of 787 and 187 km². The larger population of Panna Tiger reserve and its surrounds sustains 24 tigers (± 1 se range 15-32) tigers. The smaller population is a relict, comprising of 1-2 tigers likely sustained by north eastern dispersal of tigers from Panna. These seem to be over estimates due to excess of tiger signs recorded in comparison to Phase-III verification of the source population.

There are eight small tiger populations in the State. These either historical relics or are sustained by dispersing individuals from the major populations. Habitats harboring these small tiger populations form crucial linkages for existence of metapopulation structure. It is essential to explore some means.
of providing an enhanced legal status or other mechanisms for Shahdol and Siddhi forming potential linkages through Sanjay conserving these areas and populations to ensure long term National Park to Palamau in Jharkhand.

Population Size: Total tiger population in the State of Madhya Pradesh was estimated to be 300 with a standard error range of 236 to 364 tigers.

Conservation Recommendations

1) Manage the Kanha-Pench landscape and the Satpura-Melghat (Maharashtra) landscape within the framework of creating a metapopulation. This requires landscape level landuse planning targeted for each district harbouring connecting forests.

2) The Kanha tiger reserve buffer needs to be extended to form the Raisen population consisting of 7-12 (± 1 se range) tigers. These populations have no linkages to any major source population and their future seems bleak. The remnant tigers in Betul-Hoshangabad-East Nimar form an intermediate presence between two source populations the Satpura Tiger reserve in Madhya Pradesh and Melghat Tiger Reserve in Maharashtra. Few Tigers tenaciously hold their ground in the forests of Seoni-Balaghat intervening Kanha and Pench Landscape. This population forms a crucial linkage for the connectivity between these 2 sources.

3) Tiger habitat in Betul-Hausangabad-East Nimar needs protection and restorative management for enhancing the value of these forests for sustaining dispersing tigers from Melghat and Satpura Tiger Reserve and maintain connectivity between these 2 sources.

4) The contiguous forest North-East of Satpura Tiger Reserve in the tehsils of Parasia and Amarwara of Chhattisgarh district need more protection and restorative management to enhance the source value of the Satpura Tiger Reserve. A unified administrative control of these forests would be beneficial.

5) The stepping stone connectivity forests (about 30 km stretch) in Parasia tehsil of Chhindwara district that form the connecting link between Maikal and Satpura Landscape needs restoration and protection to reconnect these major tiger occupied landscapes in MP.

6) The connecting forests North East of Bandhavgarh Tiger Reserve in the tehsil of Beohari, Jaisingh Nagar in Shadol district and Jopad banas tehsil of Siddhi District need protection and restorative management. These forests will then serve as a conduit for dispersing tigers from the high density Bandhavgarh source and help repopulate Sanjay and Chhattisgarh forests.

7) Low density Tiger presence is distributed all along the forests on the Northern banks of Narmada extending from Jabalpur all the way to West Nimar. These tigers tenaciously hold their ground in spite of all odds. Urgent restorative actions to enhance protection, habitat quality especially in terms of prey availability are required for ensuring their survival in the future (Figure 3.11).
The state has a total forest cover of 53,619 km² with mapable tiger occupancy reported in 4,273 km². Maharashtra reported leopard presence in 4,982 km² and sloth bear presence in 6,557 km² of forested habitat. Amongst prey species wild pig was reported from 7,270 km², nilgai from 4,794 km², chital from 5,970 km² and sambar from 5,730 km² of forested habitat.

Tigers were distributed in three major populations, namely

a) Melghat comprising a part of the Satpura Landscape, having a recorded tiger presence in 1,828 km², supporting a population of 80 (± 1 se range 21-29) tigers. The tiger distribution in Melghat is contiguous with the population in Madhya Pradesh forming a meta population with the Satpura Tiger Reserve as the other source population.

b) Pench (Maharashtra) being contiguous with the forest patch of Pench Tiger Reserve in MP forming a part of the Mahakal Landscape, has a recorded tiger presence in 424 km² and supports a population of 19 (± 1 se range 16-23) tigers, some of which it shares with MP.

c) Tadoba-Andhari landscape of 2000 km² has a tiger occupancy in 775 km² and supports 34 (± 1 se range 27-41) tigers. This landscape has potential to serve as a source for the Navegaon-Indravati Landscape through the need to strengthen tiger populations in the Districts of Chandrapur, Garhchiroli and Bhandara. In the south stepping stone forest patches exist in the Tehsils of Gond Pipri and Sirpur. Sporadic tiger presence of about 12-27 (± 1 se range) tigers is recorded in the forests of Bhrampuri, Garhchiroli, Nagbir, Chunnur, and Ahiri tehsils. This possibly indicates habitat connectivity to populations in Indravati Tiger Reserve in Chhattisgarh and the Northern forests of Andhra Pradesh.

**Population Size**

Total tiger population in the State of Maharashtra was estimated to be 103 with a standard error range of 76-131 tigers. Sixty percent GPS coordinates of a) Melghat comprising a part of the Satpura Landscape, having a recorded tiger presence in 1,828 km², supporting Maharashtra beats were unmapable. However, high density tiger occupancy was mapped for the state and included in the above estimate.

**Conservation Recommendations**

Tiger source populations of Melghat, Tadoba, and Pench need to be consolidated through enhanced protection and habitat management, especially in forest areas surrounding these tiger reserves. This would increase the survival of dispersing tigers thereby increasing the tiger population and its effective source value. Interstate cooperation for management of Melghat and Pench is vital for the long term survival of the Satpura and Mahakal Landscape tiger populations. Habitat connectivities of the Tadoba-Andhari population towards the north and south need protection and restorative management to maintain and enhance the value of this source for the larger landscape (Figure 3.12).
The state has a total forest cover of 27,967 km² with tiger occupancy reported in 3,609 km². Chhattisgarh reported leopard presence in 14,939 km², dhole presence in 3,794 km² and Sloth bear presence in 20,951 km² of forested habitat. Amongst prey species wild pig were reported from 25,058 km², nilgai 9,250 km², chital from 18,540 km², gaur from 3,369 km² and sambar from 7,604 km² of forested habitat.

Tigers were distributed in three populations, namely the landscapes of:

a) Achanakmar having a recorded tiger presence in 1,066 km², supporting a population of 19 (± 1 se range 18-22) tigers. Forested habitat of Achanakmar is a part of the Matkal landscape and is contiguous with the tiger habitat of Kanha-Pench landscape in Madhya Pradesh likely forming a meta population.

b) Few tigers (6-8, ± 1 se range) are recorded in the forests of Udanti having an occupancy of 636 km². The habitat and tiger occupancy in this block is contiguous in Orissa with Sonabeda Wildlife Sanctuary and forms a part of the larger Indravati Landscape.

c) Indravati likely forms a major source in the largest intact habitat patch of 34,000 km². It has habitat connectivity with tiger source populations of Tadoba, and Kanha and is also connected with tiger occupied forests in Northern Andhra Pradesh and Western Orissa. Unfortunately no information is available to assess the occupancy or population size of this important Tiger occupied landscape. Sporadic tiger occurrences are recorded in Northern and Southern Chhattisgarh (Figure 3.13).

Population Size: The tiger population for the state of Chhattisgarh (except Indravati) is estimated to be 26 with a standard error range of 23-28 tigers. Tigers were distributed in three populations, namely the landscapes of

Chiavari having a recorded tiger presence in 1,066 km², supporting a population of 19 (± 1 se range 18-22) tigers. Forested habitat of Chaitavari is a part of the Malta landscape and is contiguous with the tiger habitat of Kanha-Pench landscape in Madhya Pradesh likely forming a meta population.

Conservation Recommendations:

Tiger population status and associated threats for the Indravati Tiger Reserve need to be assessed urgently as its vital to sustain tiger occupancy of this large landscape. Achanakmar-Kanha (MP) and Udanti-Sonabeda (Orissa) linkages need to be sustained through protection and restorative management for long term survival of these populations.

Chhattisgarh
ORISSA

The state has a total forest cover of 27,427 km² with a mapable tiger occupancy reported in 9,144 km². Orissa reported mapable leopard presence in 25,516 km², dhole presence in 8,215 km² and Sloth bear presence in 45,236 km² of forested habitat. Amongst prey species wild pig were reported from 21,525 km², nilgai from 711 km², chital from 6,040 km², Gaur from 2,772 km² and sambar from 6,112 km² of forested habitat. The smaller tiger occupied units having between 6-8 tigers were:

- From 21,525 km², nilgai from 711 km², chital from 6,040 km², Gaur from 2,772 km² and sambar from 6,112 km² of forested habitat.
- In the forested area of Raigarha tehsil in Koraput district from 2,772 km² and sambar from 6,112 km² of forested habitat.

The tiger population in Orissa was estimated to be 45 (37 to 53) tigers. Conservation Recommendations: The major source population of tigers in Orissa is in Simlipal. Due to its large size and good habitat it can potentially sustain a viable population for long term conservation. It also has the potential to connect with the forests of Saranda in Jharkhand. However, currently the tiger population occurs at low density. This needs to be rectified by better protection, and enhancement of prey populations through reduction of anthropogenic pressures. The tiger population in Simbeda has to be conserved through inter state cooperation and coordination with Chhattisgarh. The Southern tiger population shares its gene pool with the tiger populations of eastern Andhra Pradesh and need to be managed as a meta population (Figure 3.13 and 3.14).
JHARKHAND

Jharkhand has a forest area of 23,630 km² with mapable tiger occupancy reported in 1,448 km². Jharkhand reported mapable leopard presence in 131 km², dhole presence in 578 km² and Sloth bear presence in 2,640 km² of forested habitat. Amongst prey species wild pig were reported from 6,226 km², nilgai from 1,108 km², chital from 721 km², gaur from 67 km² and sambar from 721 km² of forested habitat.

Tiger presence was reported from the forests of Suranda and in the forests of Ranchi tehsil. Both these areas form a contiguous forest patch of 7,448 km² that extends into Northern Orissa. The Palamau Tiger reserve forms a crucial linkage via forests of Chattisgarh upto Sanjay National Park in Madhya Pradesh and possible links through stepping stone forests to Bandhavgarh. The forest patch containing Palamau is 12,580 km² spread in three states and has the potential to harbor a good tiger population. The major problem in managing this tiger population is insurgency. If this problem is resolved, and anthropogenic pressures reduced by community participation in conservation management with appropriate economic incentives, this area could serve as a good source population of tigers.

Conservation Recommendation

Palamau Tiger Reserve forms a crucial linkage via forests of Chattisgarh upto Sanjay National Park in Madhya Pradesh and possible links through stepping stone forests to Bandhavgarh. The forest patch containing Palamau is 12,580 km² spread in three states and has the potential to harbor a good tiger population. The major problem in managing this tiger population is insurgency. If this problem is resolved, and anthropogenic pressures reduced by community participation in conservation management with appropriate economic incentives, this area could serve as a good source population of tigers.

Figure 3.15: Tiger occupied forests, individual populations, their extents and habitat connectivity in Jharkhand
Central Indian and Eastern Ghats Landscape

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STATUS OF TIGERS, CO-PREDATORS AND PREY IN INDIA

EASTERN GHATS LANDSCAPE COMPLEX

Eastern Ghats are a long chain of broken hills and elevated plateaus, running along the Indian east coast and passing through the states of Orissa, Andhra Pradesh and Tamil Nadu (with more than 50% of it being in Andhra Pradesh). The region has a regime of climate that favours luxuriant growth of vegetation and forests. This zone has important biological values including viable elephant, gaur and other mammalian populations, as well as a wide diversity of plant communities, with a mixture of subtropical and tropical evergreen elements. Considering contiguity of tiger habitats and forests we have considered the Northern parts of the Eastern Ghats i.e. the Godavari valley as a part of the Central Indian Landscape. Herein we report the status of central and southern Andhra Pradesh.

The Eastern Ghats are endowed with a lot of diversity as it harbours various types of coastal ecosystem such as, estuaries, mangroves, lagoons and coral reefs. They extend over a length of several hundred kilometres between the rivers Mahanadi and Vaigai along the East Coast (after Rodgers and Panwar 1988).

The forests of Eastern Ghats mainly include tropical dry and moist deciduous types with few patches of semi-evergreens existing in association with highlands. Floristic surveys carried out at district and zonal levels reported nearly 2000 species of flowering plants in the region.

Although the historic continuity of Eastern Ghats forests with those in Central India along the Chota Nagpur Plateau is now almost lost, there are still large forest areas within this landscape (Figure 4.1). Nagarjunasagar Srisailam Tiger Reserve, the largest Tiger Reserve in India, adds to its conservation value. However, this habitat is presently plagued by extremist problems, which makes implementation of conservation measures difficult.

Total geographic area : 120,764 km²

Political units : Andhra Pradesh only.

Average population density : 65.1 km² (Figure 21)

Total protected area : 3,385.2 km² (2.8% of the total Land Area)

Total forested area : 2,416.4 km²

Major biogeographic zones : 1. Deccan Peninsula (Central Plateau (SD) & Deccan South (6E)) and 2. Coasts—East Coast (SB)
### Table 4.1: Landscape Characteristics of the Eastern Ghats Landscape Complex

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ANDHRA PRADESH

Andhra Pradesh comprises of two major disjunct landscape complexes namely the Godavari basin Landscape in the Northern portion of the state (considered herein under the Central Indian Landscape) and the Eastern-Ghat Complex in the South Central part of the State. The state has a total forest cover of 54,844 km² with tiger occupancy reported in 22,128 km². Andhra Pradesh reported Reported magepaul leopard presence in 37,699 km², dhole presence in 41,093 km² and Sloth Bear presence in 54,673 km² of forested habitat. Amongst prey species wild pig were reported from 58,336.00 km², nilgai from 26,526 km², chital from 37,814 km², gaur from 3,139 km², and sambar from 33,159 km² of forested habitat.

In the part of the Central Indian highlands and Northern Eastern Ghats Landscape, Andhra Pradesh has four distinct tiger populations interconnected through forested habitat. These populations are:

a) In the district of Adilabad having a tiger occupancy of 3,955 km² distributed in 2 major blocks with a few sporadic occurrences. Tiger populations were estimated to be 19 (7 to 34).
b) The second population is in the district of Karimnagar, Warangal and Khamam (West) having a tiger occupancy of 2,233 km² in two blocks with an estimated population of 12 (10-14) tigers.
c) The third population is in the district of Khamam (East), East Godavari, and Vizianagaram having a tiger occupancy of 6,019 km² distributed in two blocks with an estimated population of 11 (9 to 13) tigers.

Amongst prey species, wild pig were reported from Chuddapah, Mahbubnagar and Guntur having a tiger occupancy in a single block of 7,772 km² having a population of about 53 (49 to 57) tigers.

In the part of the Central Indian highlands and Northern Eastern Ghats Landscape, Andhra Pradesh was estimated to be 19 (7 to 34). Eastern Ghats (eg. Tirupati forests). The Northern tiger populations were disjunct though the habitat in terms of forest cover is contiguous. These populations can be interconnected by prey base restoration. Tiger populations in Northern Andhra Pradesh are a part of the larger tiger occupied landscape of Indravati, extending through Chhattisgarh, Maharashtra and Orissa. These populations need to be managed with interstate cooperation and a holistic landscape management plan (Figure 4.2).

Conservation Recommendations:

The source population of tigers in Srisailam needs to be fostered through prey base enhancement and protection so that it sustains a larger high density tiger population. This population can then provide dispersing tigers to repopulate the Southern Eastern Ghats (eg. Tirupati forests). The Northern tiger populations are disjunct though the habitat in terms of forest cover is contiguous. These populations can be interconnected.

Figure 4.2: Tiger occupied forests, individual populations, their extents and habitat connectivity in Andhra Pradesh.
STATUS OF TIGERS, CO-PREDATORS AND PREY IN INDIA

WESTERN GHATS COMPLEX

Principal Investigators
QAMAR QURESHI, K. SANKAR, RAJESH GOPAL, Y.V. JHALA

Research Team
The Western Ghats is one of the major tropical evergreen forested regions in India rich in biodiversity especially endemic species. The landscape has already lost a large part of its forest cover, and the remaining forests are threatened with ever increasing anthropogenic pressures (Rodgers and Panwar 1988). This necessitates strict conservation measures for preventing further loss of biodiversity and ecosystem processes. These forests play a major economic role by maintaining water supply to the Krishna, Godavari and Cauvery river systems of peninsular India which have importance for irrigation and hydro-electric power. The scale of forest degradation which is causing loss of dry season flow and siltation of reservoirs is a cause for concern.

The high rainfall, gentle slopes and good soil resources of the Western Ghats are conducive for commercial plantation of tea, coffee, cocoa, rubber, cardamom, pepper and quinine. This has lead to logging and clearance of natural forest on a large scale and their replacement by monoculture plantations. The States of the Western Ghats have high human densities with a growing population. Thus, there is increasing pressure for the diversion of forest lands for agriculture and development. India has some 15,000 species of higher plants, of which around 4,000 (27%) are reported from the Western Ghats, which is only 5% of over total land area (Rodgers and Panwar 1988).

Botanical values include a great range of major associations, each with a very high proportion of endemics. These endemics are often highly localised by dispersal barriers and many are extremely vulnerable due to increasing habitat disturbance. High levels of endemism are found in vertebrates especially in herpetofauna (Mani 1974). The Western Ghats were historically a good habitat for the tiger which was distributed throughout its forests. Currently most of the northern Western Ghats have lost their tiger populations while the southern portion of this landscape complex is a major stronghold for the species due to its large and contiguous forested tracts (Figure 5.1).
Table 5.1: Landscape Characteristics of the Western Ghats Landscape Complex

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Tiger Habitat Status

Districts from which tigers have become locally extinct within the recent historical past from the Western Ghats Landscape was 17%. Currently tigers occupy 21,435 km² of forests within the Western Ghats Landscape comprising 21% of the forested area. Tiger occupancy in the landscape complex was 34,094 km² having tiger population of 412 (236 to 477).

The Western Ghats landscape complex consists of 3 major forested landscape units (Figure 4.2). 1) North-Central Western Ghats Landscape: The largest of these landscapes extends from the district of Pune in the north and stretches south along the Western Ghats to the district of Palghat in Kerala, and to the eastern district of Thanjavur in Tamil Nadu (39,600 km²). There are several National Parks, Sanctuaries and Tiger Reserves in this landscape eg: Koyna, Radhangir, Bhagwan Mahavir, Ani, Kudremukh, Bhadra Tiger Reserve, Nagarhole-Bandipur Tiger Reserve, Silent Valley, Dr. Jayalalitha, Eravikulam, Mysuru and Banergutta. This landscape covers contiguous forest area of 39,000 km² and has the highest potential for long term tiger conservation. Though the area coverage is large, the forested landscape towards the North is narrow along the Western Ghats ridge. This area needs protection and prey restoration for fostering tiger conservation.

2) South-Central Western Ghats Landscape: Forested areas to the south of Palghat gap comprising the sanctuaries of Chinnar, Parambikulam, Anamalid, Thattekadu, Indira Gandhi, Chimmur, Idukki, Sheela forest and Kodai Kanal.
This covers a contiguous area of about 4,400 km². This area, though not having any National Park or Tiger Reserve, has a potential for tiger conservation. It is also connected to the South through degraded forest patches which may likely permit tiger movement with the landscape comprising of Periyar complex.

3) Southern Western Ghats Landscape : Periyar-Agasthyamalai-Kalakad is the Southern most tiger occupied landscape covering an area of about 6000 km². It has some potential connectivity with the Northern forests, which can be restored by management and protection (in the tehsils of Palaiyam, Udumbanchola, Todupulai and Permed). This would enhance the value of this landscape as a metapopulation within a larger landscape of over 10,000 km².

Landscape occupancy of Co-predators and prey in Western Ghats

Leopard occupancy was detected in 43,383 km² (Figure 5.3), Wild Dog occupancy was detected in 46,321 km² (Figure 5.4), Sloth bear occupancy was detected in 40,877 km² (Figure 5.5), Chital occupancy was detected in 58,847 km² (Figure 5.6), Sambar occupancy was detected in 69,790 km² (Figure 5.7), Wild Pig occupancy was detected in 50,576 km² (Figure 5.8), Gaur occupancy was detected in 29,531 km² (Figure 5.9) and Elephant occupancy was detected in 18,232 km² (Figure 5.10).
Figure 5.4: Wild Dog occupied forests, individual populations, their extents and habitat connectivity in Western Ghats Complex.

Figure 5.5: Sloth Bear occupied forests, individual populations, their extents and habitat connectivity in Western Ghats Complex.
Figure 5.6: Chital occupied forests, individual populations, their extents and habitat connectivity in Western Ghats Complex.

Figure 5.7: Sambar occupied forests, individual populations, their extents and habitat connectivity in Western Ghats Complex.
Figure 5.8: Wild Pig occupied forests, individual populations, their extents and habitat connectivity in Western Ghats Complex

Figure 5.9: Gaur occupied forests, individual populations, their extents and habitat connectivity in Western Ghats Complex
Figure 5.10: Elephant occupied forests, individual populations, their centers and habitat connectivity in Western Ghats Complex.

Y.V. Jhala
KARNATAKA

The forest cover of Karnataka is 40,226 km², comprising 21% of the geographic area of the State. Forests of Tiger Conservation Priority I & II were 24,182 km² in Karnataka. Currently tigers occupy an area of 18,715 km² of these forests having estimated tiger population of 290 (241 to 339). Leopard occupancy 20,306 km², Sloth Bear occupancy was 20,749 km² and Dhole 15,862 km². Amongst prey species occupancy of Chital was 42,349 km², Sambur was 43,412 km², Wild pig 21,999 km². Karnataka has three populations of tigers constituted by:

a) Nagarhole-Madumalai-Wayanad Population: This population extends from Madumalai Wildlife Sanctuary (Tamil Nadu) Wayanad Wildlife Sanctuary (Kerala) Bandipur-Nagarhole Tiger Reserve (Karnataka)-forests of Nilgiri and Periyar districts of Tamil Nadu and Biligiri Rangaswamy Temple Sanctuary to Cauvery Sanctuary (Karnataka). The forest patch containing this population (and several other tiger populations) extends from Palghat gap (Kerala) northwards to Bhimasankar Sanctuary in the District of Pune, Maharashtra and eastwards in the district of Dharmapuri in Tamil Nadu covering a forest area of 39,000 km². This population has a tiger occupancy of 10,800 km². In Karnataka tiger occupancy of this population is 3,651 km² with an estimated tiger population of 192 (152 to 232).

b) Koyna-Madhya-Bhadra: This population of tigers, though distinct from the Madhumalai-Wayanad-Nagarhole population, occurs in the same contiguous forest patch that extends from Palghat Gap (Kerala) to Bhimasankar (Maharashtra) of 39,000 km². Tiger occupancy of this population was 7,054 km² with an estimated tiger population of 58 (52 to 65).

c) Sharavathi Valley-Dandeli-Khanapur Population: This population of tigers too is within the same contiguous forest as the above two populations. Several Protected areas like Sharavathi valley, Attiveri, Dandeli, Sanctuaries in Karnataka having tigers, constitute this population. Adjacent areas of Amba, Nelliyampathy, and Melmers in Goa are likely to have dispersing tigers from this population. Tiger occupancy of this population was 7,309 km² with an estimated population of 33 (31 to 34) tigers.

Total tiger population for the state of Karnataka was estimated at 290 (241 to 339) tigers.

Conservation Recommendations

1) The tiger populations of Karnataka are doing well in terms of population size, extent, and connectivity in relation to...
tiger populations in other parts of the country. The major conservation concern is to provide protection from poaching of tigers and their prey both for commercial purposes and subsistence. Tigers have a good chance of long term persistence in the Western Ghats landscape complex provided the several populations that currently exist continue to exchange individuals through contiguous forest corridors. Such movement and meta-population structure can be ensured by enhancing the tiger friendliness of intervening matrix through enhanced prey base and reduction of anthropogenic disturbances.

2) Sporadic tiger occurrences are reported between the southern Madumalai-Wayanad-Nagarhole Population and the Kudremukh-Bhadra population lending evidence that these two populations likely exist as a meta-population. Tiger presence is also recorded between Kudremukh-Bhadra population and Sharavathi Valley-Dandeli-Khanapur Population, these populations too likely exchange dispersing tigers. Thus, all tiger populations within Karnataka and across the state to Tamil Nadu and Kerala are likely forming a meta-population. This attribute needs to be fostered by forest and prey base contiguity.

3) The Protected areas of Goa can possibly sustain tiger populations as they can be easily colonized by dispersing tigers from Sharavathi Valley-Dandeli-Khanapur Population. Management to enhance prey base in these protected areas would enhance the chances of fostering breeding tigers.
TAMIL NADU

The forest cover of Tamil Nadu is 24,662 km², comprising 19% of the geographic area of the State. Forests of Tiger Conservation Priority I & II were 8,400 km² in Tamil Nadu. Currently tigers occupy an area of 9,211 km² of these forests having estimated tiger population of 76 (56 to 95). Leopard occupancy: 14,484 km², Sloth Bear occupancy was 13,224 km² and Dhole 19,658 km². AAmongst prey species occupancy of Chital was 13,567 km², Sambar was 15,900 km², Wild pig 19,768 km², Nilgai 2,505 km², and Gaur was 15,442 km².

Tamil Nadu has three major populations of tigers constituted by:

a) KMT-Peryar Population: Extending from KalakadMunduntthurai in Tamil Nadu to Peppara and Peryar in Kerala having a tiger occupancy of 3,288 km² in a forested area of 6000 km². Within Tamil Nadu tiger occupancy of this population was 1,625 km² with an estimated tiger population of 6-8 tigers.

b) Parambikulam-Indira Gandhi Population: Extending from Indragandhi Wildlife Sanctuary-Chinnar Wildlife Sanctuary (in Tamil Nadu) and Parambikulam Wildlife Sanctuary in Kerala. This population has a tiger occupancy in 2,744 km² within a contiguous forest patch of 4,400 km². Within Tamil Nadu the tiger occupancy of this population was 1,691 km² with an estimated population of 6-8 tigers.

c) Nagarhole-Madumalai-Wayanad Population: The third population extends from Madumalai Wildlife Sanctuary (Tamil Nadu) Wayanad Wildlife Sanctuary (Karnataka)- forests of Nilgiri and Periyar districts of Tamil Nadu and Biligiri Rangaswami Temple Sanctuary to Cauvery Sanctuary (Karnataka). The forest patch containing this population (and several other tiger populations) extends from Palghat gap (Palghat District Karnataka) northwards to Bhimasankar Sanctuary in the District of Pune, Maharashtra and eastwards in the district of Dharapuram in Tamil Nadu covering a forest area of 39,000 km². This population has a tiger occupancy of 10,800 km². In Tamil Nadu alone tiger occupancy of this population is 5,326 km² with an estimated population of 62 (44 to 80) tigers.

Conservation Recommendations

1) Since Kalakad-Peryar Landscape and Indragandhi-Parambikulam landscape are rainforest habitats. Prey densities and consequently tiger densities are naturally low in such forests. This attribute dictates that larger
conservation areas would be needed for maintaining a genetically and demographically viable tiger population. The current tiger occupancy and density can be enhanced by strict protection and control of subsistence level poaching of wild ungulates.

Madumalai tiger population is part of the single largest tiger population in India. It acts as a source for populating the Northern and Eastern parts of the Western Ghat landscape complex. This tiger population is capable of existing at reasonably high density due to the deciduous nature of its forests. This population needs to be fostered with strict protection from poaching to enhance its contribution for long term tiger conservation.
The forest cover of Kerala is 15,631 km², comprising 40% of the geographic area of the State. Forests of Tiger Conservation Priority I & II were 13,367 km² in Kerala. Currently tigers occupy an area of 6,168 km² of these forests with tiger population of 46 (39 to 53). Leopard occupancy 8,363 km², Sloth Bear occupancy was 6,904 km² and Dhole 10,801 km².

Amongst prey species occupancy of Chital was 2,931 km², Sambar was 10,469 km², Wild pig 8,809 km², and was Gaur 5615 km². Kerala has three major populations of tigers constituted by:

a) KMTR-Periyar Population: Extending from Kabakad-Mundumkur in Tamil Nadu to Peppers and Periyar in Kerala having a tiger occupancy of 3,288 km² in a forested area of 6000 km². Within Kerala tiger occupancy of this population was 2,314 km² with an estimated population of 23 (20 to 27) tigers.

b) Parambikulam-Indira Gandhi Population: Extending from Indira Gandhi Wildlife Sanctuary-Chinnar Wildlife Sanctuary (in Tamil Nadu) and Parambikulam Wildlife Sanctuary in Kerala. This population has a tiger occupancy in 2,744 km² within a contiguous forest patch of 4,400 km². Within Kerala the tiger occupancy of this population was 1,425 km² with an estimated population of 7 to 8 tigers.

c) Nagarhole-Madumalai-Wayanad Population: The third tiger population extends from Mudumalai Wildlife Sanctuary (Tamil Nadu) Wayanad Wildlife Sanctuary (Kerala) Bandipur-Nagarhole Tiger Reserve (Karnataka)- forests of Nilgiri and Periyar districts of Tamil Nadu and Biligiri Rangaswami Temple Sanctuary to Cannery Sanctuary (Karnataka). The forest patch containing this population (and several other tiger populations) extends from Palghat gap (Palghat District Kerala) northwards to Bhamasankur Sanctuary in the District of Pune, Maharsatlas and eastwards in the district of Dharampur in Tamil Nadu covering a forest area of 39,000 km². This population has a tiger occupancy of 10,800 km². In Kerala alone tiger occupancy of this population is 5,816 km² with an estimated population of 13 (11 to 15) tigers.

Conservation Recommendations

Tiger populations in Kerala are viable if managed as a contiguous population across Tamil Nadu and Karnataka. By itself the State cannot support a demographically and genetically viable population. Thus, inter state cooperation and for conservation planning is mandatory. Though, tiger populations in Kerala are by themselves small due to the nature of the habitat, their importance should not be undermined as they form crucial linkages for genetic exchange in the Western Ghat tiger populations and thus permit long term persistence of these populations.
NORTH EASTERN HILLS & BRAHMAPUTRA FLOOD PLAINS

Principal Investigators
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Research Team
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NORTH EASTERN HILLS AND BRAHMAPUTRA FLOOD PLAINS

The north east is one of the most important areas in the Indian subcontinent from a conservation perspective. Of all zones in India, it is perhaps the richest in communities, species and endemics. There are more species in this zone which have been included in Schedule I of the Wildlife (Protection) Act, 1972 than anywhere else in the country.

This area represents the transition zone between the Indian, Indo-Malayan and Indo-Chinese biogeographical regions, as well as a meeting place of the Himalayan Mountains and peninsular India. The north east is the biographical gateway for much of India’s fauna and flora and as a consequence has the richest biological values (Rodgers & Panwar 1988).

The lowland-highland transition zone has the highest diversity of biomes and ecological communities. The Khasi-Jaintia hills of Meghalaya were described as one of the richest botanical habitats of Asia as early as 1854. It is not only the plant communities that are diverse, but also the animal communities exhibit species richness not found elsewhere in the region (Rodgers & Panwar 1988). North east India contains large populations of many important mammalian fauna like the elephant (Elephas maximus), rhino (Rhinoceros unicornis), water buffaloes (Bubalis bubalis) and a diverse Primate community. The north east landscape complex is still biologically inadequately explored. The tiger, though widely distributed throughout the landscape complex due to the large patch size and contiguity of forest patches (Figure 5.1), it inherently occurs at low densities due to low prey availability in dipterocarp dominated ever green forests. The Brahmaputra flood plains, in contrast, have high prey biomass and in turn support one of the highest tiger densities reported in the world (Karanth & Nichols, 2000).

Figure 6.1: Tiger occupied forests, individual populations, their extents and habitat connectivity in North East Hills and Brahmaputra Flood Plains

- **Total geographic area**: 271,129 km²
- **Average population density**: 114 km² (Figure 13)
- **Total protected area**: 12,527 km² (6.8% of the total Land Area)
- **Total forested area**: 156,896 km²

Major biogeographic zones:
1. Trans Himalaya-Tibetan Plateau (1B),
2. Himalaya (Central Himalaya (2C) & East Himalaya (2D)),
3. Gangetic Plains-Lower Gangetic Plains (7B)
4. North East (Brahmaputra Valley (9A) & North East Hills (9B))

Tiger Habitat status:
Districts from which tigers have become locally extinct within the recent historical past from the North East Hills and...
Table 6.1: Landscape Characteristics of North East Hills And Brahmaputra Flood Plains

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Brahmaputra Flood Plains landscape was 22.5%. Currently tigers occupy 4,230 km² of forests within the North East Hills and Brahmaputra Flood Plains Landscape. Potential habitat for tiger occupancy in the landscape complex: 64,295 km² (41% of the forested area).

1. The largest contiguous forested landscape is over 136,000 sq km. This landscape unit commences in the North West from Pakke Tiger Reserve through the forests of Pala, Tale valley, Morening and Dr. D. Ering Sanctuaries into Dibang National Park and upto Sundarapaham Tiger Reserve in the East. The landscape continues south through some degraded areas into Intaki National Park, and further South to Dampa Tiger Reserve and Blue Mountain National Park. Kaziranga National Park in the Brahmaputra flood plains is connected through the Karbi Anglong Hills to Intaki in the South. This connectivity through Karbi Anglong is crucial for dispersal of tigers from their source population in Kaziranga. Kaziranga has lost its connectivity to the North (to Pakke) due to intensive agriculture on Northern banks of Bhramaputra (1) The largest contiguous forested landscape is over 136,000 sq km. This landscape unit commences in the North West from Pakke Tiger Reserve through the forests of Pala, Tale valley, Morening and Dr. D. Ering Sanctuaries into Dibang National Park and upto Sundarapaham Tiger Reserve in the East. The landscape continues south through some degraded areas into Intaki National Park, and further South to Dampa Tiger Reserve and Blue Mountain National Park. Kaziranga National Park in the Brahmaputra flood plains is connected through the Karbi Anglong Hills to Intaki in the South. This connectivity through Karbi Anglong is crucial for dispersal of tigers from their source population in Kaziranga. Kaziranga has lost its connectivity to the North (to Pakke) due to intensive agriculture on Northern banks of Bhramaputra (1) The largest contiguous forested landscape is over 136,000 sq km. This landscape unit commences in the North West from Pakke Tiger Reserve through the forests of Pala, Tale valley, Morening and Dr. D. Ering Sanctuaries into Dibang National Park and upto Sundarapaham Tiger Reserve in the East. The landscape continues south through some degraded areas into Intaki National Park, and further South to Dampa Tiger Reserve and Blue Mountain National Park. Kaziranga National Park in the

2. Leopards are patchy and fragmented, but the landscapes are connected through the forests of Bhutan. On the Indian side, “stepping stone” connectivity exists between forests. Connectivity between Rups Chirang and Manas is lost on the Indian side.

3. The tiger populations in this landscape have historical evolutionary significance as they share the connecting gene pool with south eastern tiger populations and represent the entry point of tigers into the Indian sub-continent.
Figure 6.2: Leopard occupied forest, individual populations, their extents and habitat connectivity in North Eastern Hills and Brahmaputra Flood Plains.

Figure 6.3: Wild Dog occupied forest, individual populations, their extents and habitat connectivity in North Eastern Hills and Brahmaputra Flood Plains.
Figure 6.4: Sloth Bear occupied forest, individual populations, their extents and habitat connectivity in North Eastern Hills & Brahmaputra Flood Plains

Figure 6.5: Chital occupied forest, individual populations, their extents and habitat connectivity in North Eastern Hills & Brahmaputra Flood Plains

STATUS OF TIGERS, CO-PREDATORS AND PREY IN INDIA

North Eastern Hills & Brahmaputra Flood Plains
Figure 6.6: Sambar occupied forest, individual populations, their extents and habitat connectivity in North East Hills and Brahmaputra Flood Plains.

Figure 6.7: Wild Pig occupied forest, individual populations, their extents and habitat connectivity in North East Hills and Brahmaputra Flood Plains.
Figure 6.8: Gaur occupied forest, individual populations, their extent and habitat connectivity in North Eastern Hills and Brahmaputra Flood Plains

Figure 6.9: Elephant occupied forest, individual populations, their extent and habitat connectivity in North Eastern Hills and Brahmaputra Flood Plains
ASSAM

The forest cover of Assam is 27,938 km², comprising 36% of the geographic area of the state. Forests of Tiger Conservation Priority I & II were 20,359 km² in Assam. Currently tigers occupy an area of 1,164 km² of these forests. Leopard occupancy was 1,500 km², Sloth Bear occurs in about 380 km² and Dhole in 285 km². Amongst prey species Sambar was recorded in 270 km², Wild Pig in 2,047 km² and Gaur in 337 km². Hog deer in 1178 km², Swamp deer in 100 km², Wild Buffalo in 590 km². Assam has three tiger populations with sporadic occurrences reported in small protected areas.

a) Buxa-Manas Population : This tiger population extends from Buxa tiger reserve in West Bengal to Manas Tiger Reserve in Assam with Royal Manas of Bhutan. This population exists in a contiguous forest extent of 7,200 km² with a tiger occupancy of 1,051 km². In Assam tiger occupancy in this population was 455 km² constituted by Manas Tiger Reserve and Bor Nadi Sanctuary.

b) Pakke-Nameri Population: This tiger population extents from Nameri Tiger Reserve in Assam to Pakke Tiger reserve in Arunachal Pradesh. The forest extent containing this population is 13,570 km² and is contiguous till Namdapha Tiger Reserve in the east, it extends south to

Intaki National Park and further south to Dumps Tiger reserve. Kaziranga connects to this forest extent through the Karbi Anglong hill forests. Tiger occupancy of this population was 1,100 km² of which about 200 km² is in Nameri, Assam.

c) Kaziranga-Karbi Anglong Population: This population extends from Kaziranga National Park through the hill forests of Karbi Anglong. Tiger occupancy of this population was 766 km².

d) Sporadic tiger occurrences were reported from Orang, Laskhoula, Barachapori, forests in the tehsils of Sibsagar and Tinsukia bordering Arunachal Pradesh.

Conservation Recommendations

The source populations of Assam are meager, constituted by Kaziranga and Manas, both prone to stochastic events of environment as well as insurgency and being of small size. Under such conditions long term tiger conservation can be ensured by

1) Increasing the size of the source population of Kaziranga by inclusion of the Karbi Anglong hills as buffer habitat. This would entail conservation partnership with the tribal council of Karbi Anglong to enhance the prey base and protection of tigers.

Figure 6.10: Tiger occupied forest, individual populations, their extents and habitat connectivity in Assam
2) Manas is recovering from the aftermath of insurgency due to support of the local population, exemplifying the importance of involving the local people in conservation efforts. The importance of the Manas Tiger population as a source is enhanced when managed in conjunction with Royal Manas in Bhutan and Buxa Tiger Reserve in West Bengal.

3) Nameri tiger population is viable when managed in conjunction with Pakke population. The sporadic tiger occurrences of tigers within forest patches along Brahmaputra are sustained by dispersing individuals from Kaziranga. Forest patches with tigers are also found along the Arunachal Boarder. An example of such forest is the Jeypore forest division which is also a good repository of biodiversity and would benefit with an enhanced legal status.
The forest cover of Arunachal Pradesh is 68,186 km², comprising 81% of the geographic area of the State. Forests of Tiger Conservation Priority I & II were 59,827 km² in extent in Arunachal Pradesh. Sampling in Arunachal Pradesh was not done in every forest rest of India, instead supervised information on tiger presence was used for survey. Only areas known to have or had high potential for tiger occupancy were surveyed. Currently tigers were reported to occupy an area of 1,685 km² of these forests. Leopards reported to occupancy 870 km², Bear (black and sun bear) occupancy was reported at 199 km² and Dhole 675 km². Arunachal Pradesh has two tiger populations Pakke-Nameri and Namdapha with sporadic occurrences reported in the forests of lower Subansiri, east Kameng, Changlang and Tirap districts.

a) Pakke-Nameri Population: This tiger population extents from Nameng Tiger Reserve in Assam to Pakke Tiger reserve in Arunachal Pradesh. The forest extent containing this population is 135,707 km² and is contiguous till Intaki National Park and further south to Dampa Tiger reserve. Kazaringa connects to this forest extent through the Karbi Anglong hill forests. Tiger occupancy of this population was 1100 km² of which about 874 km² is in Pakke Arunachal Pradesh. Pakke has the largest tiger population in Arunachal.

b) Namdapha has a small tiger population having a tiger occupancy of 540 km². It probably shares tiger contiguity with Myanmar.

Conservation Recommendations
Due to the nature of the forests and habitats of Arunachal Pradesh prey and consequently tiger densities are naturally low. Under such situation large tracts of contiguous habitat are required to support viable populations of tigers. Tigers continue to exist in Arunachal due to the vastness of the contiguous landscape. The source populations of Arunachal Pradesh are meager, constituted by Pakke and Namdapha. The value of these populations as sources for dispersing tigers would be enhanced by management to increase prey base and through participatory conservation models in tribal owned forests. These populations represent the historical entry points of tigers as a species into the Indian Sub-continent and would therefore have higher genetic and conservation value.
MIZORAM

The forest cover of Mizoram is 17,961 km², comprising 85% of the geographic area of the State. Forests of Tiger Conservation Priority I & II were 9,084 km² in extent in Mizoram. Currently tigers occupy an area of 758 km² of these forests. Leopard occupancy was 2,324 km², Bear occupancy was 479 km² and Dhole 776 km². Amongst prey-species Sambar was recorded in 1700 km², Wild pig 1,489 km² and was Gaur 281 km².

Mizoram has a single tiger population in Dampa Tiger Reserve and a few scattered occurrences in Blue Mountain Ngengpui forests which are contiguous with Myanmar. Dampa has a tiger occupancy 482 km² in a contiguous forest extent of 135,707 km² within India.

Conservation Recommendations

Due to the nature of the forests and habitats of Mizoram prey and consequently tiger densities are naturally low. Under such situation large tracts of contiguous habitat is required to support viable populations of tigers. Tigers continue to exist in Mizoram due to the vastness of the contiguous landscape which also extends into Myanmar.
NORTHERN WEST-BENGAL

The forest cover of West Bengal is 9,081 km², comprising 12% of the geographic area of the State. Currently tigers occupy an area of 596 km² of these forests. Leopard occupancy was 1,135 km², and Dhole in 301 km². Amongst prey species Sambhar was recorded in 2,632 km², Chital in 280 km² and Wild pig in 4,439 km².

Northern West Bengal has one tiger population comprised of Buxa, Jaldapara and Gorumula with sporadic occurrences reported in small protected areas.

Buxa-Manas Population: This tiger population extends from Buxa tiger reserve in West Bengal to Manas Tiger Reserve in Assam with Royal Manas of Bhutan. This population exists in a contiguous forest extent of 7,200 km² with a tiger occupancy of 1,051 km². In West Bengal tiger occupancy of this population was 596 km² constituted by Buxa Tiger Reserve, Gorumara and Jaldapara Wildlife Sanctuaries. The source population of tigers in Bhutan are maintaining the tiger occupancy in Buxa and these habitat linkages need to be fostered.
STATUS OF TIGERS, CO-PREDATORS AND PREY IN INDIA

SUNDARBANS

Principal Investigators
Y.V JHALA, QAMAR QURESHI AND RAJESH GOPAL

Research Team
Rishi Kumar Sharma
The Sunderban mangroves are part of the sub-continent’s largest mangrove system, and harbour a tiger population in a unique ecological setting. These forests have salt water crocodiles (*Crocodylus porosus*), estuarine and marine turtles, three species of fresh water dolphins and avifauna. With its network of tidal rivers, channels, mudflats, creeks and an archipelago of around 54 islands – Sunderbans provide a dynamic eco-system which is geologically still under formation. Sunderbans provide shelter to a large number of euryhaline / brackish water algae, a wide variety of fishes, and to crustaceans like shell-fish, prawns, estuarine crabs and ghost shrimps in its rivers and nutrient enriched creeks. They serve as nurseries for several commercially important fish species. Besides the tiger other species of interest are fishing cat (*Felis viverrina*), chital, rhesus monkey (*Macaca mulatta*), wild pig (*Sus scrofa*), otters, Irrawady and Gangetic dolphins, monitor lizards (*Varanus spp*), snakes (including python), estuarine crocodiles, sharks, and a large variety of local and migratory birds.

Ecological services of Sunderbans are extremely valuable to local communities. On an average, 500 quintals of honey and 50 quintals of wax are being collected every year by local people under license from the forest department.

Although deltaic mangrove systems are known to be very productive, most of that productivity remains confined to the aquatic system, and the habitat can support only low densities of terrestrial mammalian prey, and in turn, tigers. Although the inherent inaccessibility of these habitats makes scientific documentation and research efforts more challenging, nevertheless it imparts some degree of natural protection to tigers. Perhaps the best protection for Sunderbans tigers is their fearsome reputation of being habitual man-eaters.

Total geographic area: 2,585 km²
Total protected area: 2,585 km²
Total forested area: 1,474 km² (Figure 29)

The Sunderbans comprise of a total forested landscape of 1,474 km² in West Bengal stretching into Bangladesh. The mangrove forest is traversed by several tidal channels forming small to large forest islands. Animal movement across the smaller islands is facilitated by several tidal creeks forming a complex network of waterways and estuaries.
channels is common. Tigers have been recorded to cross larger (>5 km width) channels as well. Therefore, the total mangrove forests of India and Bangladesh have a tiger population that can potentially share their gene pool. Tiger occupancy in the Indian Sunderbans was reported to be 1,586 km². The Sunderbans are isolated and do not have any forest connection to other tiger occupied landscapes (North Eastern Hills). Being the only forest in the region, there is heavy biotic pressure for forest resources, fisheries, and non-timber forest produce (NTFP) collection. These need to be regulated and the forest protected to ensure the long term survival of the tiger in this unique landscape.

Table 7.1: Landscape Characteristics of the Sunderbans

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of forest patches</td>
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</tr>
<tr>
<td>Forest patch density per 1000 km²</td>
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</tr>
<tr>
<td>Mean forest patch area (km²)</td>
<td>3.1</td>
</tr>
<tr>
<td>Mean forest perimeter to area ratio</td>
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<tr>
<td>Total forest core area (km²)</td>
<td>534.4</td>
</tr>
<tr>
<td>Number of disjunct forest core areas</td>
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</tr>
<tr>
<td>Mean forest core area (km²)</td>
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</tr>
<tr>
<td>Median forest core area (km²)</td>
<td>14.29</td>
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<tr>
<td>Total forest core area in forest patches &gt;1000 km²</td>
<td>534.42</td>
</tr>
</tbody>
</table>

Figure 7.2: Tiger occupied forest, individual populations, their extents and habitat connectivity in Sunderbans
Phase III

Double sampling for estimating absolute densities of tigers and their prey was done in 5% of the tiger occupied forests spanning across the Indian Sub-continent. We sampled 29 sites covering major tiger populations. Density estimates of tigers from these sampled sites ranged between 0.125 tiger per 100 km$^2$ to 20 tigers per 100 km$^2$ (Figures 8.1 and 8.2).

Occupancy models (Royle, 2004) fitted to tigers show a significant positive effect of prey, forest area and canopy, vegetation density, and negative effects of human disturbance indices (Table 8.1).

### Table 8.1: Tiger occupancy model results for significant covariates. The model was expanded using a stepwise addition procedure.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Iter1</th>
<th>Iter2</th>
<th>Iter3</th>
<th>Iter4</th>
<th>Iter5</th>
<th>Iter6</th>
<th>Iter7</th>
<th>Iter8</th>
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<td>-</td>
<td>-</td>
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<td>-</td>
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</table>

* Iter – Model Iteration

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STATUS OF TIGERS, CO-PREDATORS AND PREY IN INDIA

Phase - III

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STATUS OF TIGERS, CO-PREDATORS AND PREY IN INDIA

144
Estimating tiger numbers over such vast geographical areas is a daunting task. Herein we attempt to provide estimates of tiger numbers, however, we caution that due to the large variances associated with these numbers they cannot be used for monitoring tiger status. Monitoring of tigers is proposed to be done by mapping site specific spatial occupancy.

The report is intended to be used as baseline information for monitoring tiger occupancy status, distribution, relative abundance individual population extents and limits (Appendix 1, and connectivities to guide policy and land use planning in the tiger landscapes of India. The above assessment has shown that though the tiger has lost much ground due to direct poaching, loss of quality habitat through anthropogenic pressures and loss of its prey by subsistence level poaching, there is still hope. Individual tiger populations that have high probability of long term persistence by themselves are only a few. These are Nagarhole-Madumalai-Ranipur-Waynad population, Corbett population, Kanha population, and possibly Sunderban and Kaziranga-Karbi Anglong populations. Tiger populations that exist and can persist in a meta population framework are Rajaji-Corbett, Dudhwa-Katamniaghat-Kohinoor (along with Bardia and Shuklaphanta in Nepal), Satpura-Melghat, Pench-Kanha, Bhandra-Kudremukh, Parambikulam-Indira Gandhi, and KMR-Preiyar, provided their connectivities are protected and maintained. The landscapes that have potential but are currently in need of conservation inputs in terms of prey enhancement, protection, habitat restoration and community participation are Srisailam Nagarjuna Sagar, Simlipal, Ranthambore-Kuno Palpur, Indravati-Northern Andhra Pradesh, and Bandhavgarh-Sanjay-Palamu. To ensure the long term survival of tigers in India it is imperative to offer strict protection to established source populations and manage areas with restorative inputs by involving local communities in buffer and corridor areas by providing them with a direct stake in conservation. Tigers are a conservation dependent species requiring large contiguous forests with fair intersegregation of undisturbed breeding areas. This leaves little choice other than to evolve strategies by mainstreaming conservation priorities in regional development policy and planning for managing Priority areas identified in the landscape complexes. Such an approach would ensure that breeding tiger populations have a possibility to share genetic material and exist in a meta-population framework, thereby enhancing the possibility of their survival.


Research Team at the Wildlife Institute of India, Dehradun

APPENDICES
APPENDIX 1.1

Faculty Members involved in conducting Training and the Research Team associated with data collection:

- Dr. S. Chowdhury
- Dr. S. Goyal
- Dr. S. Athiyakumar
- Dr. S. A. Hussain
- Dr. Purag Nigam
- Dr. B. S. Adikari

Research Team (153 Nos.)

- Jimmy Borah
- Shirish Kayatham
- Research Team (63 Nos.)
- John C.E.
- Shubhadeep
- Agni Mitra
- B.Agni
- Mitra
- Pridhivi Raj
- Purima manar
- R.K.
- Jadhlok Singh
- Rajendra Chakraborti
- Rajendra P. Gupta
- Rajiv Singh
- Karabi Ghari
- Raju Sharma
- Raju LaL Gurje
- Ramulhandran, K
- Rashid Bari
- Rehna Hazarika
- Rishi Kumar Sharma
- Satyaranjan Behera
- Shalini Bharadwaj
- Shantani Basu
- Shilpi Gupta
- Jimmy Borah
- Shirish Kayatham
- John C.E.
- Shubhadeep
- B.Agni
- Mitra

APPENDIX 1.2

National and International Peers who participated in developing and implementing the monitoring exercise:

National Peers:

- Andhra Pradesh: Shri M.G. Gogate
- Chattisgarh: Shri P.K. Mishra
- Madhya Pradesh: Shri P.K. Mishra
- Maharashtra: Shri P.K. Mishra
- Orissa: Shri P.K. Mishra
- Rajasthan: Shri P.K. Mishra
- Shilpi Gupta

International Peers:

- Dr. Luigi Boitani, Prof. University of Rome, Italy
- Dr. John Seidensticker, (IUCN) Smithsonian Institution, USA
- Dr. Ramona Maraj, IUCN, Canada
- Dr. Andrew Royale, Bio Statician, Pataxent Wildlife Research Center (USGS), USA

Office Staff:

- Babita and Vivek Badoni
APPENDIX 1.3
LITERATURE USED FOR HISTORICAL TIGER DISTRIBUTION MAP PREPARATION


APPENDIX 1.4
DETAILS OF SPATIAL AND ATTRIBUTE DATA USED FOR ASSESSING PATTERNS OF TIGER DISTRIBUTION

Biogeography

We have used biogeographic classification based on Rogers and Panwar (1988) and Ecoregion classification by Wikramanayake et al. (2002).

Biogeographic Classification of India

<table>
<thead>
<tr>
<th>BIOCODE</th>
<th>ZONE</th>
<th>PROVINCE</th>
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</thead>
<tbody>
<tr>
<td>1A</td>
<td>Tran Himalaya</td>
<td>Ladakh Mountains</td>
</tr>
<tr>
<td>1B</td>
<td>Tran Himalaya</td>
<td>Tibetan Plateau</td>
</tr>
<tr>
<td>2A</td>
<td>Himalaya</td>
<td>North-West Himalaya</td>
</tr>
<tr>
<td>2B</td>
<td>Himalaya</td>
<td>West Himalaya</td>
</tr>
<tr>
<td>2C</td>
<td>Himalaya</td>
<td>Central Himalaya</td>
</tr>
<tr>
<td>2D</td>
<td>Himalaya</td>
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</tr>
<tr>
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</tr>
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</tr>
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<td>Semi-Arid</td>
<td>Punjab Plains</td>
</tr>
<tr>
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<td>Gujarat Rajasthan</td>
</tr>
<tr>
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<td>Western Ghats</td>
<td>Malabar Plains</td>
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<td>West Coast</td>
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<td>8B</td>
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<td>8C</td>
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<td>North-East</td>
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<tr>
<td>10B</td>
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</tbody>
</table>

APPENDIX A
DETAILS OF SPATIAL AND ATTRIBUTE DATA USED FOR ASSESSING PATTERNS OF TIGER DISTRIBUTION

Biogeography

The biogeographic classification is based on Rogers and Panwar (1988) and Ecoregion classification by Wikramanayake et al. (2002).

APPENDIX 1.4
DETAILS OF SPATIAL AND ATTRIBUTE DATA USED FOR ASSESSING PATTERNS OF TIGER DISTRIBUTION

Table 1: Details of remotely sensed data used for analyzing patterns governing tiger occupancy.

<table>
<thead>
<tr>
<th>Dataset</th>
<th>Sensors</th>
<th>Spatial Resolution</th>
<th>Radiometric Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest Cover</td>
<td>IRS 1D LISS III</td>
<td>23.5 m</td>
<td>4 Multispectral bands</td>
</tr>
<tr>
<td>Normalized Difference Vegetation Index (NDVI)</td>
<td>Advanced Very High Resolution Radiometer (AVHRR)</td>
<td>1000 m</td>
<td>3 Multispectral bands</td>
</tr>
<tr>
<td>Night-time visible lights</td>
<td>US Air Force Defense Meteorological Satellite Program (DMSP) Operational Linescan System (OLS)</td>
<td>1000 m</td>
<td>1 band</td>
</tr>
</tbody>
</table>

Night Light Data

Night light data was obtained from NOAA/NGDC using the Defense Meteorological Satellite Program’s Operational Linescan system (DMSP-OLS) for a pixel size of 2.7 km x 2.7 km. The visible (0.47 - 0.95 µm) and near-infrared (VNIR) spectral bands which are sensitive to the night-time light of cities, towns, fires, lightning, etc. are useful for mapping human habitation (Elvidge et al. 1997). The high contrast between lit and unlit areas and the sensor’s spatial resolution makes it a useful tool to identify regions of intense human activity (Croft 1973, 1978).

AVHRR-NDVI

Normalized difference vegetation index (NDVI) composites with 10-day interval for four years were derived from the 1-kilometer (km) advanced very high resolution radiometer (AVHRR) data acquired by the National Oceanic and Atmospheric Administration’s (NOAA) Television Infrared Observation Satellite (TIROS) (Townsend 1995). Advanced Very High Resolution Radiometer (AVHRR) to derive the Normalized Difference Vegetation Index (NDVI), is a way to quantify the biomass of actively photosynthesizing vegetation (Eidenshink, 1992). The relationship between NDVI and vegetation is well documented (Birkey, 2001; Rahman, 2003). NDVI has been used to predict the vineyard and unlit areas and the sensor’s spatial resolution makes it a useful tool to identify regions of intense human activity (Croft 1973, 1978).

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Normalized difference vegetation index (NDVI) composites with 10-day interval for four years were derived from the 1-kilometer (km) advanced very high resolution radiometer (AVHRR) data acquired by the National Oceanic and Atmospheric Administration’s (NOAA) Television Infrared Observation Satellite (TIROS) (Townsend 1995). Advanced Very High Resolution Radiometer (AVHRR) to derive the Normalized Difference Vegetation Index (NDVI), is a way to quantify the biomass of actively photosynthesizing vegetation (Eidenshink, 1992). The relationship between NDVI and vegetation is well documented (Birkey, 2001; Rahman, 2003). NDVI has been used to predict the vineyard and unlit areas and the sensor’s spatial resolution makes it a useful tool to identify regions of intense human activity (Croft 1973, 1978).

AVHRR-NDVI

Normalized difference vegetation index (NDVI) composites with 10-day interval for four years were derived from the 1-kilometer (km) advanced very high resolution radiometer (AVHRR) data acquired by the National Oceanic and Atmospheric Administration’s (NOAA) Television Infrared Observation Satellite (TIROS) (Townsend 1995). Advanced Very High Resolution Radiometer (AVHRR) to derive the Normalized Difference Vegetation Index (NDVI), is a way to quantify the biomass of actively photosynthesizing vegetation (Eidenshink, 1992). The relationship between NDVI and vegetation is well documented (Birkey, 2001; Rahman, 2003). NDVI has been used to predict the vineyard and unlit areas and the sensor’s spatial resolution makes it a useful tool to identify regions of intense human activity (Croft 1973, 1978).
Ecoregion Mapping

Ecoregions of the Continents characterize global potential natural vegetation at approximately 1/2-degree resolution. The dataset is based on a Russian vegetation map prepared by Gerasimov in 1964 which was updated by the US Fish and Wildlife Service (Bailey and Hogg, 1986 and Bailey 1989). Projected to geodetic coordinates at the World Conservation Monitoring Center, England.

<table>
<thead>
<tr>
<th>Code Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Rock and ice</td>
</tr>
<tr>
<td>2 Andaman Islands rain forests</td>
</tr>
<tr>
<td>3 Brahmaputra Valley semi-evergreen forests</td>
</tr>
<tr>
<td>4 Chin Hills-Atar Toma montane forests</td>
</tr>
<tr>
<td>5 Eastern highlands moist deciduous forests</td>
</tr>
<tr>
<td>6 Himalayan subalpine broadleaf forests</td>
</tr>
<tr>
<td>7 Lower Gangetic Plains moist deciduous forests</td>
</tr>
<tr>
<td>8 Malabar Coast moist forests</td>
</tr>
<tr>
<td>9 Maldives-Lakshadweep-Chagos Archipelago Tropical Monsoon Forest</td>
</tr>
<tr>
<td>10 Meghalaya subtropical forests</td>
</tr>
<tr>
<td>11 Mizoram-Manipur-Kachin rain forests</td>
</tr>
<tr>
<td>12 Nicobar Islands rain forests</td>
</tr>
<tr>
<td>13 North Western Ghats montane rain forests</td>
</tr>
<tr>
<td>14 North Western Ghats moist deciduous forests</td>
</tr>
<tr>
<td>15 Orissa semi-evergreen forests</td>
</tr>
<tr>
<td>16 South Western Ghats moist deciduous forests</td>
</tr>
<tr>
<td>17 South Western Ghats montane rain forests</td>
</tr>
<tr>
<td>18 Sundarbans freshwater swamp forests</td>
</tr>
<tr>
<td>19 Upper Gangetic Plains moist deciduous forests</td>
</tr>
<tr>
<td>20 Central Deccan Plateau dry deciduous forests</td>
</tr>
<tr>
<td>21 Chota Nagpur dry deciduous forests</td>
</tr>
<tr>
<td>22 East Deccan dry-evergreen forests</td>
</tr>
<tr>
<td>23 Khasi-Kirat-Gir dry deciduous forests</td>
</tr>
<tr>
<td>24 Narmada Valley dry deciduous forests</td>
</tr>
<tr>
<td>25 North Eastern dry deciduous forests</td>
</tr>
<tr>
<td>26 South Deccan Plateau dry deciduous forests</td>
</tr>
<tr>
<td>27 Himalayan subtropical pine forests</td>
</tr>
<tr>
<td>28 Northeast India-Myanmar pine forests</td>
</tr>
<tr>
<td>29 Eastern Himalayan broadleaf forests</td>
</tr>
<tr>
<td>30 Northern Triangle temperate forests</td>
</tr>
<tr>
<td>31 Western Himalayan broadleaf forests</td>
</tr>
<tr>
<td>32 Eastern Himalayan subalpine conifer forests</td>
</tr>
<tr>
<td>33 Western Himalayan subalpine conifer forests</td>
</tr>
<tr>
<td>34 Terai-Duar savanna and grasslands</td>
</tr>
<tr>
<td>35 Rann of Kutch seasonal salt marshes</td>
</tr>
<tr>
<td>36 Deccan thorn scrub forests</td>
</tr>
<tr>
<td>37 Northwestern thorn scrub forests</td>
</tr>
<tr>
<td>38 Thar desert</td>
</tr>
<tr>
<td>39 Goodean-Krishna mangroves</td>
</tr>
<tr>
<td>40 Indian River Delta-Arakan Sea mangroves</td>
</tr>
<tr>
<td>41 Sundarbans mangroves</td>
</tr>
<tr>
<td>42 Northwestern Himalayan subalpine conifer forests</td>
</tr>
<tr>
<td>43 Central Tibetan Plateau alpine steppe</td>
</tr>
<tr>
<td>44 Eastern Himalayan alpine shrub and meadows</td>
</tr>
<tr>
<td>45 Karakoram-West Tibetan Plateau alpine steppe</td>
</tr>
<tr>
<td>46 North Tibetan Plateau-Kunlun Mountains alpine desert</td>
</tr>
<tr>
<td>47 Northwestern Himalayan alpine shrub and meadows</td>
</tr>
<tr>
<td>48 Pansar alpine desert and tundra</td>
</tr>
<tr>
<td>49 Western Himalayan alpine shrub and Meadows</td>
</tr>
<tr>
<td>50 Tarah Tsangpo and steppe</td>
</tr>
<tr>
<td>51 Baluchistan xeric woodlands</td>
</tr>
</tbody>
</table>

Forested areas in each ecoregion that currently harbour tigers or have potential tiger habitat were estimated.

Climatological Data

The precipitation data (New et al., 2002) was generated from a 10 latitude/longitude data set of mean monthly surface climate over global land areas. The climatology includes 8 climate elements precipitation, wet-day frequency, temperature, diurnal temperature range, relative humidity, sunshine duration, ground frost frequency and wind speed which was interpolated from a data set of station means for the period between 1961 to 1990. This data was used to understand the influence of meteorological factors of tiger distribution and for evaluating potential tiger habitats.

Census data

Human population data was obtained from the office of Registrar General, India for the year 1991, under the section Primary Census Abstract (PCA). The PCA gives the data on number of houses and households, total population, Scheduled Castes and Scheduled Tribes, population in the age group 0-6 years, number of literates, number of workers classified by industrial categories, marginal workers and non workers. These data are available at the resolution of the village level for rural areas, and at ward level for cities and towns. We summarised this data at the Tehsil level to model tiger distribution.
Forested habitats are like islands in a sea of human dominated landscapes. People living on the edges (and within forests) utilize these forests to varying degrees, depending on their life styles, legal status of the forests, and implementation of protection measures. These anthropogenic pressures penetrate inwards from the edges. To model these effects and to assess the amount of forest that likely remains free of such disturbances we buffered each forest patch with an inward buffer of 3 km. These buffered “disturbance free” patches are referred to as cores.

### Core Areas

For the Landscape characterization and evaluation, fragmentation metrics like forest patch size, distribution and density, patch shape complexity and core area metrics were calculated using Fragstat (McGarigal and Marks 1995).

We derived Euclidian distance from protected areas, night light, drainage, roads and density of roads and drainage in 10 x 10 km grids to assess the human influence and habitat suitability (Appendix 3).

### Table: Tiger Numbers

<table>
<thead>
<tr>
<th>State</th>
<th>Lower Limit</th>
<th>Upper Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uttarakhand</td>
<td>1901</td>
<td>3683</td>
</tr>
<tr>
<td>Uttar Pradesh</td>
<td>2766</td>
<td>2936</td>
</tr>
<tr>
<td>Bihar</td>
<td>510</td>
<td>552</td>
</tr>
<tr>
<td>Shikar-Gangte, Prat Landscape Complex</td>
<td>5,177</td>
<td>7,171</td>
</tr>
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<td>5,177</td>
<td>7,171</td>
</tr>
</tbody>
</table>

### Population Estimates

- Population estimates are based on possible density of tiger occupied landscape in the area, not assessed by double sampling.
- **Data were not amenable to population estimation of tigers. However, available information about the landscape indicates low densities of tigers in the area ranging from 0.5 to 1.5 per 100 km².**
STATUS OF TIGERS, CO-PREDATORS AND PREY IN INDIA

Joseph Vattakaven