STATUS OF TIGERS, CO-PREDATORS & PREY IN INDIA

YADVENDRADEV V. JHALA, RAJESH GOPAL, QAMAR QURESHI
EDITORS

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National Tiger Conservation Authority
Ministry of Environment & Forests

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PREFACE

For 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, and holistic, addressing an array of parameters related to the survival of the species by using the blend of the best available science and technology. In case of the tiger our National animal, the only form of country wide monitoring was based on the pugmark system which depended on identifying individual tigers by experts. The system generated a total count of tigers in the states and in the country, but gave no indication of spatial occupancy, population extent and limits, connectivity between habitats and prey conditions which constitute the crucial elements for the continued survival of the tiger in a landscape. Realizing the shortfalls of the pugmark monitoring system in keeping pace with modern conservation biology needs for a monitoring scheme, the Project Tiger Directorate commenced a project in collaboration with the Wildlife Institute of India and the Forest Department of Madhya Pradesh in 2003 to evolve a monitoring program for “Tigers, Co-predators, Prey and their Habitat” in the Sariska-Maikal Landscape. This pilot project evolved field friendly data 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. 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. Pradipksh Ghosh, Secretary (Red.), Ministry of Environment and Forests took personal interest in ensuring the success of the program in the true spirit of an independent scientific endeavour. We thank Ms. Mereu Gupta, Secretary Ministry of Environment and Forests for her support. Dr. Pradipksh Ghosh, Secretary (Red.), Ministry of Environment and Forests took personal interest in ensuring the success of the program in the true spirit of an independent scientific endeavour. We thank Ms. Mereu Gupta, Secretary Ministry of Environment and Forests for her support.
acknowledge their contribution with gratitude. Dr. K Sankar, helped coordinate the logistics and recruitment of researchers at the Wildlife Institute of India. Faculty members of the Wildlife Institute of India are acknowledged for assisting in various field training workshops (Appendix 1.1). We thank Dr. S.A. Hossein and Dr. V.P. Uniyal, Hostel Wardens of WII for accommodating our large team 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 for his assistance in planning 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 unerring efforts. Dr. Andrew Royle is acknowledged for his assistance in occupancy modeling of tigers. We are grateful to the comments, critiques, 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. Ritu 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, Parbati Basu, Vivek Bhadon, Vinay Sharma, Virendra Sharma, Manoj Aggarwal, 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

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EXECUTIVE SUMMARY

Tiger occupied forests in India have been classified into 6 landscape complexes namely (a) Shihtal-Gangarit 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. 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.

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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.
Executive Summary

The Shivalik-Ganggetic plain landscape complex is composed of two landscape units, (a) Kadelur to Kishenpur and (b) Dudhwa to Valmiki. The landscape complex had about 20,800 km² of potential tiger habitat on the Indian side. The Dudhwa-Valmiki landscape is now connected only via Nepal forests, and needs to be managed through international co-operation with Nepal. Currently the tiger occupies 5880 km² of forested habitats with an estimated population size of 297 (216-313) in six separate populations. The most important tiger population within this landscape is Corbett tiger presence in 15,244 km² with an estimated population size of 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, Kishenpur and Katramaghat 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 Hardwar Forest Division) and Dudhwa National Park.

Within the forest area of the Central Indian Landscape tiger presence is currently reported from 47,122 km² (11.6 % of forests) with an estimated tiger population of 451 (347 to 564) distributed in 17 populations. The Central Indian landscape complex consists of eleven separate landscapes out of which four have potential for high density tiger populations. These are the (a) Kaha-Pench landscape of about 16,000 km² with tiger occupancy of 3,880 km² with an estimated population of 121 tigers (b) Satpura-Melghat landscape of 12,700 km² with a tiger occupancy in 3,331 km² and a population estimate of 22 tigers (c) Satpura-Melghat landscape of 13,700 km² and (d) Navgarh-Indravati landscape of 34,000 km². Five other landscapes with single source populations which could potentially persist due to their reasonable large size and potential for high density tiger population are (e) Bandhavgarh with tiger occupancy in 1,578 km² and a population estimate of 47 tigers (f) Panna with tiger occupancy in 974 km² and a population estimate of 24 tigers (g) Ramnagar-Kuno-Palpur with tiger occupancy in 3,300 km² and a population estimate of 36 tigers (d) Tadoba with tiger occupancy in 775 km² and a population estimate of 18 tigers. (e) Simlipal has a meta-population of about 229 km² and a population estimate of 20 tigers. Areas that need major inputs for achieving their conservation objectives and potential are Simlipal, Palamau Sanjay landscape, and Indravati landscape (which could not be assessed due to insurgencies). The above landscapes are large, contiguous forest patches with legal conservation status and therefore can potentially sustain viable tiger populations. Some parts of Maharashtra having low tiger intensity could not be used for analysis due to non-exact information.

The Eastern Ghat landscape complex currently has about 15,000 km² of potential tiger habitat. Tigers occupy 5,772 km² of forested habitats with an estimated population size of 83 (49 to 57) in a single contiguous forest block constituted by the Sri Lanka-Nagpur tiger Reserve and adjoining forests of Kurnool, Parakasam, Chinthadira and Mahabubnagar and Guzaur. This landscape is capable of supporting higher densities of tigers than currently reported. Major problems in achieving this potential is insolvency, biotic pressures, and subsistence level poaching of tiger prey.

Currently tigers occupy 21,435 km² of forests within the Western Ghat 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 Ghat landscape complex consists of three landscape units; (a) Forested area from the district of Pune to Palghat in Kerala, and eastwards up to Bhaumapuri 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 can be managed through international co-operation with the Government of Bangladesh. (b) Forest areas South of Palghat up to Kodaikanal having some connectivity with the Periyar landscape (c) The Periyar-Kalakad landscape unit of about 10,000 km². The current tiger population is likely consisting of the populations of Karnataka, Tamil-Nadu and Kerala 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 connectivity through the Karbi Anglong hills it serves as a major source of tigers into North-Eastern Hills and Brahmaputra plains. Thus Kaziranga is an important source population.

The Sunderban 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 Sunderben 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 Sunderban tiger population needs to be managed through International co-operation with the Government of Bangladesh.

State wise summery of tiger occupancy and estimated population is provided in table ES.1.
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 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 conservation. Tigers are a conservation dependent species need of conservation inputs are Sirsailam Nagarjun Sagar, possibility to share genetic material and exist in a meta-polygon framework, thereby enhancing the possibility of Andhra Pradesh, and Bandhavgarh-Sanjay-Palamau. To ensure their survival.

Executive Summary

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<th>Bear km</th>
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Table ES.1: Forest occupancy of Tigers, Co-Predator, Prey and population estimates of tigers.
A Camera Trap picture of a tigress in Kanha Tiger Reserve. The camera unit is visible in the picture.
**INTRODUCTION**

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 crucial in regulating and perpetuating ecological processes and systems (Terboggt J. 1995, Sinaputi 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 McDougall 1993, Karanth and Sansequi 1995, Carbone et al. 1999).

Unlike Africa, Latin America or South-East Asia, the forest borders in India appear to have stabilized while forest quality continues to deteriorate due to resource extraction (Ghumer 1979, Ganitulkle & 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 comparable period of time in human history. Meeting the vast sea of ecologically unsustainable land uses of varying degrees. Tiger reserves and some protected areas serve as source populations of tigers while intervening forested areas act as corridors. Thus the “tiger bearing forest” need to be fostered with protection as well as restorative inputs to ensure their 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.

This report attempts to take stock of what we have and where. 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 are being analysed using GIS and multivariate statistical models. It provides spatial data on tiger distribution at the best level and its associated landscape characterization at 100 km² grids, which is a precursor for land use planning incorporating conservation concerns and priorities.

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.

India harbors a reasonably large proportion of the World’s tiger population. This is attributed to a good forest cover (678,333 km², 20.64%), reasonable number (613) of good protected areas with a wide coverage, 28 established tiger reserves and 10 proposed tiger reserves.

The only forms of tiger population monitoring undertaken in the country is a total count (census) of the country-wide tiger population every four years, and in tiger reserves every two years. The census is based on intensive monitoring of tigers within areas, identifying individual tigers by visual inspection of pugmark tracings/plaster casts, mapping tiger distribution at the local scale and inferring total numbers from the above information (Choudhury 1979, 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; and 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 Wege et al 2004 and...
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 officials for field data collection. The trained forest officials in turn trained 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 1995 and 1998, Karanth and Nichol 1998, 2000 and 2012, Karanth et al. 2004 and Kawanishi and Sunquist 2004). The other two potential methods that can be used in smaller sample areas for monitoring source tiger populations are the (b) tiger prey presence and relative abundance and (c) habitat quality and anthropogenic pressures at a high spatial resolution (Jhala et al. 2001, Karanth et al. 2005). We have tried to address the issue of reporting inflated numbers 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; discrepancies in reporting were relatively easy to pinpoint. There was an audit mechanism in place to scrutinise the data collection, compilation and analysis. National and international experts acted as observers while officers in-charge ensured accountability of this agency which is primarily responsible for adherence to the prescribed protocol and transparency of protocol implementation. The system, once institutionalised and implemented, will not only serve to monitor tiger populations but will also monitor the status of other biodiversity resources of all tiger occupied landscapes. 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 officials for field data collection. The trained forest officials in turn trained 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 (Jhala et al. 2001, Karanth et al. 2005).

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 recognised by forest staff. The sampling was systematically 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 sampled, but all beats were sampled as large human accessible was for sampling). In forest areas, where beat boundaries are not delineated (< 20 per cent of tiger occupied forests in the country) such as the northeast 15-20 sq km sampling units were identified on the basis of natural boundaries (ridges, drainage, etc). The detailed methodological approach for sampling carnivore signs, ungulate encounter rates, pelleting counts, habitat and anthropogenic pressures are presented in the ‘Field Guide’ (Jhala, Qureshi and Gopal 2005). The target data were extremely easy to collect did not require high level of technical skills or equipment. It is crucial that the forest department staff is primarily responsible for the data collection due to the sheer magnitude of the task involved. Furthermore, the involvement of the forest department staff insinuates ownership and accountability of this agency which is primarily responsible for the protection and management of wildlife resources.

The spatial data generated was scientifically robust, amenable for statistical analysis and inference. Since several replicate surveys were taken in each beat, we were able to model tiger occupancy, detection probability of tiger signs, and relative sign density at a high spatial resolution (stratified on the basis of ecological characteristics, range or a superimposed grid of varying scale) using the approach of MacKinnon et al. (2002); Royale and Nichols (2003) and Royale (2004). Since the data was analysed in a GIS domain, several spatial and attribute data like human density, livestock density, road network, topographical features, forest type and cover, meteorological data, poaching pressures and landscape characteristics was used as covariates to model tiger occupancy and relative abundance in a landscape and individual forest patches. Time series analysis of the data at a larger spatial resolution is likely to have sufficient precision for monitoring spatial occupancy of tigers in association with changes in tiger prey, habitat quality and anthropogenic pressures. We have tried to address the issue of reporting inflated numbers by laying emphasis on animal signs instead of numbers. Furthermore, the resolution of the data generated will be reduced to four-five categories (high, medium, low and absent). Several corroborating variables like prey encounter rates, pellet group counts and habitat condition will help in ensuring quality data; discrepancies in reporting were relatively easy to pinpoint. There was an audit mechanism in place to scrutinise the data collection, compilation and analysis. National and international experts acted as observers while officers in-charge ensured adherence to the prescribed protocol and transparency of protocol implementation. The system, once institutionalised and implemented, will not only serve to monitor tiger populations but will also monitor the status of other biodiversity resources of all tiger occupied landscapes, truly exemplifying the role of the tiger as a flagship. It will serve as an effective tool for decision makers, managers and conservationists alike and will help guide and plan land use policy at a landscape level.

PHASE II: Spatial and attribute data
The spatial and attribute data that are likely to influence tiger occupancy of a landscape will be used for modeling in a GIS domain. The vegetation map, terrain model, night light satellite data, drainage, transportation network, forest cover, climate data, Normalised Difference Vegetation Index, livestock abundance, human density, socio-economic parameters, etc were used for modelling habitat condition and tiger occupancy. Beat-wise vegetation sampling was done to generate broad
Introduction & Methods

Status of Tigers, Co-predators and Prey in India

that landscape (Conn et al. 2002). Line transects (Buckland et al. 2001, Chao & Yang 2003, Efford 2007, Karanth 1995 and 1998, I et al. 1990, Per Wegge et al. 2004 and Rextad & Burnham 2004, 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 widths 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 (Buckland 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 (Buckland et al. 1993). Pellet group counts on tiger tracks 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 peers. A public debate was invited over email 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). 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 distribution of tigers, potential habitats, threats to crucial we estimated actual tiger density in 5 to 13 replicates of sufficient vegetation map. IRS (LISS III and AWiFS), LANDSAT and AVHRR satellite data was used. Part of this component was done in collaboration with Forest Survey of India and Survey of high, medium, low and no tiger sign at the beat and larger spatial resolution (100 km). In each of these strata, within a landscape we estimated actual tiger density in 5 to 10 replicates of sufficient width (100-200 km). We primarily depended on remote camera traps to identify individual tigers based on stripe patterns, population estimates based on mark-recapture framework were done using CAPTURE, Care 2 and Demosy (Carbon et al. 2001, Chao & Yang 2003, Efford 2007, Karanth 1995 and 1998, Karanth and Nichols 1998, 2000 and 2002, Karanth et al. 2004, Pollock et al. 1990, Per Wegge et al. 1993, Robinson et al. 1991). Based on the relationships development between tiger density and indices/covariates. These densities were then extrapolated for the areas under various density classes within the landscape to arrive at a tiger population estimate. We do realize that these population estimates 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 for the need for converting a relevant ecological index to a more comprehensive concept of number of tigers. The tiger population reported by us throughout the core data (Conn et al. 2004, Pollock et al. 2002, Skalski and Robinson, 1992, Williams et al. 2002).

Tiger Numbers

We stratified each landscape into tiger sign abundance classes of high, medium, low and no tiger sign based on the beat and larger spatial resolution (100 km). In each of these strata, within a landscape we estimated actual tiger density in 5 to 10 replicates of sufficient width (100-200 km). We primarily depended on remote camera traps to identify individual tigers based on stripe patterns, population estimates based on mark-recapture framework were done using CAPTURE, CARE 2 and Demosy (Carbon et al. 2001, Chao & Yang 2003, Efford 2007, Karanth 1995 and 1998, Karanth and Nichols 1998, 2000 and 2002, Karanth et al. 2004, Pollock et al. 1990, Per Wegge et al. 1993, Robinson et al. 1991). Based on the relationships development between tiger density and indices/covariates. These densities were then extrapolated for the areas under various density classes within the landscape to arrive at a tiger population estimate. We do realize that these population estimates 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 for the need for converting a relevant ecological index to a more comprehensive concept of number of tigers. The tiger population reported by us throughout the core data (Conn et al. 2004, Pollock et al. 2002, Skalski and Robinson, 1992, Williams et al. 2002).

PHASE III: Estimating the population of tigers and its prey

PHASE II: Regular 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 kraising, 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 (Pawar 1979, Pradhan 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 distribution of tigers, potential habitats, threats to crucial we estimated actual tiger density in 5 to 13 replicates of sufficient vegetation map. IRS (LISS III and AWiFS), LANDSAT and AVHRR satellite data was used. Part of this component was done in collaboration with Forest Survey of India and Survey of high, medium, low and no tiger sign at the beat and larger spatial resolution (100 km). In each of these strata, within a landscape we estimated actual tiger density in 5 to 10 replicates of sufficient width (100-200 km). We primarily depended on remote camera traps to identify individual tigers based on stripe patterns, population estimates based on mark-recapture framework were done using CAPTURE, Care 2 and Demosy (Carbon et al. 2001, Chao & Yang 2003, Efford 2007, Karanth 1995 and 1998, Karanth and Nichols 1998, 2000 and 2002, Karanth et al. 2004, Pollock et al. 1990, Per Wegge et al. 1993, Robinson et al. 1991). Based on the relationships development between tiger density and indices/covariates. These densities were then extrapolated for the areas under various density classes within the landscape to arrive at a tiger population estimate. We do realize that these population estimates 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 for the need for converting a relevant ecological index to a more comprehensive concept of number of tigers. The tiger population reported by us throughout the core data (Conn et al. 2004, Pollock et al. 2002, Skalski and Robinson, 1992, Williams et al. 2002).
STATUS OF TIGERS, CO-PREDATORS AND PREY IN INDIA

Introduction & Methods

Mapping tiger occupancy but it was not possible to extrapolate tiger densities for the landscape from this data. Since Sunderbans is a unique and hostile tiger habitat we have evolved a separate protocol for evaluating tiger, prey, and habitat status for the Sunderban landscape. Population estimates and detailed status report would be provided later as per this protocol. Herein we provide data on tiger distribution and occupancy of this landscape.

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 districts. 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

[Image of tiger map]
Figure 1.2: Tiger occupied landscapes, Potential Tiger habitat and Tiger Reserves

Introduction & Methods

The status of tigers, co-predators and prey in India 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.

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). The probability of tiger occupancy in forested areas of each landscape complex (based on the logistic model) was used to map habitat suitability for tigers. The variables that explained probability of tiger occupancy were level of forest (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 Characteristics (ROC) Curves. The area under ROC curve varied between 98 to 99 percent for all landscape models indicating a good fit.

The probability of tiger occupancy in forested areas of each landscape complex (based on the logistic model) was used to map habitat suitability for tigers. The variables that explained probability of tiger occupancy were level of forest fragmentation, size of forested patch, prey presence, and anthropogenic pressures. 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 Characteristics (ROC) Curves. The area under ROC curve varied between 98 to 99 percent for all landscape models indicating a good fit.

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SHIVALIK-GANGETIC FLOOD PLAINS

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

Research Team
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. 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, 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 course 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 (Johnsingh et al. 2004).

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 (Johnsingh et al. 2004).
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 population size of 297 (259 to 335) in six separate populations 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, Kishenpur 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 Hardwar Forest Divisions) and Valmiki Tiger Reserve.

Figure 2.2: Tiger occupied forests, individual populations, their extent and habitat linkages within the Shivalik-Gangetic floodplain landscape

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

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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).

Chital occupancy was detected in 8,274 km² (Figure 2.6), Sambar occupancy was detected in 5,718 km² (Figure 2.7), Wild Pig occupancy was detected in 11,545 km² (Figure 2.8), Nilgai occupancy was detected in 9,291 km² (Figure 2.9) and Elephant occupancy was detected in 579 km².

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

Figure 2.4: Wild Dog occupied forest, individual populations, their extents and habitat connectivity in Shivalik Gangetic Landscape Complex
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 Gangetic 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 were 13,000 km² in Uttarakhand. Currently tigers occupy 1,901 km² of these forests having tiger 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 the 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 West 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 the population. Another smaller population (14, 11 to 17) is recorded in Rajaji National Park covering an occupied area of 390 km². Sporadic occurrences of tigers are reported in the forests of Tehri upto an elevation of 3000m (Figure 2.1).

Conservation Recommendations

1. The source population of Corbett Tiger Reserve having a tiger occupancy in 1,534 km² with an estimated population of 164 (151-178) tigers sustains all reported 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 the 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 West 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 the population. Another smaller population (14, 11 to 17) is recorded in Rajaji National Park covering an occupied area of 390 km². Sporadic occurrences of tigers are reported in the forests of Tehri upto an elevation of 3000m (Figure 2.1).

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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.

(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 impermeable 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) Boar river b) Nehal-Bhakra, d) Gola River, e) Kilpur-Khatima-Surai corridors. All of the above river corridors have intense bolder mining activity and associated settlements of labor colonies making them barriers to wildlife movements.
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, Kataraghat 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 Kataraghat 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 Sehgalbara 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 Kataraghat, Dudhwa, and Kishenpur-Pilibhit that have intersecting 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 subsidies. 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...
other source populations in Nepal. This meta-population structure needs to be maintained through transboundary connectivity’s 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 (3-10) tigers. It potentially has connectivity via the Shivalik hills (Mahadevpuri-Lamahi corridor) of Nepal with Chitwan National Park and Valmiki Tiger Reserve, in Bihar. Sohagibarwa 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 Chhattisgarh. 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, drift 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 form 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 Palamu Tiger Reserve and can potentially have tiger occupancy through dispersing tigers if Palamu source population is improved.
CENTRAL INDIAN & EASTERN GHATS LANDSCAPE

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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, sambar, nilgai, greater diversity in the hill ranges. Relict populations of buffalo chowsingha. However, some species are more frequent than others, while a few species are restricted to moister areas, e.g. barking deer, tigers, blackbuck, and chinkara. Principal catchment for many of Central and Southern India's main river systems (Narmada, Tapti, Mahanadi and Godavari) which have small relict population include elephant, the wild gaur, and the hard ground swamp deer. The gharial is restricted to a few rivers flowing into the Ganges. Loss of forest cover is already discernable in increased frequency of drought, floods, erosion and reservoir siltation. Thus, there is a need for greater conservation inputs for wildlife, forest resource and water catchment purposes (Rodgers & Panwar 1988). The better protected areas do provide example 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 (Figure 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>
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</tr>
<tr>
<td>Forest patch density per 1000km²</td>
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</tr>
<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>
<td>30272</td>
</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>
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 need for major source population. 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 Gondal, Pipli, and Sipir 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. There 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 patches exists between Bandhavgarh and Sanjay-Palamau landscape. 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, Jaisingh Nagar and Sehagpur to increase the conservation value of this landscape.

Central Indian and Eastern Ghats Landscape

Figure 3.1: Distribution of Protected Areas and various size of forest patches in the Central Indian 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 Wara 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.

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 patches 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
managed can sustain a sizable tiger population.

(c) **Ranthambore–Kuno–Palpur–Madhav**: Though Ranthambore forest patch (300 km²) is physically disjointed, 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 ravineous terrain which is conducive for movement of dispersing tigers. The possibility of tigers dispersing into Madhav-Shivpuri (650 km² forest patch) via stepping stone forest patches also exists.

(d) **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.

(e) **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, Pithulba and Ganjam, covering an area of about 15,000 km².

(f) **Tadoba Tiger Reserve**: 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.
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 Nagarjunasagar Tiger Reserve-Gudalur Brahmeeduwa proposed National Park, 3000 km² block of forest comprising of Srivencatkalwa National Park and 700 km² forest patch in the teehils of Kanigiri, Badula, Udayagiri and Giddalur. The Nagarjunasagar 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.

The total forested area occupied was 85,962 km² (Figure 3.4) of forested habitat (Figure 3.5) Chital was distributed in 109,873 km² of forested habitat (Figure 3.6) Sambar was distributed in 861,322 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 21,392 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 Mandsaur 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 Sarai 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 3.5).

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 km, leopard presence in 24,736 km, chital presence in 28,508 km and sloth bear presence in 40,960 km of forested habitat. Amongst prey species, wild pig occupied 59,903 km, nilgai 41,704 km, gaur 5,577 km, chital 41,509 km, and sambar 33,550 km of forested habitats. The relict population of Barasingha was restricted to a single landscape in Madhya Pradesh (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) tigers. 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 are either historical relicts 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 Sidhi forming potential linkages through Sanjay conserving these areas and populations to ensure long term tiger survival in the larger landscapes.

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 landscape within the framework of connecting link between Bandhavgarh and tiger populations forming the Kaisen 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.

2) The Kanha tiger reserve buffer needs to be extended forming 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 Chhinda 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 two major tiger occupied landscapes in MP.

6) The connecting forests North East of Bandhavgarh Tiger Reserve in the tehsils of Bhojpur, Jaisingh Nagar in Shahdol 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 Satpura 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).

Central Indian and Eastern Ghats Landscape
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 were reported presence in 7,370 km², nilgai 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 30 (± 1 se range 21-39) tigers. The tiger distribution in Melghat is contiguous with the population in Madhya Pradesh forming a metapopulation with the Satpura Tiger Reserve as the other source population.

b) 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 protection and restorative management to maintain and enhance the value of this source for the larger landscape (Figure 3.12).

c) Pench (Maharashtra) being contiguous with the forest patch of the graph 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.

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 a population of 30 (± 1 se range 21-39) 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.

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).
CHATTISGARH

The state has a total forest cover of 27,967 km² with tiger occupancy reported in 3,609 km². Chattisgarh 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.

Population Size: The tiger population for the state of Chattisgarh was estimated to be 26 with a standard error range of 23-28 tigers.

Conservation Recommendations:
- 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.
- 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 Chattisgarh (Figure 3.13).

Figure 3.13: Tiger occupied forests, individual populations, their extents and habitat connectivity in Chattisgarh.

Central Indian and Eastern Ghats Landscape
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 8,272 km² and sambar in 6,112 km² of forested habitat. Amongst prey species wild pig were reported from 21,525 km², nilgai from 711 km², chital from 6,040 km² and sambar from 6,112 km² of forested habitat. The low density reported mapable leopard presence in 25,516 km², dhole population was estimated to about 6 tigers. The area covers the districts of Kulbani, Gangam, and Kalahandi. Tigers were distributed in four larger occupied units, three smaller units and sporadic occurrences largely in Southern and Central part of the State. The larger occupied units comprise of:

a) Simlipal Landscape comprising of 3,824 km² patch of forest has recorded tiger presence in 2 units having a total tiger occupancy of 2,297 km² with an estimated tiger population of 20 (17-24) tigers.

b) Sonabeda-Usatini-Indravati Landscape is part of a contiguous forest patch of 34,000 km² having a tiger occupancy in Orissa of 570 km² of about 9 (7-11) tigers.

c) Tiger population in the tehsil of Malakangari in the district of Koraput comprising the sanctuary of Baimila and Kondakhambe comprises a part of the forested patch of 6254 km² that extends from East Godavari, Khammam and Vizagapatnam of Andhra Pradesh. Tiger occupancy in this forest patch in Orissa was reported in 879 km². Sporadic tiger presence is recorded in several places within Koraput district.

d) Satkosia Landscape is part of a forest patch of 13,459 km² and has tiger occupancy in 787 km² with several smaller pockets reporting tiger presence. The low density population was estimated to about 6 tigers. The area covers the districts of Khitari, Gangan and Khulbandi. The smaller tiger occupied units having between 6-8 tigers were:

a) In the forested area of Raigarah tehsil in Koraput district with a tiger occupancy of 97 km².

b) The tiger occupancy of 221 km² was recorded in Sonagabad tehsil.

c) The Bargh steel having an occupancy of 142 km².

The total tiger population in Orissa was estimated to be 45 (37 to 53) tigers. Conservation Recommendations:

a) In the forested area of Raigarah tehsil in Koraput district with a tiger occupancy of 97 km².

b) Tiger population in the tehsil of Malakangari in the district of Koraput comprising the sanctuary of Baimila and Kondakhambe comprises a part of the forested patch of 6254 km² that extends from East Godavari, Khammam and Vizagapatnam of Andhra Pradesh. Tiger occupancy in this forest patch in Orissa was reported in 879 km². Sporadic tiger presence is recorded in several places within Koraput district.

d) Satkosia Landscape is part of a forest patch of 13,459 km² and has tiger occupancy in 787 km² with several smaller pockets reporting tiger presence. The low density population was estimated to about 6 tigers. The area covers the districts of Khitari, Gangan and Khulbandi. The smaller tiger occupied units having between 6-8 tigers were:

a) In the forested area of Raigarah tehsil in Koraput district with a tiger occupancy of 97 km². The larger occupied units comprise of:

b) The tiger occupancy of 221 km² was recorded in Sonagabad tehsil.

c) The Bargh steel having an occupancy of 142 km².

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 Sonabeda 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).

Figure 3.14: Tiger occupied forests, individual populations, their extents and habitat connectivity in Orissa
JHARKHAND

Jharkhand has a forest area of 23,630 km² with mapable tiger occupancy reported in 1,468 km². Jharkhand reported mapable leopard presence in 131 km², 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 Saranda and in the forests of Ranchi tehsil. Both these areas form a contiguous forest patch of 7,448 km² that extends into Northern Odisha. The Palamau Tiger reserve did not report any tiger signs during Phase I survey. However, questionnaire survey of Phase I data indicates tiger presence which requires further field verification for evaluating status of the population. Subsequent data provided by the state was not as per the Phase I protocol but indicating presence and absence of tigers conducive only for mapping occupancy (Figure 3.15). Due to this limitation it was not possible to estimate population size of tigers for this state.

Conservation Recommendation

Palamau Tiger Reserve forms a crucial linkage via forests of Chattisgarh up to 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.
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 forest. 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 km⁻² (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 (6D) & Deccan South (6E)) and 2. Coasts—East Coast (6B)
Table 4.1: Landscape Characteristics of the Eastern Ghats Landscape Complex

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ANDHRA PRADESH

Andhra Pradesh comprises of two major disjoint 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 54,544 km² with tiger occupancy reported in 22,128 km². Andhra Pradesh reported mappable leopard presence in 37,609 km², dhole presence in 26,526 km², chital presence in 37,182 km², gaur presence in 3,139 km², and sambar in 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 was estimated to be 19 (17 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.

Among the Southern Eastern Ghats the major tiger population is located in the Srisailam-Nagarjuna Sagar Tiger Reserve and adjoining forests in the districts of Kurnool, Parakasam, Srikakulam and Guntur having a tiger occupancy in a single block of 7,772 km² having a population of about 53 (49 to 57) tigers.

The Tiger population for the State of Andhra Pradesh was estimated at 95 (84 to 107).

Conservation Recommendations:

The source population of tigers in Srisailam needs to be fostered through preybase enhancement and protection so that it sustains a larger high density tiger population. This population can than 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 by prey base restoration. Tiger populations in Northern Andhra Pradesh are a part of the larger tiger occupied landscape of Indravati, extending through Chattisgarh, Maharashtra and Orissa. These populations need to be managed with interstate cooperation and a holistic landscape management plan (Figures 3.2 and 4.2). Enhancing the legal status of the Forests harbouring tigers in the districts of Adilabad, Karimnagar, Khamam and East Godavari would foster tiger conservation in this region.

Figure 4.2: Tiger occupied forests, individual populations, their extents and habitat connectivity in Andhra Pradesh.
WESTERN GHATS COMPLEX

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

Research Team
STATUS OF TIGERS, CO-PREDATORS AND PREY IN INDIA

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 15000 species of higher plants, of which around 4000 (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 (Mara 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 still a major stronghold for the species due to its large and contiguous forested tracts (Figure 5.1).

Total geographic area: 281,726 km$^2$
Political units: Tamilnadu, Kerala, Karnataka, Maharashtra (partially).
Average population density: 318.7 km$^{-2}$
Total protected area: 10,099.9 km$^2$ (5.8% of the total land area)
Total forested area: 101,467 km$^2$

Major biogeographic zones: 1. Western Ghats (Malabar Plains (5A) & Western Ghats Mountains (5B)), 2. Deccan Peninsula (Central Plateau (6D) & Deccan South (6E)) and 3. Coasts (East Coast (8A) & West Coast (8B)).
Table 5.1: Landscape Characteristics of the Western Ghats Landscape Complex

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</tbody>
</table>

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 (156 to 487).

The Western Ghats landscape complex consists of 3 major forested landscapes (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 Dhanasari in Tamil Nadu (39,600 km²). There are several National Parks, Sanctuaries and Tiger Reserves in this landscape eg. Koyna, Kudalangi, Bhagwan Mahavir, Ani, Kudremukh, Bhadra Tiger Reserve, Nagarhole-Bandipur Tiger Reserve, Silent Valley, Dr. Jayalalitha, Eravikulam, Muthurli and Banergutta. This landscape covers contiguous forest area of 39,800 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, Anamalai, Thrissur, Indira Gandhi, Chinnur, Idukki, Shola forest and Kodai Kounal.
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-Agastyamalai-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),
- Sambhar 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 centres and habitat connectivity in Western Ghats Complex.
KARNATAKA

The forest cover of Karnataka is 40,236 km², comprising 21% of the geographic area of the State. Forests of Tiger Conservation Priority I & II were 24,182 km² in Karnataka. b) Kudremukh-Bhadra: This population, though distinct from the Madumalai-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 (52-65). 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, Attive, Dandeli, Sanctuaries in Karnataka having tigers, constitute this population. Adjacent areas of Amba, Netravali, and Mollem 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

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Conservation Priority I & II were 24,182 km² in Karnataka. b) Kudremukh-Bhadra: This population of tigers, though distinct from the Madumalai-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 (52-65). 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, Attive, Dandeli, Sanctuaries in Karnataka having tigers, constitute this population. Adjacent areas of Amba, Netravali, and Mollem 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 form 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 Kadremukh-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. Amongst 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) KMTT-Periyar Population: Extending from Kalakad-Mundumthurai in Tamil Nadu to Peppara and Periyar 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 Indiragandhi-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 (Kerala) Bandipur-Nagarhole Tiger Reserve (Karnataka)- forests of Nilgiri and Periyar districts of Tamil Nadu and Nilgiri Rangaswami Temple Sanctuary to Cauvery Sanctuary (Karnataka). The forest patch containing this population (and several other tiger populations) extends from Palghat gap (Palghat District Kerala) northwards to Bhumikanagar 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 3,326 km² with an estimated tiger population of 62 (44 to 80) tigers.

Conservation Recommendations

1) Since Kalakad-Periyar Landscape and Indiragandhi-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 Ghats 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-Mundumthurai in Tamil Nadu to 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 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 Ranganatham Temple Sanctuary to Cauvery Sanctuary (Karnataka). The forest patch containing this population (and several other tiger populations) extends from Palghat gap (Palghat District Kerala) northwards to Bhimashankar Sanctuary in the District of Pune, Maharashtra and eastwards in the district of Dharanapuri 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 8,186 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 Ghats tiger populations and thus permit long term persistence of these populations.
NORTH EASTERN HILLS & BRAHMAPUTRA FLOOD PLAINS

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

Research Team
Ashem Rahul Singh, Dr. Jimmy Borah, Dr. Karabi Deka, Peer Munamul Shams, Rajni Sharma, Raju Lal Gurjar Subhadeep Bhattacharjee, Tanu Mevada, Uday K. Das, Umeshkumar Tiwari
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 a 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 this 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). Total geographic area : 271,129 km². Political Units : It consists of Sikkim, Assam, Arunachal Pradesh, Meghalaya, Manipur, Mozoram, Nagaland, Tripura & West Bengal partially or fully. Average population density : 114 km⁻² (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) and 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, Morling and Dr. D. Ering Sanctuaries into Dibang National Park and upto Sundaraphu Tiger Reserve in the East. The landscape continues south through some degraded areas into Itanaki National Park, and further South to Dampa Tiger Reserve and Blue Mountain National Park. Kaziranga National Park in the Bhamaputra flood plains is connected through the Kairi Anglong Hills to Itanaki in the South. This connectivity through Kairi 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 Brahmaputra (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, Morling and Dr. D. Ering Sanctuaries into Dibang National Park and upto Sundaraphu Tiger Reserve in the East. The landscape continues south through some degraded areas into Itanaki National Park, and further South to Dampa Tiger Reserve and Blue Mountain National Park. Kaziranga National Park in the Bhamaputra flood plains is connected through the Kairi Anglong Hills to Itanaki in the South. This connectivity through Kairi 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 Brahmaputra flood plains. Itanaki National Park is also connected westwards through priority III forests upto Balphakram National Park. This landscape has contiguous forest across the International border with Myanmar. The weak links in this landscape are the forests in the districts of Mon, Mokok Chung, Tuirang, Zabehtoo, Wokha, and Pehi in the East. The landscape between Balphakram National Park and Itanaki National Park through the districts of Karbi Anglong, West Khasi Hills, East Khasi Hills and East and West Garo Hills is fragmented. The major source populations of tigers in this landscape are Kaziranga and Pakke in India and dispersing tigers from Bhutan and Myanmar.

(2) Manas - Ripu Chirang - Buxa/Jaldapara Gorurama - Singhmah landscape unit. This landscape is about 7,220 km² with a single block of 5,000 km² from North and West Bengal (Gorumara) to the contiguous forests of Sikkim (Singmah). The connectivities in the Bhamaputra plains are patchy and fragmented, but the landscapes are connected through the forests of Bhutan. On the Indian side, “stepping stone” connectivity exists between Gorurama, Jaldapara, Buxa, and Ripu Chirang through the district of Jalpaiguri. Connectivity between Ripu Chirang and Manas is lost on the Indian side. This landscape needs to be managed through transboundary International cooperation with the Government of Bhutan.

(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.

Landscape occupancy of Co-predators and prey in North East Hills and Brahmaputra Flood Plains

Leopard occupancy was detected in 5,629 km² (Figure 6.2), Wild Dog occupancy was detected in 2,037 km² (Figure 6.3), Bear occupancy was detected in 1,058 km² (Figure 6.4), Chital occupancy was detected in 280 km² (Figure 6.5), Sambar occupancy was detected in 2,632 km² (Figure 6.6), Wild Pig occupancy was detected in km² (Figure 6.7), Gaur occupancy was detected in km² (Figure 6.7) and Elephant occupancy was detected in km² (Figure 6.7)
Figure 6.2: Leopard occupied forest, individual populations, their extents and habitat connectivity in North East Hills and Brahmaputra Flood Plains

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

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

Figure 6.9: Elephant occupied forest, individual populations, their extents and habitat connectivity in North East 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 occur 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 117.9 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 135,707 km² and is contiguous till Namdapha Tiger Reserve in the east, it extends south to Intakti National Park and further south to Dampas 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, Laskhowa, Baruahpore, 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.
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. An example of such forest is the Arunachal Boarder. 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 form Kaziranga. Forest patches with tigers are also found along the Assamchul Boarder. An example of such forest is the Jeympre forest division which is also a good repository of biodiversity and would benefit with an enhanced legal status.
ARUNACHAL PRADESH

The forest cover of Arunachal Pradesh is 68,186 km², comprising 83% 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 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 670 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 Nameri 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. Kaziranga 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 778 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 1,700 km², Wild pig 1,489 km² and 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 forest 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.

Figure 6.12: Tiger occupied forest, individual populations, their extent and habitat connectivity in Mizoram.
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 Gorumala 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
SUNDERBANS

The Sunderban mangroves are part of the subcontinent'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 80 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 Sundarbans tigers is their fearsome reputation of being habitual man-eaters.

Total geographic area : 2,585 km²
Political units : South 24 Paragana(s) (West Bengal).
Population density : 1,437.4 km²
Total protected area : 2,585 km²
Total forested area : 1,474 km² (Figure 29)
Major biogeographic zone : It comes under east coast 8B of biogeographic zones, and Sunderbans mangroves of ecoregions.

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
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 potentially share their gene pool. Tiger occupancy in the Indian Sunderbans was reported to be 1,386 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

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<td>Mean forest perimeter to area ratio</td>
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<td>Total forest core area in forest patches &gt;1000 km²</td>
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**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. The model allows detection probability, $p$, to be less than 1.0

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* Iter – Model Iteration
Estimating tiger numbers over such vast geographical areas with precision 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-Mudumalai-Bandipur-Wayanad population, Corbett population, Kanha population, and possibly Sunderban and Kaziranga-Kurigram-Anglong populations. Tiger populations that exist and can persist in a meta population framework are Rajaji-Corbett, Dudhwa-Katarniaghat-Kishenpur (along with Bardia and Shuklaphanta in Nepal), Satpura-Melghat, Pench-Kanha, Bhandra-Kudremukh, Parambikulam-Indira Gandhi, and EMTR-Preiyr, 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, habitant restoration and community participation are Srisailam Nagarjun Sagar, Similipal, Ranthambore-Kuno Palpur, Indravati-Northern Andhra Pradesh, and Bandhavgarh-Sanjay-Palamau. 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 intercession 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.


References


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:

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APPENDIX 1.2

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

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Madhava Pradehesh Shri A.S. Negi
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Dr. Chris Carbone, Zoological Society of London, UK
Dr. Ramou Maraj, IUCN, Canada
Dr. Andrew Rosey, Bio Statician, Pataxent Wildlife Research Center (USGS), USA
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 Rodgers and Panwar (1988) and Ecoregion classification by Wikramanayake et al. (2002).

Biogeographic Classification of India

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<td>Central Highlands</td>
<td>10B</td>
<td>Islands</td>
<td>Nicobar</td>
</tr>
</tbody>
</table>

Appendices

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>
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</thead>
<tbody>
<tr>
<td>Forest Cover</td>
<td>IKS 1D LISS III</td>
<td>23.5 m</td>
<td>4 Multispectral bands</td>
</tr>
<tr>
<td>Normalized Difference</td>
<td>Advanced Very High</td>
<td>1000 m</td>
<td>3 Multispectral bands</td>
</tr>
<tr>
<td>Vegetation Index (NDVI)</td>
<td>Resolution Radiometer (AVHRR)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digital Elevation Model</td>
<td>Shuttle Radar Topography</td>
<td>90 m</td>
<td>2 Multispectral bands</td>
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<tr>
<td>(DEM)</td>
<td>Mission (SRTM)</td>
<td></td>
<td></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/NODC 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. 1997b). 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).
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</th>
<th>Description</th>
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</thead>
<tbody>
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<td>Brahmaputra Valley semi-evergreen forests</td>
</tr>
<tr>
<td>4</td>
<td>Chin Hills-Arakan Yoma montane forests</td>
</tr>
<tr>
<td>5</td>
<td>Eastern highlands moist deciduous forests</td>
</tr>
<tr>
<td>6</td>
<td>Himalayan subtropical broadleaf forests</td>
</tr>
<tr>
<td>7</td>
<td>Lower Gangetic Plains moist deciduous forests</td>
</tr>
<tr>
<td>8</td>
<td>Himalayan alpine tundra</td>
</tr>
<tr>
<td>9</td>
<td>Brahmaputra Valley semi-evergreen forests</td>
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<td>Eastern Himalayan broadleaf forests</td>
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<tr>
<td>11</td>
<td>Himalayan subtropical broadleaf forests</td>
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<tr>
<td>12</td>
<td>Western Himalayan alpine conifer forests</td>
</tr>
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<td>Eastern Himalayan subalpine conifer forests</td>
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<tr>
<td>14</td>
<td>Western Himalayan subalpine conifer forests</td>
</tr>
<tr>
<td>15</td>
<td>Terai-Duar savanna and grasslands</td>
</tr>
<tr>
<td>16</td>
<td>Himalayan alpine tundra</td>
</tr>
<tr>
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<td>Sundarbans freshwater swamp forests</td>
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<td>19</td>
<td>Chhota-Nagpur dry deciduous forests</td>
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<td>Central Deccan Plateau dry deciduous forests</td>
</tr>
<tr>
<td>25</td>
<td>Northeastern Himalayan alpine conifer forests</td>
</tr>
<tr>
<td>26</td>
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<td>27</td>
<td>Northeast India-Myanmar pine forests</td>
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<td>28</td>
<td>Eastern Himalayan broadleaf forests</td>
</tr>
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<td>29</td>
<td>Northern Triangle temperate forests</td>
</tr>
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<td>30</td>
<td>Western Himalayan alpine conifer forests</td>
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<td>Terai-Duar savanna and grasslands</td>
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<tr>
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<td>Himalayan alpine tundra</td>
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<tr>
<td>35</td>
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<tr>
<td>50</td>
<td>Himalayan alpine tundra</td>
</tr>
<tr>
<td>51</td>
<td>Himalayan alpine tundra</td>
</tr>
</tbody>
</table>

Forest Cover Map

Forest cover map was obtained from Forest Survey of India (FSI 2003). The assessment is based on digital interpretation of satellite data for the entire country. LISS-III sensor data of IRS-1C satellite with a resolution of 23.5 m has been used. This was one of the main layers in the GIS that was used for deriving landscape characteristics.

Roads & Drainage

The roads and drainage maps of digital chart of the world (ESRI 1992) for the country at a scale of 1: 100,000 was used. Euclidean distances and densities were generated using ArcGIS (ESRI) software.

Protected Areas

The locations of the Protected Areas, National Parks, Wildlife Sanctuaries, and Tiger Reserves were obtained from the Wildlife Database cell, Wildlife Institute of India and Project Tiger Directorate.

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.

Climatological Data

The precipitation data (New et al., 2002) was generated from a 10 latitude/longitude data set of mean monthly surface climate of 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 windspeed 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 habitat.
Core Areas

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.

Landscape Characterization

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).

Appendix 1.5  :Forest occupancy of Tigers, Co-Predators, Prey and population estimates of tigers.

* 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.

State | Tiger km² | Leopard km² | Dhole km² | Bear km² | Chital km² | Sambar km² | Wild Pig km² | Nilgai km² | No. | Tiger Numbers
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Uttarakhand</td>
<td>1901</td>
<td>3683</td>
<td>-</td>
<td>853</td>
<td>2161</td>
<td>2756</td>
<td>3214</td>
<td>422</td>
<td>178</td>
<td>161 195</td>
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<td>2130</td>
<td>5317</td>
<td>2641</td>
<td>7761</td>
<td>8375</td>
<td>109</td>
<td>91 127</td>
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<td>510</td>
<td>552</td>
<td>121</td>
<td>532</td>
<td>576</td>
<td>321</td>
<td>570</td>
<td>494</td>
<td>10</td>
<td>7 13</td>
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<tr>
<td>Shrikrishna-Gangtey Plains Landscape Complex</td>
<td>5,177</td>
<td>7,171</td>
<td>513</td>
<td>4,515</td>
<td>8,274</td>
<td>5,718</td>
<td>11,345</td>
<td>9,281</td>
<td>297</td>
<td>259 335</td>
</tr>
</tbody>
</table>

Central Indian Landscape Complex and Eastern Ghats Landscape Complex

Andhra Pradesh | 14126 | 37009 | 41093 | 54673 | 37394 | 33339 | 58363 | 62636 | 95 | 84 107 |
| Chhattisgarh | 3609 | 14376 | 28508 | 40999 | 41509 | 33551 | 59033 | 41704 | 300 | 236 364 |
| Madhya Pradesh | 4273 | 4992 | 4331 | 6557 | 5970 | 4574 | 103 | 76 131 |
| Orissa | 9144 | 25156 | 8215 | 43236 | 6040 | 6122 | 21525 | 711 | 45 37 53 |
| Rajasthan | 356 | - | 3040 | 721 | 721 | 6226 | 1108 | - | - |

Total Tiger Population 1,411 1,165 1,657
STATUS OF TIGERS, CO-PREDATORS AND PREY IN INDIA

Joseph Vattakaven