

Mammals on the margin: Documenting recent changes to large mammal distributions in a densely populated biodiversity hotspot

Preliminary report from a research programme to assess habitat quality, connectivity and large mammal distribution in the Western Ghats, India

Supported through grants from
The Rufford Small Grants Foundation, U.K.

Implemented by
Nature Conservation Foundation
www.conservation.in

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Acknowledgements

We thank the Ministry of Environment and Forests, Government of India for research permits. We are grateful to the State Forest Departments of Kerala, Tamil Nadu, Karnataka, Maharashtra and Goa for permission, support and cooperation during the survey. Shri Dilan Mandanna and Shri H.P. Ashwin provided invaluable assistance during the survey to assess changes in large mammal distributions. We are grateful to the Rufford Small Grants Foundation for financial support and encouragement.

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Preliminary report for the period March 2010 - July 2011

1. Introduction

The Western Ghats mountain chain is recognized as one of the world's eight 'hottest hotspots' of biological diversity along with Sri Lanka. Approximately 137 mammal species (48 of them bats) have been recorded in the Western Ghats, with 17 endemic species (CEPF 2007). Large mammals (defined here as diurnal mammals of body size > 3 kg) of the Western Ghats include large carnivores such as the tiger *Panthera tigris*, leopard *Panthera pardus*, dhole *Cuon alpinus* and sloth bear *Melursus ursinus*, ungulates such as the gaur *Bos gaurus*, sambar *Cervus unicolor*, chital *Axis axis*, and Nilgiri tahr *Hemitragus hylocrius*, and primates including the lion-tailed macaque *Macaca silenus* and Nilgiri langur *Trachypithecus johnii*. The Western Ghats is also home to the largest population of the endangered Asian elephant *Elephas maximus*, believed to exceed 10000 animals. The Protected Area (PA) network in the Western Ghats includes 14 National Parks (NP) and 44 Wildlife Sanctuaries (WLS) and covers a mere 9% of its land area, with a majority of the forest types in this landscape falling outside PAs. Over two-thirds of these PAs are small (<500 km²), isolated and hence, occur as fragments in the landscape.

Globally, large mammals have undergone major declines in recent decades, highlighting the need for large-scale, rigorous monitoring programs to document substantial changes of apex large carnivore and prey populations over time and space and take appropriate management actions. While the impacts of habitat loss and fragmentation pervade across all taxa, the fallout on large mammals is particularly severe due to their large body size and trophic requirements, increasing sharply above a threshold body mass of around three kilograms. Habitat loss, fragmentation, degradation and hunting, the foremost threats to large carnivores and their prey, have led to substantial range contractions of several species in tropical Asia. Between 1920 and 1940, the Western Ghats lost 40% of its primary forest cover. This is hardly surprising as the Western Ghats harbours the highest human population density among the global biodiversity hotspots. Many of the large mammals in the Western Ghats are landscape species whose conservation cannot depend upon a protected area centric approach alone.

Until recently, studies have tended to examine how spatiotemporal trends in abundance rather than distribution relate to environmental factors and anthropogenic threats. Alternative state variables to abundance are occupancy or the proportion of area occupied by a species (MacKenzie & Nichols 2004; MacKenzie et al. 2002) and species richness or the number of species inhabiting a predefined area (Mackenzie et al. 2005). With the recent development of analytical methods such as occupancy estimation (MacKenzie et al. 2002; MacKenzie et al. 2006), it is now possible to reliably estimate the proportion of area occupied by a species, despite the possibility that a survey may fail to detect a species that is actually present in a sampled area. Such false absences are accounted for by estimating the probability of detecting at least one individual of a species during a particular sampling occasion, given its presence in a sampled area. Although the monitoring of change in the regional occurrence of a species is not as informative as direct estimates of abundance, this approach nevertheless targets a large number and breadth of species at the expense of more detailed population data. Traditional abundance estimation methods such as distance sampling or mark-recapture are also more labour-intensive and expensive, which limits their potential for large-scale multispecies monitoring programs.

2. Project Objectives

Current species assessments provide valuable information on the distribution and abundance of species at global scales but corresponding information at regional scales is lacking. The Western Ghats ranks among the most densely populated global biodiversity hotspots where 350 people/km² live alongside some of the world's most unique and endangered biodiversity. At a landscape scale we still do not understand how, over space and time, human presence and activities have influenced the past and current distributions of wildlife. The vast area of the Western Ghats poses serious logistical challenges to documenting species distributional changes using conventional methods.

We leveraged the fact that nearly every part of the Western Ghats is inhabited by local communities who can reliably identify the wildlife occurring today and that which occurred in the past. When combined with a theoretical framework such as occupancy estimation, there is immense potential to use this detection/non-detection data recorded from knowledgeable key informants to estimate the proportion of area occupied by different species at different time periods. We have successfully field-tested this method to assess changes in large mammal distributions in the 13000 km² southern Western Ghats sub-region (Pillay et al. 2011). We now extend this to the rest of the Western Ghats to reliably reconstruct recent historical distributions of tigers,

prey species and other large mammals in the Western Ghats to document contraction/expansion/persistence of their ranges and identify the environmental and anthropogenic correlates of recent range dynamics. An extensive field interview survey was undertaken to estimate:

- i. The proportion of area occupied by 18 species of large mammals in the Western Ghats
- ii. Recent historical changes in occupancy parameter across the Western Ghats
- iii. Vital rates of occupancy dynamics, extinction & colonization parameters
- iv. Changes in relative abundance over recent historical time
- v. Spatio-temporal variation in occupancy and other parameters between PAs and non PAs
- vi. Anthropogenic threats limiting distributions of tigers and prey species

3. Description of Survey Landscapes in Western Ghats

3.1. Sahyadri Landscape

The Western Ghats of southern Maharashtra, called the Sahyadri is a rugged and majestic landscape of over 2,000 km². High, flat mountain tops, tablelands, valleys, peaks and spurs of the Sahyadri provide unique habitats for the growth of various kinds of plant species and plant communities, many of which are restricted to the northern reaches of the Western Ghats. The landscape includes three PAs, namely Koyna WLS (424 km²), Chandoli NP (318km²) and Radhanagari WLS (351km²). The landscape supports several large mammals including tiger, sambar and gaur.

The presence of numerous barren rocky lateritic plateaus locally called *sadas* is the unique feature of the Sahyadri. These plateaus possess very characteristic herbaceous ephemeral vegetation. More than 850 species of flowering plants have been reported from the region. Of these, 39 species find mention in the IUCN Red Data Book as endangered, forming approximately 6% of the total Red Data species. The Koyna WLS spanning an altitudinal range of 600 to 1100 m, along with the Kas Plateau forms the northern limit of the Sahyadri landscape. The rivers Koyna, Kandati and Solashi, originating in the Western Ghats, span the sanctuary. It forms and protects the catchment of river Koyna and the reservoir Shiv Sagar formed by the dam on it. To the south lies, Chandoli NP located at the junction of four districts, Sangli, Kolhapur, Satara and Ratnagiri of Western Maharashtra. It spreads along the crest of the Sahyadri Range of the Western Ghats and lies between Koyna and Radhanagari WLS. It forms and protects many perennial water channels, water holes and the Vasant Sagar reservoir. Radhanagri WLS, the first wildlife sanctuary of Maharashtra, was notified in 1958. It consists of the catchment area of the two major

reservoirs namely Rajarshi Shahu Sagar and Laxmi Sagar in Radhanagari Taluka of Kolhapur district. Bhogavati, Dudhganga, Tulshi, Kallamma and Dirba are among some of main rivers those flows through the sanctuary area, which drain out into the River Krishna, a major river of the Deccan Peninsula. Radhanagari WLS contains some of the tropical evergreen forests typical of the northern Western Ghats. The Sahyadri, a distinctive sub-region within the Western Ghats contains remarkable features that represent the entire range of geological and biological features of the Western Ghats.

The tropical evergreen and semi-evergreen forests of the Sahyadri represent the northern limit for many evergreen and endemic trees, including species such as *Myristica malabarica* and *Diospyros sylvatica*. The Koyna WLS contains relatively undisturbed semi-evergreen formations in the higher reaches and along several valleys with minimal likelihood of adverse anthropogenic influence in the future. The presence of large trees of species such as *Harpulia arborea*, *Scolopia crenata* and *Turpinia malabarica* and the endangered *Mappia foetida* has been recorded in the sanctuary. The moist forests extend along the rivers into the dry forest tracts and act as riparian corridors for many mammals, birds and reptiles that are typically found in the moist forests of southern Western Ghats. Tracts of evergreen and semi-evergreen forest characterized by high diversity also occur in the Chandoli NP and Radhanagari WLS. Radhanagari WLS possesses luxuriant tropical rainforest vegetation comprising over 1,500 flowering plant species. On western side of the WLS, dense evergreen forest or rainforest forms climax vegetation locally known as *dangs* or *rai*. The eastern parts have semi-evergreen to moist mixed deciduous forests.

The Sahyadri region harbours almost 90 mammal species, including two endemic species, the critically endangered and possibly extinct Malabar civet and Wroughton's fretailed bat. Other threatened species in the region include the tiger, gaur, sloth bear and Indian giant squirrel *Ratufa indica*. More than 325 bird species are known to inhabit the region, and two of the sites (Koyna and Radhanagari WLS) are also recognized as Important Bird Areas.

3.2. Uttara and Dakshin Kanara and Malenad

All site elements in the Uttara and Dakshin Kanara and Malenad regions are situated in Karnataka state. Pushpagiri Wildlife Sanctuary (92.65 km²) has dense evergreen and semi-evergreen vegetation, with shola-grassland in areas of higher elevation. The steep terrain of the Sanctuary has resulted in scenic waterfalls along its many mountain streams. Altitude varies from 160 to 1,712 m, the highest point being the Pushpagiri Peak in the north of the park. Temperatures range from 10-38°C, with

annual rainfall exceeding 6,500 mm. Brahmagiri Wildlife Sanctuary (181.29 km²) also consists of evergreen and semievergreen forests in the lower-lying areas with shola-grassland habitat in the higher altitudes. The eastern tip of the Sanctuary is adjacent to the north-western boundary of Rajiv Gandhi (Nagarahole) National Park, separated by a narrow strip of coffee plantations. The highest point in the Sanctuary is the Brahmagiri Peak on the south-eastern boundary, while elevation varies between 65 m and 1,607 m. Temperatures range from 5°-32° C, and mean annual rainfall varies from 2,500 mm to 6,000 mm. Talacauvery Wildlife Sanctuary (105.01 km²) is located in the Kodagu (Coorg) district of Karnataka. Its forests are predominated by tropical evergreen forests. It is named after Talacauvery the origin of the Cauvery river which lies on the eastern edge of the Sanctuary. Altitudinal and temperature ranges are 64-1,659 m and 10°-35° C, respectively. Annual rainfall is above 6,500mm. This area has approximately 500 km² of low to mid elevation tropical evergreen forests, shola-grassland ecosystems, and has a unique floristic composition since it falls in the transition zone of the *Mesua ferrea-Palaquium ellipticum-Cullenia exarillata* and *Dipterocarpus indicus-Kingiodendron pinnatum-Humboldtia brunonis* forest types. Species such as *Hopea jacobi* and *H. canarensis* are strictly confined to this region alone.

The Brahmagiri-Pushpagiri area of the Talacauvery region has a total of 34-35 mammal species of which 14 are in the IUCN Red List threatened categories (including the lion-tailed macaque *Macaca silenus* and the Nilgiri langur) and six are endemic to India. It is one of the few areas in the Western Ghats where all of the primates of southern India are found in sympatry although the area currently receives no official protection. The southern part of this region is a conspicuous ecotone in the Western Ghats because it is at the southern-most range of forests dominated by *Cullenia exarillata*, and the southern limit of the lion-tailed macaque's range is in this ecotone. Two species of flying squirrel, one of them (the small Travancore flying squirrel *Petinomys fuscocapillus*), a very poorly understood species, found only in the Western Ghats make their home in the Brahmagiri forests.

The Kudremukh National Park, Someshwara Wildlife Sanctuary, and surrounding Reserved Forests of Someshwara, Agumbe and Balahalli of Karnataka state are situated centrally in the Western Ghats Biodiversity Hotspot. Kudremukh National Park has one of the most beautiful landscapes in the Western Ghats, encompassing evergreen, semi-evergreen and grasslandshola habitat characteristic of high altitude Western Ghats regions. Altitude varies from 120 to 1,892 m, the highest point being the Kudremukh Peak in the south of the Park. The Park has average temperatures ranging between 17° C and 28° C. Annual rainfall varies from 1,778

mm to 6,350 mm, with an average of 4,000 mm and a maximum recorded rainfall of 10,000 mm in 1994. The topography is mountainous with a central ridge running north-south through the Park. The Park is dotted with crystal-clear streams and picturesque waterfalls. Kudremukh National Park is flanked by coffee and tea estates on the north and east, whereas on the west, the land drops down to the Arabian Sea. In the northwest is a forest corridor that connects the Park with the Someshwara Wildlife Sanctuary. The Sanctuary, named after the famous Someshwara Temple located within it, and the adjoining 105.3 km² of Reserved Forest are predominantly evergreen forests, along with semi-evergreen vegetation. These Reserved Forests are in the process of being included within the Sanctuary. Elevation ranges from 75-870 m and the temperature varies between 20° C and 30° C, with an average annual rainfall of 6,000 mm. Kudremukh is probably one of the largest reserves of high altitude grasslands in the Western Ghats. The region has the single largest population of the endemic and endangered lion-tailed macaque (about 200-300 individuals) north of the Palghat Gap. It is also home to 31 other species of mammals (>0.5 kg in body mass) and is one of the only remaining habitats of other threatened fauna like the critically endangered Malabar civet *Viverra civettina* and other vulnerable species like the Indian giant squirrel *Ratufa indica* and rusty-spotted cat *Prionailurus rubiginosus*.

3.3. Nilgiri Biosphere Reserve

The c. 5,500 km² Nilgiri Biosphere Reserve in the central Western Ghats, straddling the states of Tamil Nadu, Karnataka and Kerala, represents one of the last strongholds for several species of large mammals, including Asian elephant and tiger. With elevations ranging from 80 m ASL to 2600 m ASL, and a marked west-east declining gradient in rainfall, the NBR harbours not just an enormous diversity of habitat, flora and fauna but a rich ethnic and cultural diversity as well. Together with the adjoining PAs in the states of Karnataka (Bandipur and Nagarhole), Kerala (Wyanad) and Tamil Nadu (Mudumalai), this landscape is made up of vast expanses of grasslands, scrub, deciduous and evergreen forests that possibly contain the single largest population of globally endangered 'large landscape' species such as the Asian elephant, gaur and tiger.

The complex interplay of topographic, geological and climatic variations has yielded starkly different ecosystems, all located within a relatively compact landscape. From the stark brown scrub forests of Attapadi near the Palghat Gap as one ascends the Nilgiri mountains, evergreen forests of the hill slopes make way for gently rolling plateaus of wind beaten *shola* grasslands perched at elevations exceeding 2,000 m ASL. Further west and to the south, this table-land plunges

dramatically into vast unbroken stretches of lowland rainforest in the Nilambur and Silent Valleys. These diverse vistas are aesthetically among the most appealing anywhere. By virtue of the elevation of the Nilgiri Plateau, this region continues to harbour relict populations of Himalayan faunal (e.g. Nilgiri tahr and Nilgiri marten *Martes gwatkinsi*) and floral (e.g., families such as *Rosaceae* and genera such as *Anaphalis* and *Gaultheria*) groups that had moved down into this landscape from the Himalaya during the glacial epochs.

Located on the high plateau, the Mukurti NP is dominated by the *shola* grassland ecosystem with many floral and faunal elements of relict fauna bearing resemblance to the Palearctic realm. The *shola* patches, usually one to 10 ha in size with few exceeding 100 ha, are confined to depressions and folds in the mountain. They are extremely dense, with 5,000 or more woody plants (>1 cm dbh) per hectare, and are dominated by the families Lauraceae, Rubiaceae and Symplocaceae. There is a sharply defined ecotone between the *sholas* and the grasslands that is maintained by frost and fire. Mukurti also has the northernmost population of the Nilgiri tahr and is one of the most important conservation areas for the endangered mountain goat.

Silent Valley NP is perhaps the most important constituent of the southern part of this landscape. Four main types vegetation types are recognized in the park: tropical evergreen forest, which forms extensive dense stands along hills and valleys between 900 m and 1,300 m; sub-tropical hill forest between 1,500 m and 2,000 m; *shola* forest which occur along drainages in the wind-swept upper hill slopes; and grasslands, which are restricted to the narrow sector west of the Kunthipuzha and to the higher slopes and hill tops in the eastern sector. Some 26 species of mammals, excluding bats, rodents and insectivores, have been recorded. Notable species include Nilgiri langur, lion-tailed macaque, tiger, leopard, brown palm civet *Paradoxurus jerdoni*, wild dog, Nilgiri marten, Asian elephant, gaur and Nilgiri tahr. Among birds, the Silent Valley region and surrounding site-elements as a whole include virtually all the species known to occur in the southern Western Ghats, including significant populations of nearly all the 16 endemics reported from the Western Ghats. To the northwest, the areas of New Amarambalam and Kalikavu areas are particularly important corridors for species such as the Asian elephant, but have fairly high levels of anthropogenic activity, ranging from Forest Department plantations to resource-use by resident communities. Settlements of ethnic tribes such as the Cholanayakans, Paniyans and Eranadans are found in New Amarambalam and Kalikavu areas. To the east, the Attapadi range is also contiguous with the evergreen forests of Silent Valley, comprising similar biodiversity values. It also contains deciduous and scrub forests, particularly towards rain-shadow areas of Aralikkonam, Mulli and Thoova.

3.4. The southern Western Ghats (comprising the Anamalai, Periyar and Agasthyamalai Landscape Complexes)

This region was extensively surveyed and field interviews were conducted in 2008-09. For descriptions of this landscape, please refer to Pillay *et al.* (2011).

4. Survey Methods

4.1. Assessment of distributional changes of tigers, sympatric large carnivores and prey species across the Western Ghats

Large mammals (species code in parantheses) on which data was gathered included carnivores such as the tiger (TGR), leopard (LPD), dhole (DHL), golden jackal (JKL), striped hyena (HYN) and sloth bear (SLB), herbivores such as the Asian elephant (ELP), gaur (GAR), sambar (SAM), spotted deer (CHT), barking deer (MJK), mouse deer (MDR), Nilgiri tahr (NTR), four-horned antelope (FHA) and wild pig (WPG), primates such as the Nilgiri langur (NLG), common langur (CLG), lion-tailed macaque (LTM) and bonnet macaque (BNT) and rodents such as the Indian giant squirrel (IGS) and Indian porcupine (POR).

We followed identical methods as we used earlier in the southern Western Ghats (Pillay *et al.* 2011). Data were collected by means of detailed interviews with informants in the five states of Kerala, Tamil Nadu, Karnataka, Maharashtra and Goa. The extensive survey was carried out from March to December 2010. The geographic scale at which each interview was conducted was the forest range, an administrative unit prevalent in forest and wildlife management throughout India. A forest range represents the third smallest forest administrative unit with sections/stations and beats being smaller and divisions and circles being larger. There are 275 forest ranges in the central and northern Western Ghats including those in the PAs. Interviews were conducted by driving to range offices and villages in each forest range throughout the southern Western Ghats including those in the PAs, to contact key informant groups including forest department personnel, tribal and non-tribal residents of forest areas and scientists/conservationists. Interviews were conducted in Malayalam, Tamil, Kannada, Marathi and Hindi in Kerala, Tamil Nadu, Karnataka, Maharashtra and Goa respectively. A minimum of five interviews were conducted in each forest range to ensure an adequate number of samples. Interviews involving multiple (> 1) respondents were considered as one interview.

The current status of a species within a forest range was recorded in the form of a presence or an absence after questioning each interviewee about direct sightings and/or indirect evidences such as vocalisations, tracks, scat, dung, droppings, pellets, marks on the vegetation/ground and kills encountered over a period of one year from the present. The cut-off for collecting data on past large mammal

distributions was set at 30 years ago. This was because people would be expected to have clearer recollections about the recent past than much further back in time. The past status of a species within a forest range was recorded in the form of a presence or absence after questioning each interviewee about any direct sightings or indirect evidences encountered 30 years ago. However, emphasis was placed on the responses of elderly people who had lived or worked in that forest range for more than 30 years. Since a few of the large mammals being surveyed shared identical local names, erroneous reporting was avoided by asking each respondent to corroborate the identity of the species from photographs in *A Field Guide to Indian Mammals* by Vivek Menon.

In order to fit into an occupancy modeling framework, each interview was considered equivalent to a distinct sampling method such as a line transect, point count or capture-recapture that would otherwise have been employed to generate species detection histories. Informant/observer reliability is an untested factor with no empirical evidence on the better detection skills of a certain group of key informants over others. Therefore, it was assumed *a priori* that all key informant groups possessed equal ability in detecting a species if present. Given that professional and/or livelihood concerns constrain all key informants to spend their lives in and around forests, this is a reasonable assumption. The data collected was summarized as past and present detection histories for each site for each species.

5. Preliminary Results

5.1. Assessment of changes in the distribution of tigers, prey species and other large mammals across the Western Ghats

We present preliminary results of changes in large mammal distributions across the five states which are covered by the central and northern Western Ghats. These preliminary results represent naïve occupancy of each species in the past (30 years ago) and present. The results are presented as changes in naïve occupancy for each species by the states of Maharashtra, Goa, Karnataka, Kerala and Tamil Nadu over which the Western Ghats spreads. Our data is currently in the process of being refined and corroborated with the help of expert interviews as carried out for the southern Western Ghats (Pillay et al. 2011). We will present robust estimates of past and present occupancy and the vital rates of extinction and colonization in the near future. These analyses will be similar to those for the southern Western Ghats (Pillay et al. 2011) but will also include tests for false presence and population closure in order to make the analysis even more robust.

Fig 1. Carnivores:

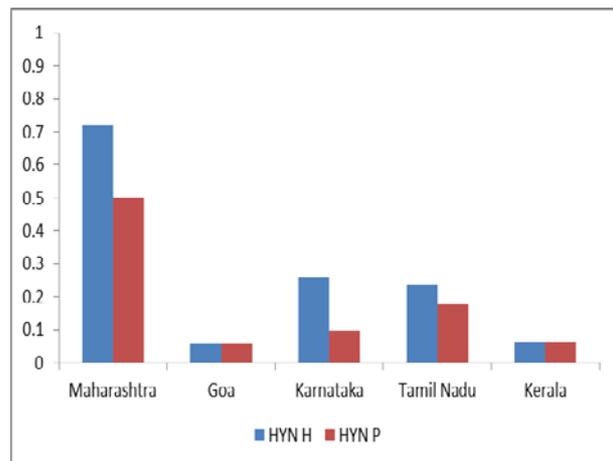
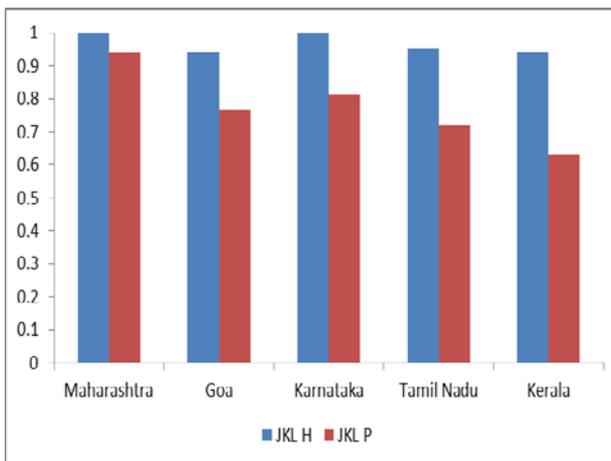
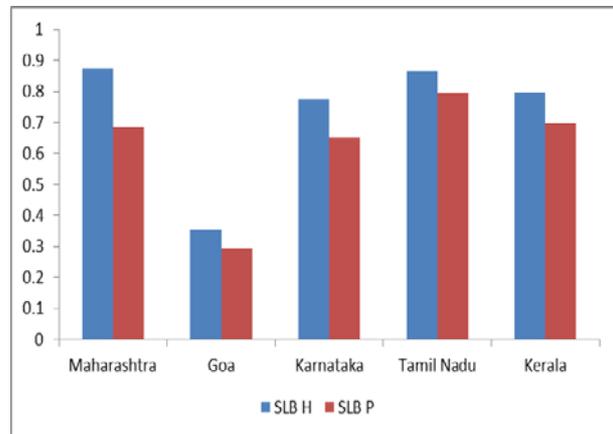
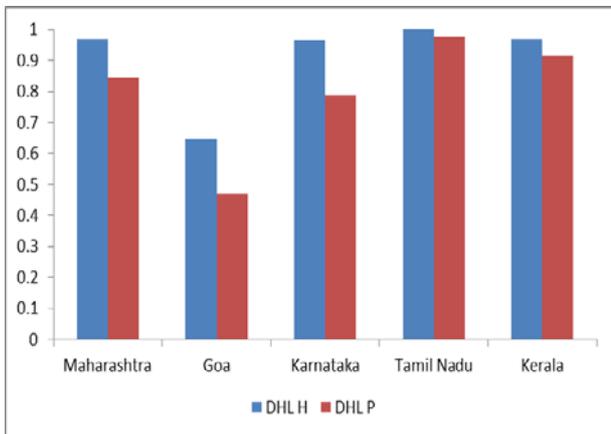
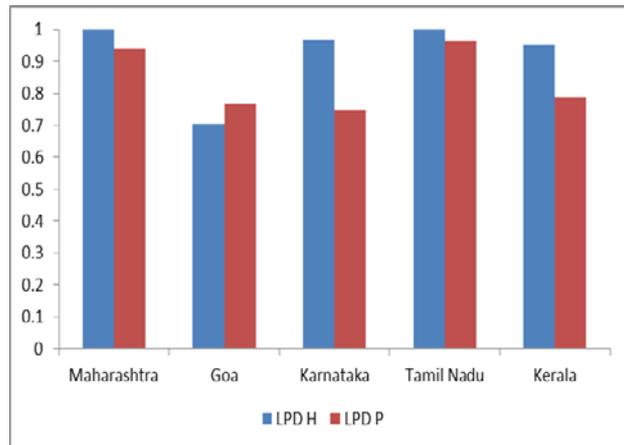
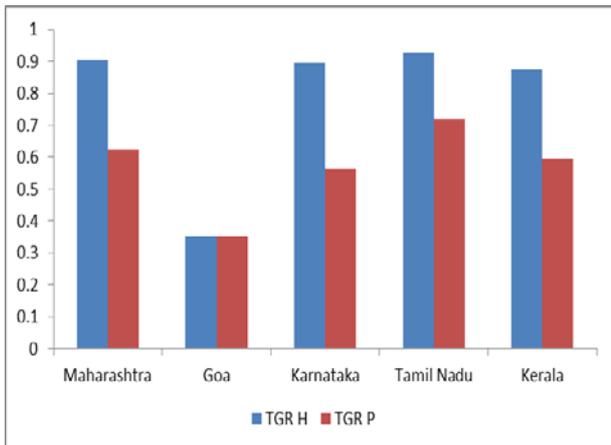


Fig. 2. Herbivores

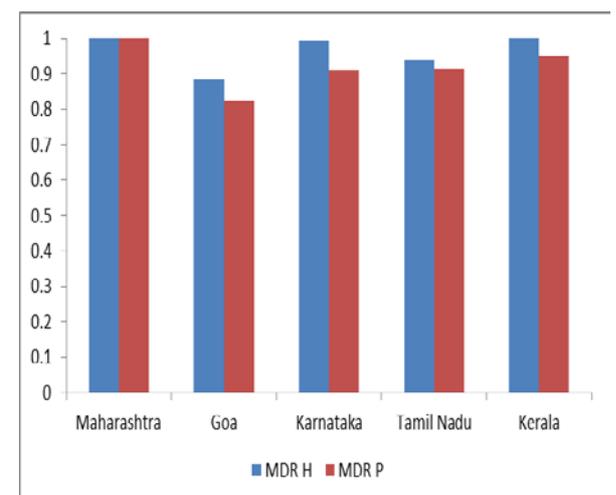
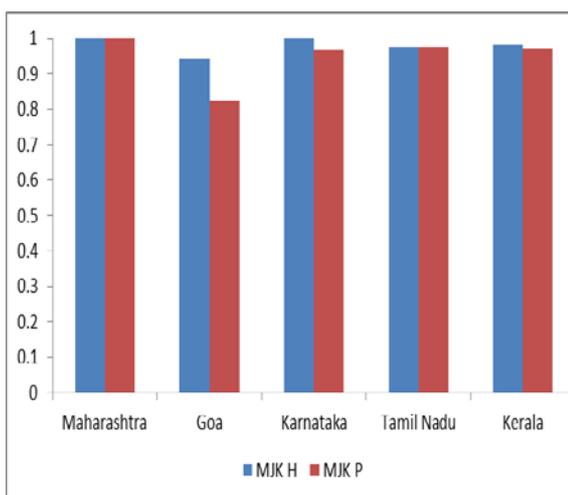
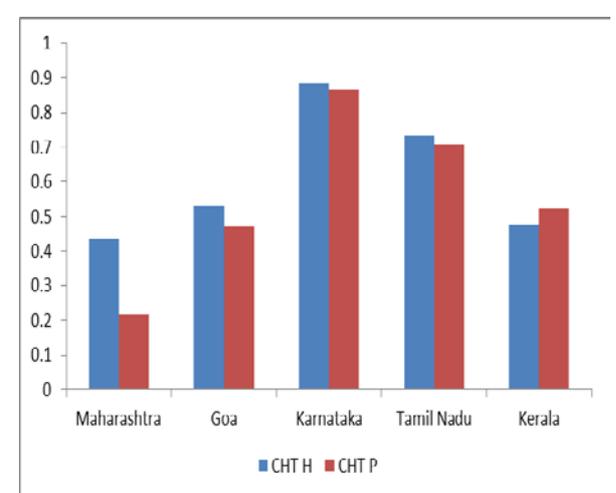
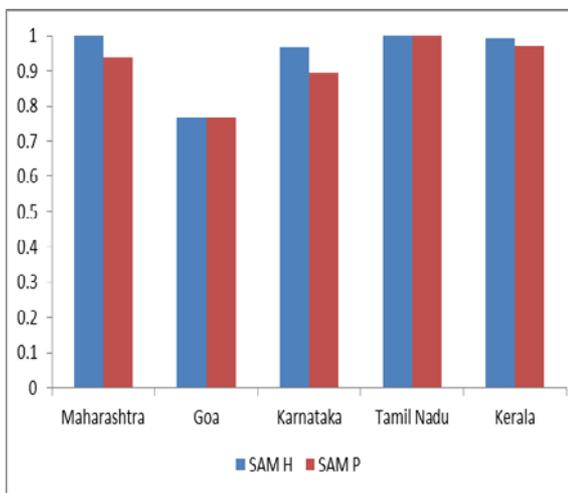
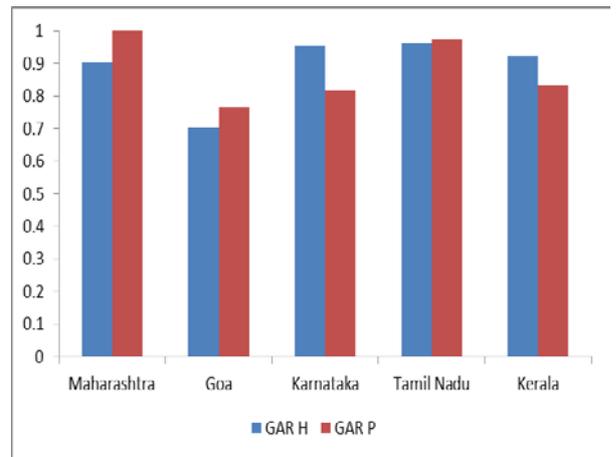
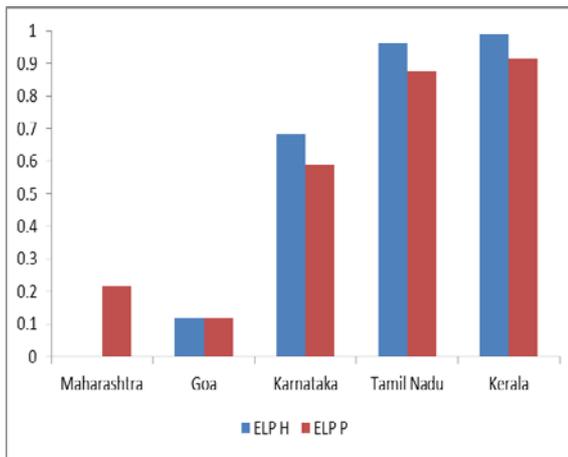


Fig. 2. Herbivores (contd.)

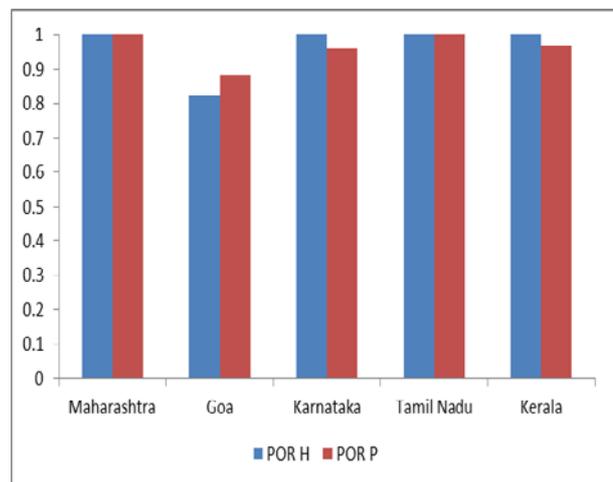
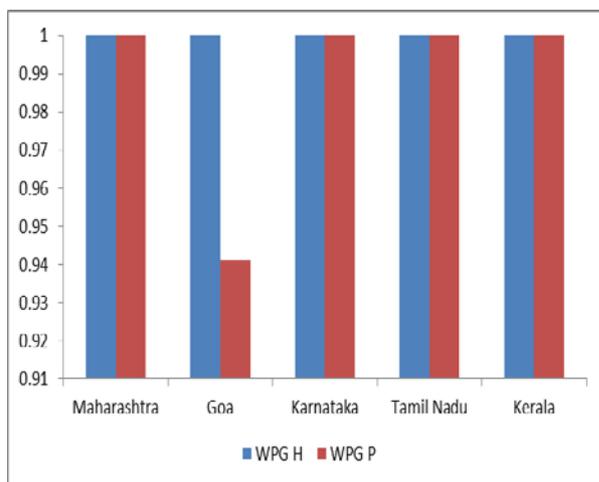
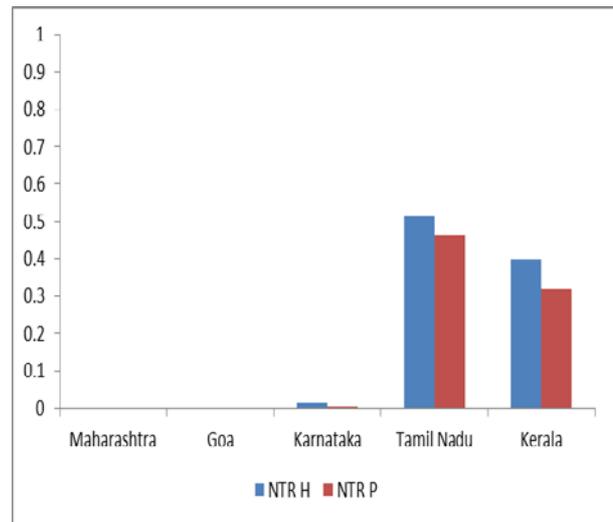
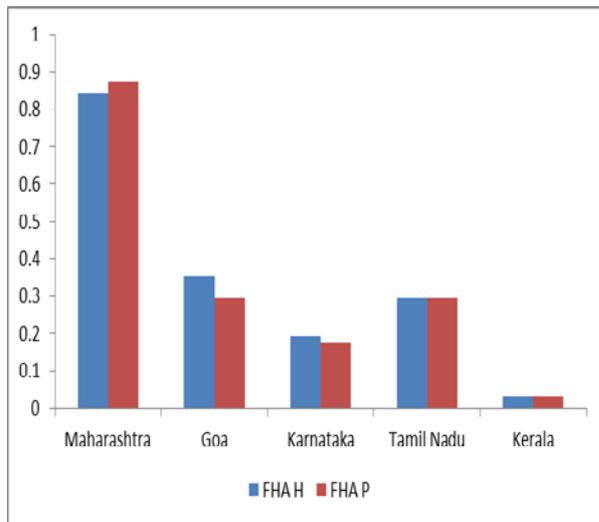
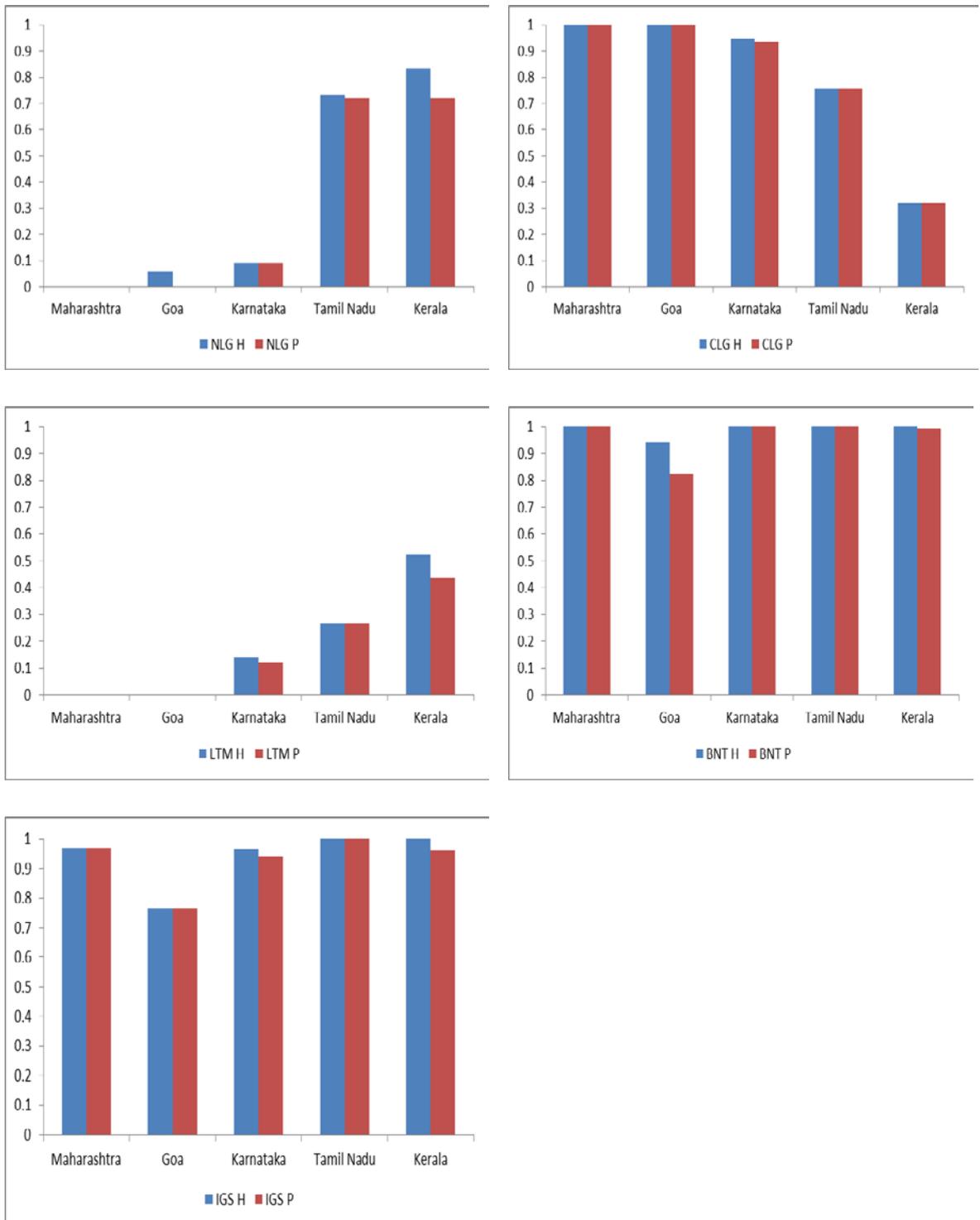


Fig. 3. Primates and other arboreal mammals



5.2. Assessment of anthropogenic threats to tigers and prey species across the southern Western Ghats

We have collected Forest range level data on 30 anthropogenic threat variables such as number and area of human settlements, encroachments, estates and population; collection of non timber forest produce, firewood, leaf litter, fodder and reeds; the presence of logging, forest fire, exotic species, human-wildlife conflict, livestock grazing, poaching, timber smuggling and marijuana cultivation and the presence of roads, railway lines, dams, powerlines, pipelines, mines, windfarms and unregulated tourism. In addition, 4 environmental variables including temperature, rainfall, elevation and Normalised Difference Vegetation Index (NDVI) were extracted using GIS at the level of Forest Range. Based on existing literature, we have grouped these variables into categories such as direct exploitation, indirect exploitation and disturbance. We have also extracted the values of the human footprint for each Forest Range. Analyses of these data as correlates of occupancy of different species is in a preliminary stage. When this is completed, we expect to have a good understanding of the anthropogenic and environmental factors limiting species distributions and come up with distribution maps of each species at the level of forest range.

Annexure 1:

Pillay, R., Johnsingh, A.J.T., Raghunath, R. and Madhusudan, M.D. 2011. Patterns of spatiotemporal change in large mammal distribution and abundance in the southern Western Ghats, India. *Biological Conservation*. 144, 1567-1576