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Key tiger habitats in the Garo Hills of Meghalaya

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Abstract

We describe assumed tiger habitat characteristics and attempt to identify potential tiger habitats in the Garo Hills region of Meghalaya, North East India. Conserving large forest tracts and protected wildlife habitats provides an opportunity for restoring populations of wide-ranging wildlife such as tigers and elephants. Based on limited field observations coupled with focused group discussion with local villagers and senior staff members of the wildlife wing of the State Forest Department of Megahlaya, we identified 20 localities in South Garo Hills, which if protected and managed for tiger conservation, could help restore this fast disappearing species. An integrated multidisciplinary landscape scale approach to wildlife management, including designation of intact forest corridors among protected areas and reserved forests, would greatly contribute to conservation of tigers and overall biodiversity of this region.

Keywords: tiger, population viability, landscape approach, conservation, corridors, core habitats

Introduction

The first ever scientific census of tiger (*Panthera tigris tigris*) populations by the National Tiger Conservation Authority (New Delhi) and Wildlife Institute of India (Dehradun) during 2007 revealed the presence of only 1,411 tigers in India (Anon. 2009a). In recent years, extirpation of local tiger populations from several places including Sariska Tiger Reserve and Panna National Park is one of the most urgent conservation issues of national concern in India. Poaching seems to be the major reason, but we should not overlook other ecological factors playing key roles in the process of local extirpation, or conservation, of the species. Other factors might include loss of core tiger habitats from increasing encroachment, forest fragmentation, and isolation. Many such factors can determine the survival chances of comparatively smaller populations within the confines of isolated habitats.

Although the disappearance of tigers from some parks and reserves may be due, in part, to poaching and other anthropogenic stressors, it is still vital to define and provide for their basic needs for habitat and prey. Tigers -- like many other wide-ranging carnivores and predators -- do not have any one set of conditions of vegetation type and structure, land cover, and topography that define their "habitat." Tigers in India and south Asia have occupied a very wide array of environments, from Sundarbans to thorn woodland of Panna National Park to Tropical Moist Evergreen Forests in Garo Hills. Even one can find fresh tiger tracks in agricultural fields adjacent to Corbett National Park, banana crops around Yaval Wildlife Sanctuary in Jalgaon district, and on open islands in the Brahmaputra River of Kaziranga National Park. "Tiger habitat" is highly variable, and likely pertains to access to reliable prey (e.g.,

Why are small isolated populations at peril?

It is well known in population viability theory that, in general, small, isolated and temporally variable populations may be subject to far greater risk of local extinction than are larger populations connected to other populations in a metapopulation network (Fraterrigo *et al.* 2003).Reasons include demographic variation, environmental variation (including effects of environmental disturbance), and loss of genetic variability due to inbreeding, drift, and other small-population effects. Extinction risk increases nonlinearly with small population size due to a combination of many of these factors (Liao and Reed 2009). Standard formulae can be used to gauge potential degree of drift and inbreeding, and to calculate effective population size which is often far smaller (half or less) than census or total population size (Waples 2002). Some factors affecting this in small populations include increased variation in birth rate, increased variance in family size, decreased number of subpopulations, loss of genetic variation within demes with resulting decrease in viability of offspring (decline in fitness), and deviations from normal sex ratio. Also, the new field of landscape genetics is providing a means of evaluating the degree and cause of population isolation (Holderegger and Wagner 2006; Manel *et al.* 2003).

For example, the inbreeding effective size of an isolated population with a total census number of 100 adults, 1 female born per adult female, and a variance of 2 offspring per adult female, is only 49 individuals, and the variance effective population size (related to changes in allele frequency) is only 33 individuals (using formulae from Waples 2002). Other measures of effective population size of 100 census adults, correcting for spatial structure, variable subpopulation migration rates, intergenic drift, and subpopulation extinction, vary from 50 to 99 individuals. Still other estimates can be calculated correcting for variance in family size, sex ratio, and fluctuation in population size (Frankham *et al.* 2002). Each estimate of effective population size measures some decrement to viability. Research is needed to determine which factors most pertain to tigers in Meghalaya and North East India.

In North East China, a combination of forest habitat disruption, decline or local extirpation of native prey species, and direct killing by humans, are likely the main threats to Siberian tigers, severely reducing or eliminating local populations in the Wandashan, Laoling, and Mudanjiang Mountains. It remains as important to briefly list the main unknowns and uncertainties as to tiger population viability in Meghalaya, as it is to list presumptions about prey, habitat use, numbers, and life history parameters. With few to no population, demography, and ecology studies having been done in Maghalaya, there is likely much uncertainty about population size, trend, habitat selection and prey selection, although one could begin to pose assumptions and hypotheses based on tiger studies conducted elsewhere in India in similar environments (e.g., south India).

sambar, chital and other ungulates), water, good hiding cover, and at least some area remote from human habitation. The Garo Hills are known for elephants, but this area also provides excellent habitat for tigers. Until 2000, tigers were sighted in the forests of Balpakram and Baghmara in South Garo Hills (personal observation of authors). A webpage at the official website of Government of Meghalaya, which was accessed on December 24, 2009, also suggests the existence of tigers in Garo Hills (Anon. 2009b). In this paper, we describe and quantify native forests of the region which seem to support tigers and that could be delineated as potential core tiger habitats, and we suggest a few conservation measures to protect this fast disappearing species.

Study Area

The study area spanned 2459 km^2 and comprised South Garo Hills district and adjoining Nokrek Biosphere Reserve and National Park along with the surrounding community land in East and West Garo Hills districts (Fig. 1). This area belongs to biogeographic zone 9B, i.e., North East - North East Hills, and falls within 90º 07′- 91º E longitude and 25º 02′- 25º 32′ N latitude (Rodgers *et al.* 2000). These protected areas (PAs) include Balpakram National Park (BNP, 220 km^2), Nokrek National Park (NNP, 47.48 km^2, later extended to 80 km2 and declared as a Biosphere Reserve), Siju Wildlife Sanctuary (SWS, 5.18 km^2), and Baghmara Pitcher Plant Sanctuary (BPPS, 2.7 ha). Four reserved forests in the study area include Baghamara (BRF, 44.29 km^2), Rewak (RRF, 6.48km^2), Emangiri (ERF, 8.29 km^2), and Angratoli (ARF, 30.11 km^2) Reserved Forests (RFs). The PAs and RFs constitute only 15% of the study area, with the remainder belonging to the local Garo community.

In general, major threats to the large, wide-ranging wildlife of the study area and Meghalaya, including tigers and elephants, are from prevailing land use and habitat-alteration practices, and increasing human encroachment. Most of the land of the region has undergone mass scale clear felling of old forest growth for shifting cultivation locally known as jhum, which involves clearing and burning of a forest patch for raising agricultural crops for a certain period usually less than 5 years. The available records of North East Indian Council (Shillong) suggest that about 19% of Meghalaya was brought under jhum up to 1979, which included 3.4% under current jhum/bun agriculture[1] (DSWC 1995). About 38% of families (100,201 people) in Meghalaya were engaged in some form of jhum in most of the accessible forestlands in the state (DSE 1995).

In Meghalaya, the area under jhum increased from 15% to 21% between 1981 and 1995 with the subsequent reduction of forest cover from 69% to 63% during this 15-year period (Roy and Tomar 2001). A study of forest fragmentation in Meghalaya revealed the reduction of intact forest cover from 54% to 38% between 1980 and 1995, which had further been reduced to 30% in 2000 during last two decades of twentieth century (Talukdar 2004). Forest fragmentation has resulted in the conversion of dense evergreen and semi-evergreen forests to open deciduous forests. Conversion occurred mainly due to unplanned land uses, especially jhum (Kumar *et al.* 2002, 2008). The remaining, larger tracts of intact evergreen and semi-evergreen forest likely provide the best habitat for wide-ranging wildlife species, especially tiger and elephant along with other carnivores and ungulates of the region. Our task was to quantify the degree of remaining forest cover, fragmentation, and locations of existing intact native forest in Garo Hills for possible consideration as additional PAs or as habitat corridors to connect PAs for elephants, tigers, and other wildlife.

Methods

We defined potential tiger habitat as tracts of evergreen and semi-evergreen forest that are most intact, least fragmented, largest, and that could be connected with existing PAs and other such forest tracts. Our assumption was that such conditions would most likely also provide for ungulate prey, hiding cover, and remoteness from human disturbance. We defined the most intact tracts that were most remote from villages and human disturbance as potential key or core tiger habitat.

We mapped potential tiger habitats by using digital satellite (IRS –1D LISS III) data with a resolution of 23.5 m to develop a landscape cover map of major forest types and broad land use categories (Kumar *et al.* 2002). We devised the habitat map by reclassifying land use and land cover categories into dense and open old forest, young forest growth, bamboo brakes and grassland. We interpreted the derived maps of forest fragmentation and forest corridors prepared by Kumar *et al.* (2008) as conditions pertinent to tiger habitat.

In South Garo Hills between 1997 and 2000 we conducted direct observations and compiled indirect evidence of tigers; however, no systematic recording of direct sightings and indirect evidence have been conducted in the study area. Therefore, we have relied on secondary information of tiger occurrences, and associated them with our vegetation and land use map categories to identify potential wildlife habitats and key tiger bearing areas, derived from the wildlife wing of the State Forest Department in the Garo Hills, published literature, and online information. We also conducted focus group discussions with local frontline staff from wildlife wing of the Forest Department of Meghalaya, as well as with local residents, to catalog tiger sightings and determine potential tiger habitat.

Results and Discussion

Tiger Numbers in Meghalaya and Garo Hills

The records of the State Forest Department of Meghalaya suggest that a considerable proportion of the state's tiger population occurred in the community-owned forestland. As per the State's tiger censuses of 1972, 1979, 1984, 1989, 1993 and 2002, the recorded number of tigers in Meghalaya were 32, 35, 125, 34, 63 and 47 individuals, respectively (previous record of NTCA, New Delhi). Census numbers by district (Fig. 2) suggested that tigers have been widely distributed in the forests of the Garo, Khasi and Jaintia Hills districts. However, there is no published information on census methods, on selection of census routes and areas, and on the degree of uncertainty or error around the tiger count values. Thus, the counts may be biased and should not be used to generate population estimates and trends, but can still be used as general indications of the consistent presence and wide distribution of tigers within Meghalaya.

The Garo Hills (8167 km^2) with perhaps 54% of the state's reported tiger numbers, harboured some of the most intact, least fragmented, and best connected tracts of old, native evergreen and semi-evergreen forests in western Meghalaya, which we interpret as high quality tiger habitat. Most of these forests within the Garo Hills occurred in the South Garo Hills district (1850 km^2), which comprised only 23% of the entire Garo Hills area but held 50% of the Garo Hills' reported tiger population (Fig. 2). Dense old tropical moist evergreen forests (TMEF) and tropical semi-evergreen forests (TSEF) occupied about 40% of South Garo Hills, whereas open, tropical moist deciduous forests (TMDF) and sal (*Shorea robusta*) plantations comprised about 29% of landscape. Bamboo growth and grassland patches along with associated young secondary forest patches and non-forest areas occupied nearly 10% of landscape area, while the rest of the land was used for various activities by native people (Fig. 3).

Meghalaya's first official tiger census in 1981 reported 10 tigers from the 120 km^2 core of BNP (then Balpakram Wildlife Sanctuary) with a crude density of one tiger per 12 km^2. In the same year and same area, State surveys of tiger prey species reported 102 wild pigs (*Sus scrofa*), 79 sambar (*Cervus unicolor*), and 172 barking deer (*Muntiacus muntijak*); however, the figures may need to be verified with new censuses. There isclearly a need to monitor the population size, density, and dynamics of tigers and their prey species using more precise, accurate, and statistically-founded census methods (e.g,. Linkie *et al.* 2006, Karanth *et al.* 2006).

Core Tiger Habitat Areas in Garo Hills

The field surveys and focused group discussion revealed the presence of tigers (direct sighting or indirect evidence) from more than 20 localities in remote hills of the study area. It is possible that some individual tigers could account for multiple reports and sightings and thus that the actual abundance might be much lower; however, overall, evidence of tiger presence was more common in South Garo Hills than elsewhere in the Garo Hills. Locations of tiger sightings and evidence in South Garo Hills corresponded largely to larger tracts of less fragmented, old native evergreen and semi-evergreen forests, which we thus interpreted as core tiger habitat.

The Garo Ahking tracts (villages) including Balpakram, Sinaru, Agal-chongoppa, Pindengru, Maogipeng, Penda, Marakabari, Pusul chiring, Deoban area, Dogep chiring, Teptepa, Ailatoli, Maheshkola, Bellibari, Narangbari, Sochet chiring, Rongdi-bisik, Nowa chiring, Ronsu-agal, Chutmang, Ampangiri, Hatitia, Passgaon, Bonbera, Nadankol, Atambing, Rongsu, and Rewak occur within the core tiger habitats in the South Garo Hills district. More such areas could be identified and designated as the tiger monitoring points, which may be used to conduct further demographic studies for adequate conservation planning in the region. Systematic monitoring with statistically based sampling (MacKenzie et al. 2003) could also include locations of assumed lower quality tiger habitat; from such data, a quantitative tiger resource selection function can be derived (e.g., Forester *et al.* 2009), which can be useful to more precisely map and predict core tiger habitat and habitat corridors (Chetkiewicz and Boyce 2009).

Habitat corridors can play an important role in the dispersal of some biota as well as facilitating gene flow between populations, thereby maintaining or increasing the heterozygosity within taxa and the biodiversity of the region (Hobbs *et al.* 1989, Norton and Nix 1991). Remotely sensed data are useful in identification and mapping of forest habitat corridors (Gulinck *et al.* 1991). In previous work (Kumar *et al.* 2002, 2008), we have identified seven potential corridors of TMEF and TSEF (Fig. 4) among existing PAs and RFs. These corridors could help connect BNP with NNP in the northwest, RRF in the west and BRF in the southwest. The corridors also connect the adjoining SWS with NNP and RRF, respectively. NNP was linked with ERF with two corridors, covering an area of 23 km^2 and 16 km^2, containing 93% and 96% of forest cover, respectively.

The total area of these all corridors was 274 km^2, with old forest growth in the form of TMEF and TSEF, constituting 23% and 54%, respectively, of old forest growth within the corridors. Most corridors comprised TSEF and TMDF with least proportion of TMEF. A corridor connecting BNP, SWS and NNP comprised the maximum area; however, its actual importance to the native wide ranging wildlife needs to be evaluated after considering topographic features of corridor area within the landscape.

Potential Approaches and Information Needs for Effective Tiger Conservation

Tiger populations are vulnerable to human disturbance such as roads, and to fragmentation of their habitat (Linkie *et al.* 2006). A new approach for determining the broader scale distribution and abundance of tigers and associated prey species needs to be adopted for successful conservation of this species. The National Tiger Conservation Authority (erstwhile Project Tiger) and Wildlife Institute of India have developed scientifically-founded guidelines to monitor tigers, co-predators, prey, and their habitats (Jhala *et al.* 2005), which shall be used in the forthcoming 2010 tiger census in India. Additional studies of vegetation and land use conditions would help determine habitat for tiger prey species including wild pig, sambar, and barking deer. Research is needed on tiger habitat relations at the landscape level and specific effects on tiger reproduction and survival from human disturbance including roads, habitations, jhum, and poaching.

The tiger crisis in the country could be attributed in part to the absence of connectivity of populations among isolated habitats (regardless of size), which were designated in all good faith as Tiger Reserves. The tiger population in the Garo Hills has a better chance of survival than in other parts of Meghalaya due to the existence of connectivity among PAs and old forest tracts which, collectively, forming key tiger habitats. Some of these connectivity routes were identified as the potential wildlife habitat corridors by Williams & Johnsingh (1996) and further examined by Kumar *et al.* (2008). Such corridors likely would facilitate the exchange of breeding individuals among tiger subpopulations and their prey throughout the broader landscapes of Garo Hills.

Conclusion

Our previous work identified areas containing native forests and Asian elephants in the Garo Hills with high concentrations in South Garo Hills (Marcot et al. 2002 and Kumar et al. submitted). Conservation of the more intact, older native forest habitats buffering existing protected areas and providing habitat corridors to connect such areas would likely help conserve not just elephants but also tigers and their prey. In this way, a multi-species approach to conservation of the wildlife community can be taken. Other species of conservation significance in the Garo Hills needing immediate management interventions may include the clouded leopard (*Neofelis nebulosa*), hoolock gibbon (*Bunopithecus hoolock*), slow loris (*Nycticebus coucang*) and many others.

The old forest growths in the South Garo Hills district and adjoining Nokrek Biosphere Reserve (National Park), along with the surrounding community land, probably provide one of the best tiger habitats in North East India. If conservation of tigers -- as well as of elephants and overall biodiversity -- is a priority, these areas would need to be protected from undue alteration. Under such urgency, the PAs, connecting corridors, and appropriate intact native forest buffering PAs could be protected under the 'Project Tiger' and 'Project Elephant' programmes of Ministry of Environment and Forests (Government of India) to help ensure the long term survival of this fast disappearing species of national pride in Meghalaya, North East India.

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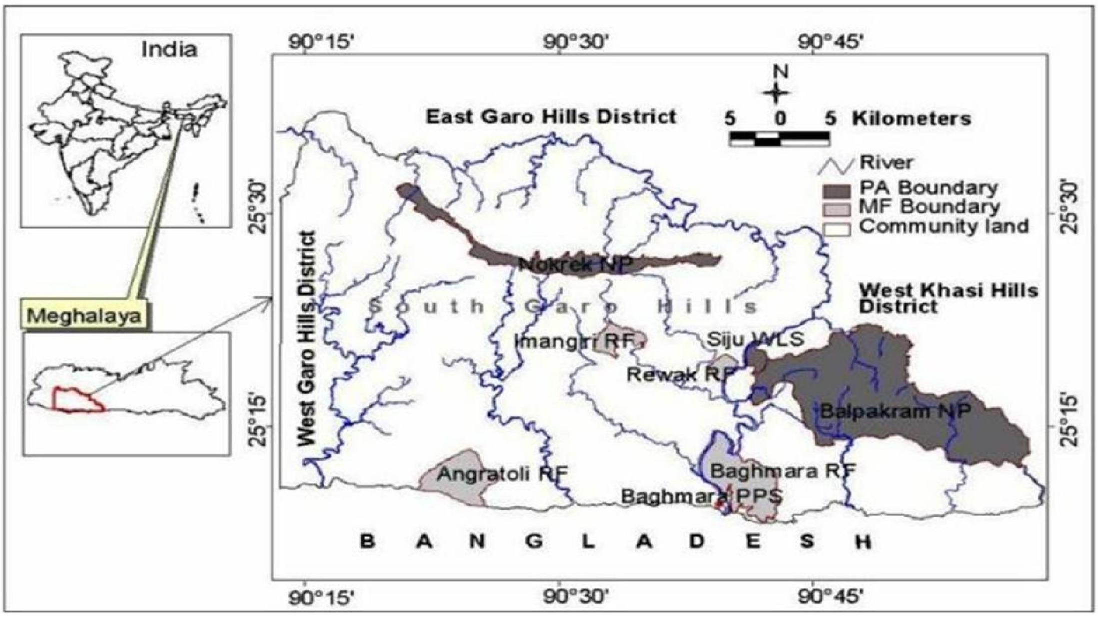

Fig 1 Study area map with geographical location within India and Meghalaya.
(PA Protected Areas; NP National Park; WLS Wildlife Sanctuary; MF Managed Forests known as RF Reserved Forests in Garo Hills; and PPS = Pitcher Plant Sanctuary).

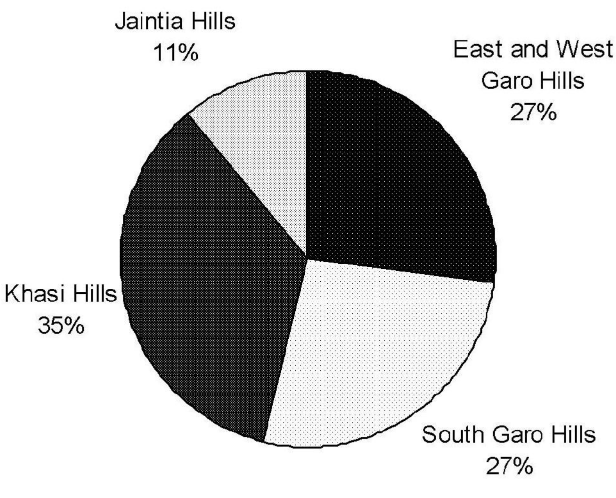

Fig 2 Tiger census statistics (1992-93) in Meghalaya
(Source: The office of Chief Wildlife Warden of Meghalaya during 1996-1997).

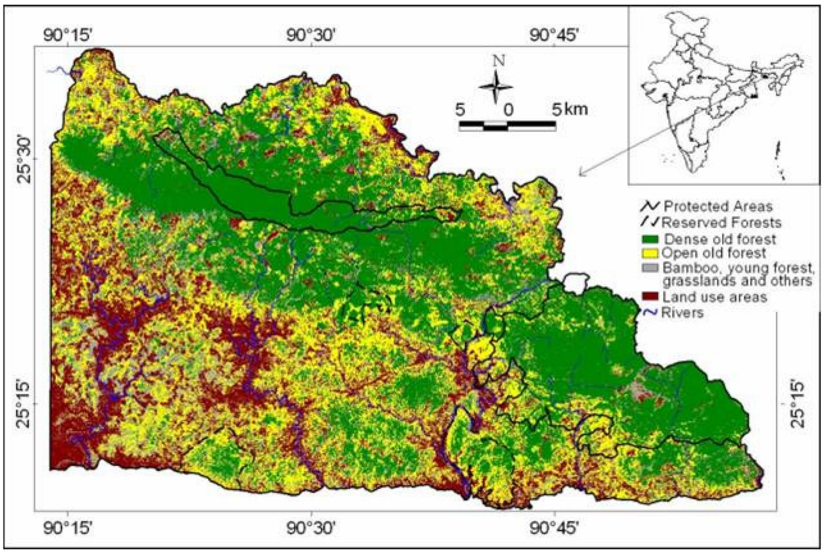

Fig 3 Land use and forest cover in the Garo Hills of western Meghalaya.
(map prepared using satellite IRS-1D LISS-III digital data of February 1999 at 23.5 m x 23.5 m resolution and Survey of India toposheets)
(Source: reclassified from land use land cover map published at Kumar et al. 2002).

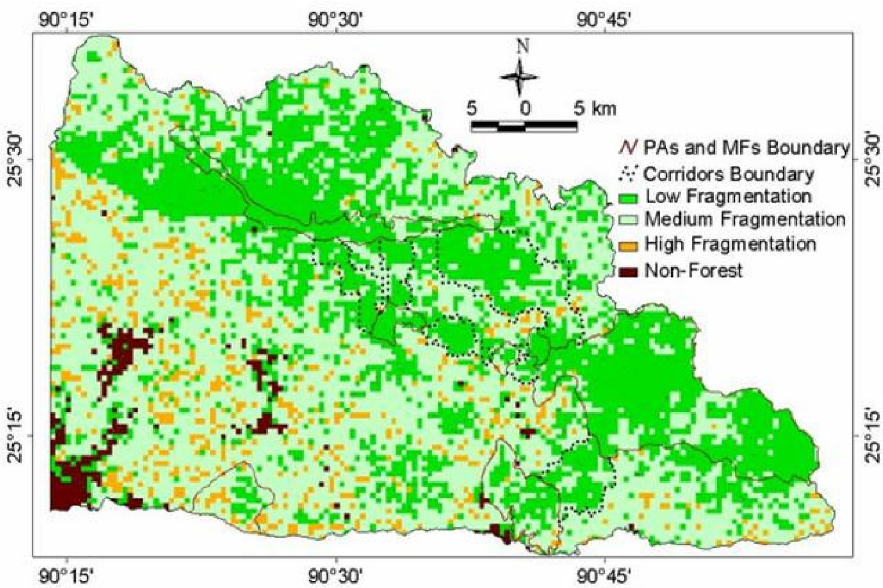

Fig 4 **Potential wildlife habitat corridors connecting adjacent Protected Areas and Reserved Forests** (Source: Kumar et al. 2008).

[1]The *jhum* agriculture involves the clearing and subsequent burning of debris of old forest growth to get the site for raising the agricultural crops (paddy, maize, cotton, potato and many vegetables) for a shorter period, while the *bun* agriculture involves the clearing and burning of shrub layer and grasses in the absence of forest cover.