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## Communication

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# Camera-trapping survey to assess diversity, distribution and photographic capture rate of terrestrial mammals in the aftermath of the ethnopolitical conflict in Manas National Park, Assam, India

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**Abstract:** Information on the presence and distribution of species is crucial for conservation planning and management within a region. Documentation of species assemblages in Manas National Park (MNP) in the aftermath of conflict is critical for informed conservation interventions. For nearly two decades (1990–2010), conservation efforts in MNP were compromised by ethno–political conflict. We conducted camera trapping surveys of terrestrial mammals across three administrative forest ranges (Panbari, Bansbari and Bhuyanpara) of MNP in 2017. A systematic survey with 118 trap locations accumulated data over 6,173 trap-days. We obtained 21,926 photographs of mammals belonging to 13 families and 25 species, of which 13 are threatened. We calculated photographic capture rate index (PCRI) using independent events. Trap specific PCRI's were used to map the spatial variation in capture rates. We observed variation in capture rate between Bansbari-Bhuyanpara where conflict ended in 2003 and has remained peaceful, and Panbari, a forest range where conflict ended later in 2016. Our results further indicate lower capture rates of mammalian prey species and small felids, but higher capture rates of four large carnivores in Panbari as opposed to Bansbari-Bhuyanpara. These results highlighted the fact that despite a history of ethno-political conflict in the region, although almost all mammalian species expected to occur in the park were detected and confirmed, present evidence indicated ethno-political conflict influences the distribution of several key species. In depth studies assessing mammalian prey densities, distribution and density are required to further understand the effects of conflict.

**Keywords:** Camera trap survey, capture rate, ethno-political conflicts, Manas National Park.

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## INTRODUCTION

Information on the presence and distribution of species within a region is crucial for planning and evaluating conservation strategies (Tobler et al. 2008). This is especially true in sites where armed conflict has complicated conservation efforts (Hanson et al. 2009; Daskin & Pringle 2018) and impacted species populations and habitats. There is no general consensus as to whether conflicts have positive impacts on wildlife (through relaxing pressure on wildlife when people avoid combat zones or the decline of extractive industries; Hallagan 1981; Butsic et al. 2015) or negative impacts (through direct killing from the use of ordnance and chemicals or bushmeat hunting by soldiers; Orians & Pfeiffer 1970; de Merode et al. 2007; Beyers et al. 2011). Thus it is critical to assess the effects of conflict on biodiversity.

Manas National Park (MNP), spanning 500km$^2$ is located in the eastern Himalayan biodiversity hotspot. Falling within two administrative districts (Chirang and Baksa) of the state of Assam that are under the administration of the Bodoland Territorial Council (BTC), this region experienced intense ethno-political conflict in the late 1980s until 2003. During this period the population of Indian Rhinoceros *Rhinoceros unicornis* was poached out, necessitating a reintroduction program to repopulate the park (Barman et al. 2014). Preliminary studies and anecdotal evidence suggest that the conflict has severely impacted other wildlife species as well (Goswami & Ganesh 2014).

It is noteworthy that 80% of worldwide armed conflicts between 1950 and 2000 overlapped with biodiversity hotspots (Hanson et al. 2009). A more recent analysis from Africa highlights the fact that population trajectories of large mammals fell significantly below replacement levels (i.e., instantaneous rate of increase of population; λ less than 1) with an increase in conflict frequency (Daskin & Pringle 2018). Therefore, documenting species assemblages in the aftermath of conflict is critical to inform subsequent conservation interventions.

In this study we conducted camera trapping surveys across three administrative forest ranges (Panbari, Bansbari and Bhuyanpara) of MNP in 2017 with the aim to (a) document the mammalian species assemblage of the park, and (b) understand the influence of civil conflict on the mammalian assemblage. Given that there is no comparable data on mammal distribution prior to the conflict from the site, it was not possible for us to make direct comparisons of pre and post conflict effects on the mammalian assemblage. Therefore, we evaluated differences in photo capture rates of mammalian prey and large carnivore species between Panbari (a forest range with conflict until 2016) and Bansbari-Bhuyanpara (forest ranges that have been conflict-free since 2003). These two forest sections of MNP differ in their history of conflict but are similar in terrain, climate, vegetation communities, and faunal assemblages. Therefore, we assume our comparisons to serve as a proxy for the effects of conflict.

## MATERIAL AND METHODS

### Study site

MNP, situated in the eastern Himalayan biodiversity hotspot, is also an UNESCO Natural World Heritage Site, a tiger reserve, an elephant reserve and a biosphere reserve. Contiguous with Royal Manas National Park (RMNP) in Bhutan, it is home to several endangered species. Located in the foothills of the Himalaya, MNP is predominantly flat, with the mountainous regions primarily falling within RMNP, Bhutan. The vegetation of MNP can be broadly classified into eastern wet alluvial grasslands, moist deciduous, and semi-evergreen forests (Champion & Seth 1968).

Spread over Kokrajhar, Chirang, Baksa and Udalguri districts of the Bodoland Territorial Areas Districts (BTAD) of Assam, much of the forests of the Manas Tiger Reserve (including core area of MNP) experienced large scale deforestation (i.e., conversion of forests to farmland and settlements) during the conflict period leading to the loss of over 40% of primary habitats (Sarma et al. 2008; Lahkar et al. 2012). While political stability was initiated in 2003 with the formation of the BTAD, since 2004, there have been several incidents of ethnic conflict in the region emphasizing the fragile socio-political environment around this site (Web data source: South Asia Terrorism Portal, Satp.org).

The forest ranges of Bansbari and Bhuyanpara have largely remained conflict free since 2003. Occasional conflict in Panbari until 2016 has resulted in our inability to conduct surveys within the forest range. Although we, in collaboration with the park management, have been carrying out long-term biological monitoring using camera traps since 2010 across Bansbari and Bhuyanpara, it was only in 2017 that surveys could be undertaken simultaneously across all three ranges of MNP (Panbari, Bansbari and Bhuyanpara).

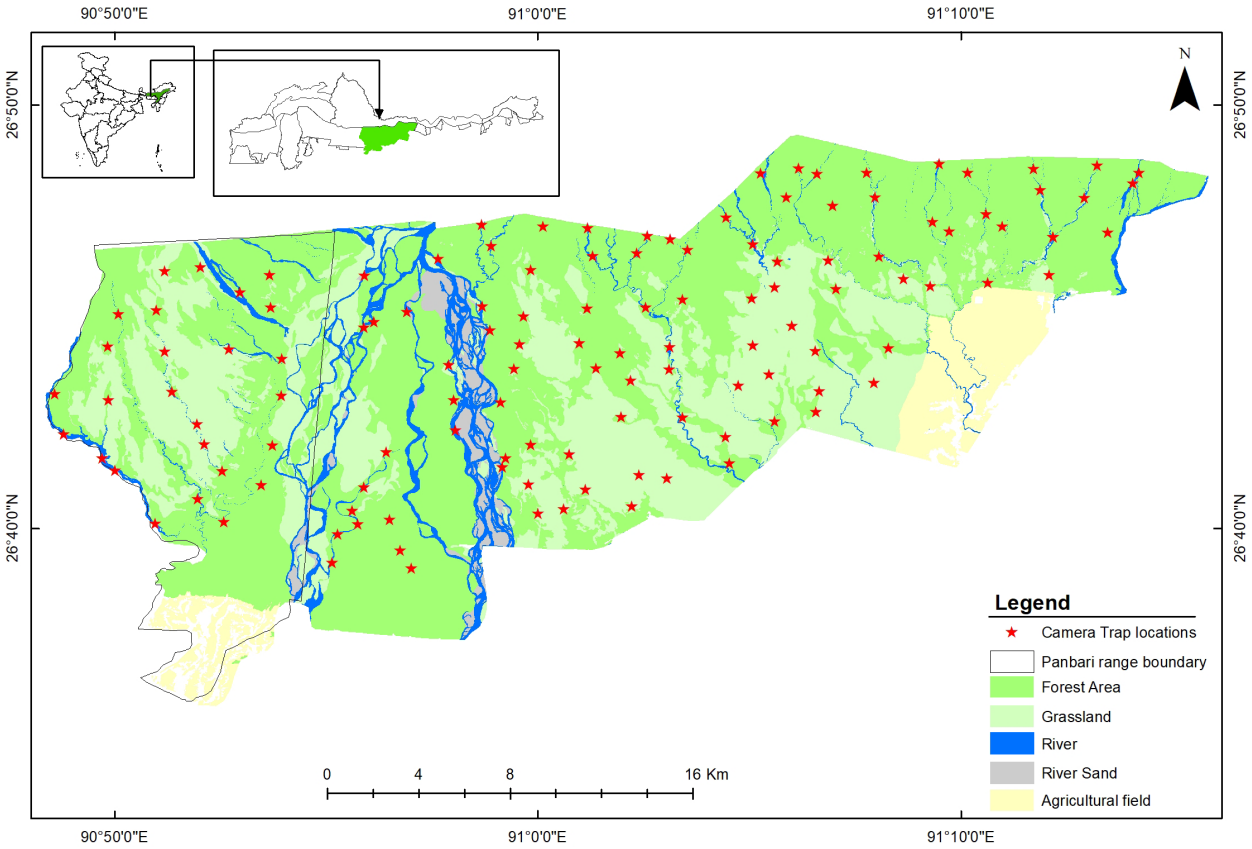


**Figure 1. Manas National Park (MNP) highlighting the Panbari range with back boundary.**

**Field and analytical methods**

We conducted a camera trapping survey in the winter of 2016–17 from 28 December 2016 to 24 February 2017 covering the three ranges of Panbari, Bansbari and Bhuyanpara. We used 4km$^2$ grids to guide camera placement. Cameras were operational for 24 hours a day. We used Panthera (New York, USA) V4 & V5 digital white flash passive camera traps mounted on trees, on poles in steel cages customised specifically for the cameras to minimise the damage from wild animals. In total, camera traps were placed at 118 locations (26 in Panbari and 92 in Bansbari-Bhuyanpara; Fig. 1).

We first downloaded photographs from all the trap stations across the park at regular intervals (usually twice a week) and catalogued all captures using Camera Trap File Manager software (Olliff et al. 2014). During the cataloguing process species identity was confirmed based on expert knowledge. We also referred to Menon (2014) to confirm species identity.

The camera traps were operational for 24 hours a day and each day was counted as a trap-day. The trapping effort at different trap locations diferred due to time and days a camera trap was active. On average camera traps were operational for 52.3 trap-days. To calculate the photo-capture rate index (PCRI) of all species captured we first identified independent captures (i.e., captures that were 30-minutes apart for each station). We then divided the number of independent captures obtained at each trap by trap-specific effort (i.e., number of trap-days that a particular trap was active) and expressed the estimate per 100 trap-days (Carbone et al. 2001). Trap specific PCRI were then used to map the spatial variation in capture rates. All maps were created in the open source software QGIS (QGIS Development Team 2012). To assess the difference in PCRI of mammalian prey and large carnivores between Panbari and Bansbari-Bhuyanpara, we summarized species–specific PCRI and tested for differences using a two sample T-test assuming unequal variances. Given that we were conducting a series of significance tests on the same set of data, we set the false discovery rate to 10% and used Benjamini-Hochberg procedure (Benjamini & Hochberg 1995).

## RESULTS

Camera trapping effort totaled 6,173 trap-days in 2016–17 spread across MNP. We obtained 21,926 photographs of mammals from which we identified 25 mammal species belonging to 13 families (Appendix 2). Of these, six species are Endangered and seven are Vulnerable as per the IUCN Red List of Threatened Species (Table 1; IUCN 2017).

In addition to 2016–17, using the data from long term monitoring study in MNP since 2010, we observed presence of number of other species which included Spotted Deer *Axis axis* (confirmed its eastern range limit in Panbari; Least Concern), Chinese Pangolin *Manis pentadactyla* (Critically Endangered), Marbled Cat *Pardofelis marmorata* (Near Threatened), Golden Jackal *Canis aureus* (Least Concern), and Painted Bat *Kerivoula picta* (Least Concern).

For mammalian prey and large carnivore species we mapped the spatial variation in photo capture rates across the Park (Figs. 2 & 3). In addition, we assessed the variation in capture rates between Panbari and Bansbari-Bhuyanpara (Figs. 4 & 5). In general our results indicated lower capture rates of mammalian prey species in Panbari as opposed to Bansbari-Bhuyanpara, while for four large carnivore species photo capture rates were higher in Panbari compared to Bansbari-Bhuyanpara. Significant differences in capture rates using a two sample T-test assuming unequal variances were, however, noticed only among four mammalian prey (Barking Deer, Sambar, Gaur and Buffalo) and one large carnivore (Wild Dog) (Figs. 4 & 5) (Appendix 1).

## DISCUSSION

Our surveys confirm the presence of 25 mammalian species photo-captured in MNP, 13 of which are

**Table 1. Summary of animals recorded in the Manas National Park, Assam, India from 28 December 2016 to 24 February 2017.**

| | Family | Common name | Scientific name | IUCN category | PCRI (CI 95%) |
|---|---|---|---|---|---|
| 1 | Felidae | Royal Bengal Tiger | *Panthera tigris* | Endangered | 4.84 (3.21–6.47) |
| 2 | Felidae | Common Leopard | *Panthera pardus* | Vulnerable | 5.42 (4.05–6.79) |
| 3 | Felidae | Clouded Leopard | *Neofelis nebulosa* | Vulnerable | 0.54 (0.08–0.99) |
| 4 | Felidae | Leopard Cat | *Prionailurus bengalensis* | Least Concern | 3.19 (2.32–4.06) |
| 5 | Felidae | Jungle Cat | *Felis chaus* | Least Concern | 0.25 (0.11–0.40) |
| 6 | Canidae | Wild Dog | *Cuon alpinus* | Endangered | 0.62 (0.32–0.92) |
| 7 | Cervidae | Barking Deer | *Muntiacus muntjak* | Least Concern | 4.24 (2.99–5.50) |
| 8 | Cervidae | Hog Deer | *Axis porcinus* | Endangered | 2.76 (1.24–4.27) |
| 9 | Cervidae | Sambar | *Rusa unicolor* | Vulnerable | 22.80 (17.86–27.73) |
| 10 | Cervidae | Swamp Deer | *Rucervus duvaucelii* | Vulnerable | 0.41 (0.0–0.92) |
| 11 | Suidae | Wild Pig | *Sus scrofa* | Least Concern | 5.45 (4.10–6.79) |
| 12 | Bovidae | Gaur | *Bos gaurus* | Vulnerable | 7.20 (5.23–9.15) |
| 13 | Bovidae | Wild Water Buffalo | *Bubalus arnee* | Endangered | 3.50 (2.36–4.64) |
| 14 | Elephantidae | Asian Elephant | *Elephas maximus* | Endangered | 17.21 (13.36–21.06) |
| 15 | Leporidae | Indian Hare | *Lepus nigricollis* | Least Concern | 1.12 (0.59–1.65) |
| 16 | Leporidae | Hispid Hare | *Caprolagus hispidus* | Endangered | 0.23 (0.03–0.42) |
| 17 | Viverridae | Large Indian Civet | *Viverra zibetha* | Least Concern | 1.30 (0.77–1.82) |
| 18 | Viverridae | Small Indian Civet | *Viverricula indica* | Least Concern | 2.69 (1.75–3.62) |
| 19 | Viverridae | Common Palm Civet | *Paradoxurus hermaphroditus* | Least Concern | 0.70 (0.29–1.11) |
| 20 | Herpestidae | Crab-eating Mongoose | *Herpestes urva* | Least Concern | 0.39 (0.18–0.59) |
| 21 | Herpestidae | Common Mongoose | *Herpestes edwardsii* | Least Concern | 0.04 (0.0–0.10) |
| 22 | Hystricidae | Malayan Porcupine | *Hystrix brachyura* | Least Concern | 1.51 (0.92–2.09) |
| 23 | Ursidae | Asiatic Black Bear | *Ursus thibetanus laniger* | Vulnerable | 0.046 (0.0–0.10) |
| 24 | Rhinocerotidae | Indian Rhinoceros | *Rhinoceros unicornis* | Vulnerable | 0.91 (0.10–1.72) |
| 25 | Mustelidae | Yellow-throated Marten | *Martes flavigula* | Least Concern | 0.13 (0.03–0.233) |

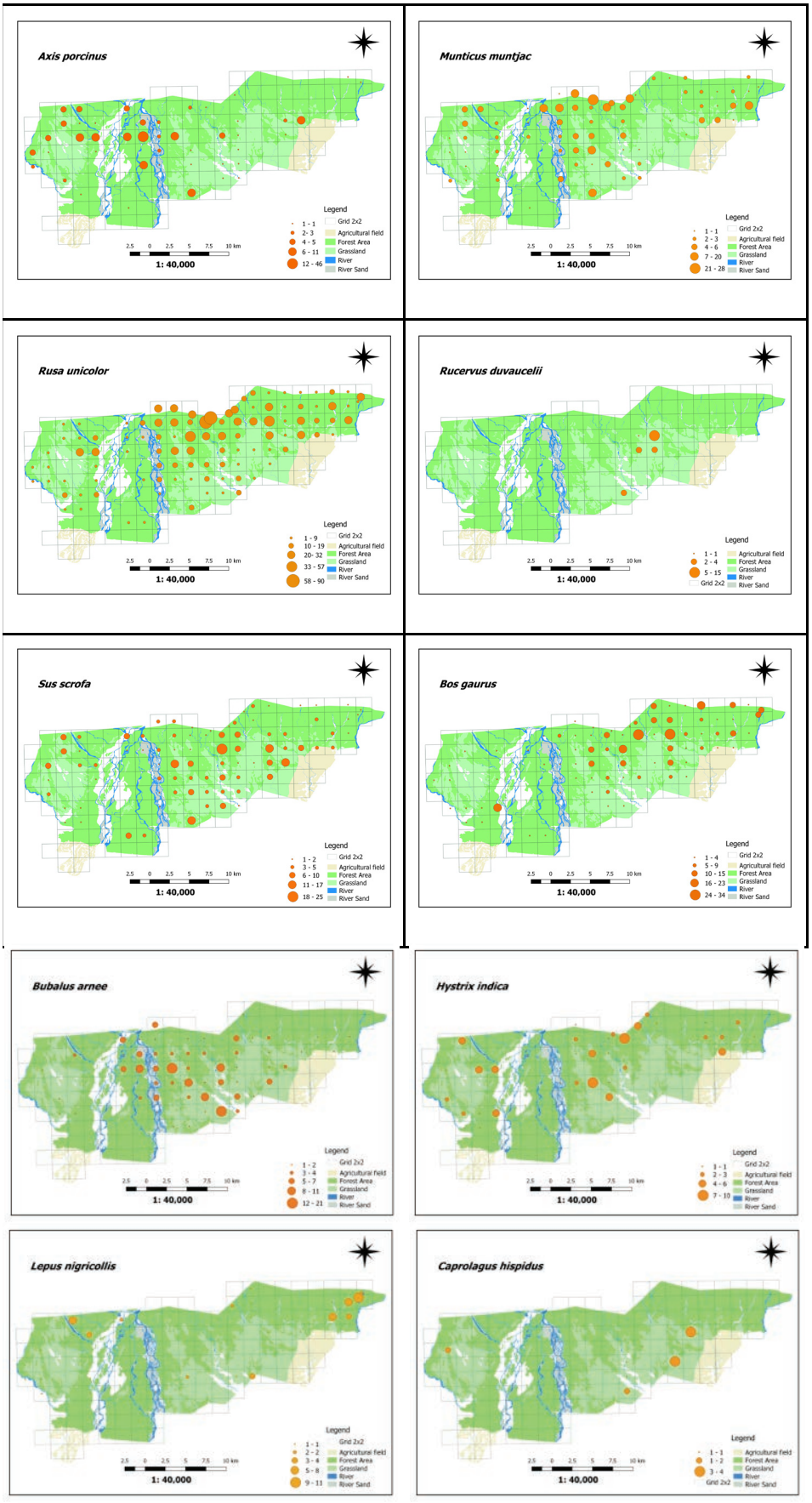


**Figure 2. Photographic capture rate index of the mammalian prey species of MNP.**

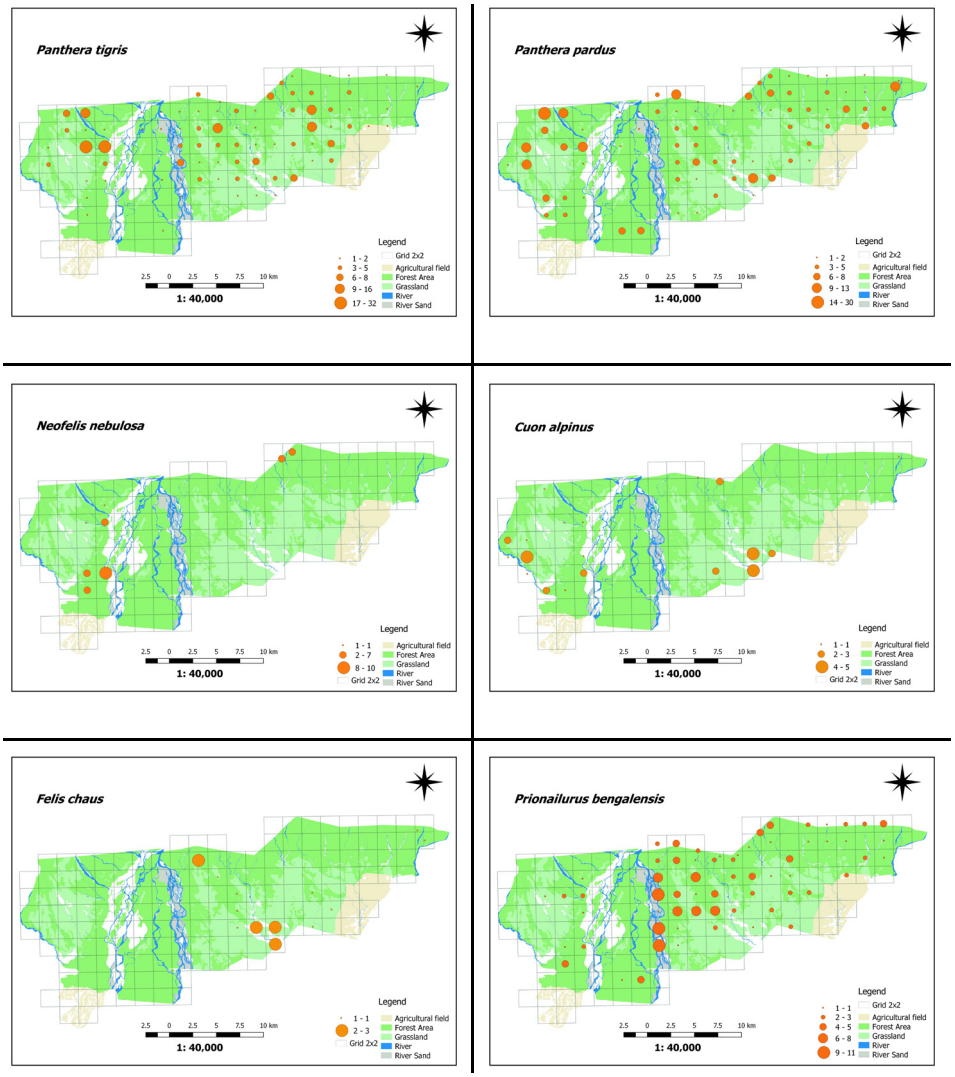


**Figure 3. Photographic capture rate index of the major mammalian predator species of MNP.**

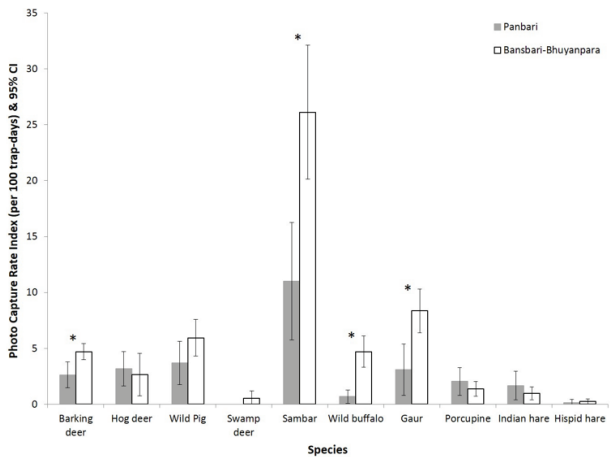


**Figure 4. Variation in photographic capture rates of mammalian prey species between Panbari and Bansbari-Bhuyanpara ranges of MNP, from 28 December 2016 to 24 February 2017. Note: * indicates that mean PCRIs differed significantly between Panbari and Bansbari-Bhuyanpara ranges**

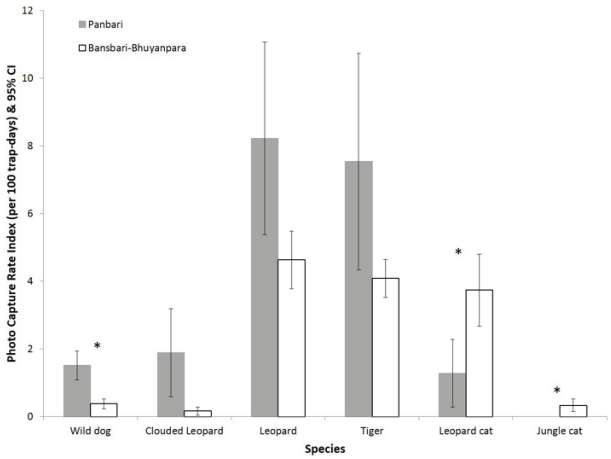


**Figure 5. Variation in photographic capture rates of mammalian carnivore species between Panbari and Bansbari-Bhuyanpara ranges of MNP, from 28 December 2016 to 24 February 2017. Note: * indicates that mean PCRIs differed significantly between Panbari and Bansbari-Bhuyanpara ranges.**

threatened species (IUCN 2017). Although the camera trapping surveys underrepresented species groups such as rodents, arboreal and aerial mammals, direct observational records confirm the presence of three species of primates, Capped Langur *Trachypithecus pileatus* (Vulnerable), Golden Langur *Trachypithecus geei* (Endangered), and Rhesus Macaque *Macaca mulatta* (Least Concern). In addition, Black Giant Squirrel *Ratufa bicolor* (Near Threatened), Himalayan Striped Squirrel *Tamiops macclellandi* (Least Concern) and one species of Suidae, Pigmy Hog *Porcula salvania* (Critically Endangered) were also recorded during the period of our long-term biological monitoring. These photo-capture results highlight the fact that despite a long history of ethno-political conflict in the region, almost all mammalian species expected to occur in the region were present and detected during this study, with the exception of Sloth Bear *Melursus ursinus* (Vulnerable) and Fishing Cat *Prionailurus viverrinus* (Vulnerable).

It is observed that ethno-political conflict likely has some impacts on abundance and distribution of species and habitats. While the mammalian species assemblage in MNP appears to be intact, we detect differences among photo capture rates of several species between Panbari (a forest range with conflict until 2016) and Bansbari-Bhuyanpara (forest ranges that have been conflict-free since 2003). In general, prey capture rates were higher in Bansbari-Bhuyanpara compared to Panbari, and significant differences were noticed for four mammalian prey species (i.e., Wild Buffalo, Gaur, Sambar and Barking Deer; Fig. 4). Three of these (Wild Buffalo, Gaur and Sambar; over 175kg) are large prey species that are all threatened and particularly vulnerable to poaching (Wolf & Ripple 2016; IUCN 2017). In the case of large mammalian carnivores, however, species capture rates were higher in Panbari compared to Bansbari-Bhuyanpara, although significant differences were noticed only for Wild Dogs (Fig. 5). While it is possible that Panbari acted as a refuge for large carnivores as villagers may have avoided the combat zone, it is also possible that disturbances emanating from the conflict could have depressed large prey populations. Disturbances, however, were more of armed militants camping deep inside the Panbari range two to three years preceding this survey, rather than ethnic conflict as such or severe anthropogenic disturbances due to natural resource collection. Thus, the disturbances within the park during that period were mostly related to hunting (potentially ungulate species) for food by those camping inside as well as subsequent sanitization operations by government forces.

From our study it appears that RMNP in Bhutan situated immediately north of MNP, next to Panbari, likely acted as a refuge, particularly for long ranging carnivore species. This is evidenced by the fact that in 2017 our camera trapping data confirmed presence of eight individual tigers (five males and three females) in Panbari range of which three individuals were captured the previous year (2016) in RMNP (Singye Wangmo pers. comm. 22 January 2018). This also indicates that the large carnivores have taken the advantage of the progressively re-established security in the area and rapidly moved there. The animals probably began using that area as well but did not relocate there - perhaps their ranges are wide enough to use portions of both areas. This may, however, also negatively impact the herbivore population that are still recovering and thus, may take longer to re-establish themselves.

Ideally, long-term data on population trajectories are required to uncover the effects of conflict-related disturbance on populations. MNP offers us the opportunity to compare capture rates of wildlife species across two study blocks that primarily differ in their history of ethno-political conflict. The contiguity within TraMCA (Trans-boundary Manas Conservation Area) certainly has a positive effect contributing to the repopulation of large carnivores in the aftermath of the conflict as RMNP has acted as a refuge for the animals displaced by disturbances in MNP. Ahmed et al. (2015) have highlighted the trans-boundary importance of the TraMCA based on data obtained through synchronized camera trapping exercises across the boundary. The present study further highlights the importance of large and contiguous conservation areas for the conservation of biodiversity.

Our study found camera trapping to be an effective method to document particularly rare and elusive mammalian species and their relative abundance across the park. Photographic capture-recapture methods could help assess the population trajectories of individually identifiable species such as tigers, leopards, clouded leopards and leopard cats. Additionally, the baselines we set through this study could be used to monitor future changes in the capture rates of several species, especially those which are not individually identifiable (e.g., Wild Dogs and Jungle Cats).

In conclusion, we present evidence that ethno-political conflict has likely influenced the spatial variation of several species in Manas National Park. It is critical, however, to note that more detailed studies assessing mammalian prey densities, distribution and density of large carnivores and correlation with specific

factors emanating from conflict are required to further understand the effects of conflict and peacetime conservation efforts on the species assemblage and abundances.

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**Appendix 1. Table for Two sample T-test.**

| Species | Photographic capture rate index | | Two sample T-test | |
|---|---|---|---|---|
| | Panbari | Bansbari-Bhuyanpara | *P* | df |
| **Mammalian prey** | | | | |
| Barking Deer | 2.62 | 4.71 | 0.0390 | 104 |
| Hog Deer | 3.17 | 2.64 | 0.6717 | 98 |
| Wild Pig | 3.70 | 5.94 | 0.0865 | 64 |
| Swamp Deer | 0 | 0.54 | 0.1085 | 91 |
| Sambar | 11.01 | 26.13 | 0.0003 | 90 |
| Wild Buffalo | 0.67 | 4.71 | 0.0000 | 113 |
| Gaur | 3.09 | 8.36 | 0.0144 | 50 |
| Porcupine | 2.04 | 1.36 | 0.3506 | 41 |
| Indian Hare | 1.66 | 0.97 | 0.3404 | 36 |
| Hispid Hare | 0.15 | 0.25 | 0.5973 | 59 |
| **Carnivores** | | | | |
| Wild Dog | 1.51 | 0.38 | 0.0173 | 31 |
| Clouded Leopard | 1.89 | 0.16 | 0.0761 | 26 |
| Leopard | 8.22 | 4.63 | 0.1715 | 27 |
| Tiger | 7.54 | 4.08 | 0.2976 | 27 |
| Leopard Cat | 1.00 | 1.07 | 0.0008 | 88 |
| Jungle Cat | 0.01 | 0.19 | 0.0010 | 91 |

**Appendix 2. Photographs of species recorded in camera traps in this study during 28 December 2016 to 24 February 2017 in the Manas National Park, Assam, India.**

*Panthera tigris*

*Panthera pardus*

*Rusa unicolor*

*Neofelis nebulosa*

*Prionailurus bengalensis*

*Sus scrofa*

*Felis chaus*

*Cuon alpinus*

*Bubalus arnee*

*Muntiacus muntjak*

*Axis porcinus*

*Lepus nigricollis*

*Rucervus duvaucelii*

*Bos gaurus*

*Elephas maximus*

*Viverra zibetha*

*Viverricula indica*

*Paradoxurus hermaphroditus*

*Herpestes urva*

*Herpestes edwardsii*

*Hystrix brachyura*

*Ursus thibetanus laniger*

*Rhinoceros unicornis*

*Caprolagus hispidus*

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