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First Addition to Manas National Park: Extension Potentiality of Manas World Heritage Site in Assam, India

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ABSTRACT

The Natural World Heritage Sites (WHS) are recognized for their global significance in biodiversity conservation. With such an intention, the eastern part of Manas Reserved Forest was upgraded to the First Addition to Manas National Park (NP) in August 2016 on the west of the existing Manas WHS and NP in Assam, India. This study was conducted to assess the abundance and occupancy of top predators and their prey species considering both direct sighting and indirect evidence including camera trap photographs recorded in this landscape. The naïve occupancy (*Psi*) of the tiger was 0.3412, while the density was 2.29 individuals per 100 sq. km. Moreover, the naïve occupancy (*Psi*) of the leopard was 0.1647 and the dhole was 0.1765. Relative abundance index (RAI) estimate of the prey species was highest for sambar (RAI=21.26) followed by Indian bison (RAI=15.84), barking deer (RAI=14.22), wild boar (RAI= 5.13) and hog deer (RAI=2.93). Recovery of the wildlife population, improved enforcement, community engagement, and transboundary cooperation will definitely increase the extension potentiality of Manas WHS to the First Addition to Manas NP on the west and maintain the integrity of the landscape with the Royal Manas NP of Bhutan on the north.

Key words: *Manas, World Heritage Site, Tiger Reserve, Conservation, First Addition*

Introduction

The UNESCO World Heritage Convention plays a key role in the identification, conservation and promotion of the world's cultural and natural heritage of Outstanding Universal Value (OUV). Of these, the natural World Heritage Sites are the masterpieces of our mother Earth recognized for their global significance of biodiversity conservation containing superlative natural phenomena and providing crucial habitats to many iconic wildlife species for in-situ conservation, as well as protecting rare ecological processes (Osipova *et al*., 2014). The presence of sufficient prey communities andviable populations of large carnivores along with other wildlife species assem blages strengthen such ecological processes and their functionality as well as provide important ecosystem services for the welfare of human beings (Karanth and Sunquist, 1995; Carbone *et al*., 1999; Mowry *et al*., 2022). The predator-prey relationship is an important paradigm of ecosystem functionality where the prey population acts as a determinant of predator species occurrence in an ecosystem (Karanth, 1993;Abrams, 2000; Karki, 2009).

The Manas Wildlife Sanctuary (WLS) covering an area of 391 sq. km. is such a natural landscape that is renowned for its rich and unique biodiversity as

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well as for its spectacular scenery located at the southern foothills of the Eastern Himalayas. It was inscribed in the list of World Heritage Sites (WHS) under the current natural criteria (vii), (ix) and (x) due to its exceptional conservation significance in northeast India (UNESCO, 1985). The dynamic ecosystems of Manas WHS support semi-evergreen forests, mixed moist and dry deciduous forests, and alluvial grasslands which provide habitats for 21 of India's most threatened mammalian fauna. It is an integral and core habitat of Manas Tiger Reserve (TR) that covers an area of 2837.31 sq. km in northwestern Assam, India (TCP, 2019). Due to the damages that occurred to the wildlife population including their habitats and infrastructure of the property during ethno-political violence since 1988; the UNESCO World Heritage Site monitoring committee reviewed the status of the property and decided to put it onthe "In Danger" list of World Heritage Sites in 1992. However, the state party showed gradual progress in the recovery of the Outstanding Universal Values of the property as well as the missions recommended by the UNESCO World Heritage Site monitoring committee. In June 2011, Manas regained its original status asa "World Heritage Site" due to collective efforts of the state party, the Bodoland Territorial Council, the Park Authority, conservation organizations and local communities (UNESCO, 2011).

The eastern part of Manas Reserved Forest (RF) was upgraded to the First Addition to Manas National Park (NP) covering an area of 350 sq. km. (vide Govt. Notification No. FRS 86/2015/215 dated 12th August 2016) on the west of existing Manas WHS and NP. The upgrade was mainly to restrict the new expansion of human settlements in the forest areas and to accommodate the future surplus wildlife of Manas NP. Though, the Manas RF was contiguous with Manas NP; no focused conservation efforts were given in the area prior to its notification as the First Addition to Manas NP. For the first time, a systematic baseline survey was conducted in the cool dry season of 2018-19 in this landscape (WTI, 2019). Another similar survey was conducted exactly after three years following the same methodology in the cool dry season of 2021-22 particularly to know the population status of different mammalian fauna in the same area. This paper will examine a comparative analysis of the abundance and occupancy of top predators and their prey species in this natural landscape. This will also help us to assess the potentiality of extension of the existing Manas WHS to the First Addition to Manas NP.

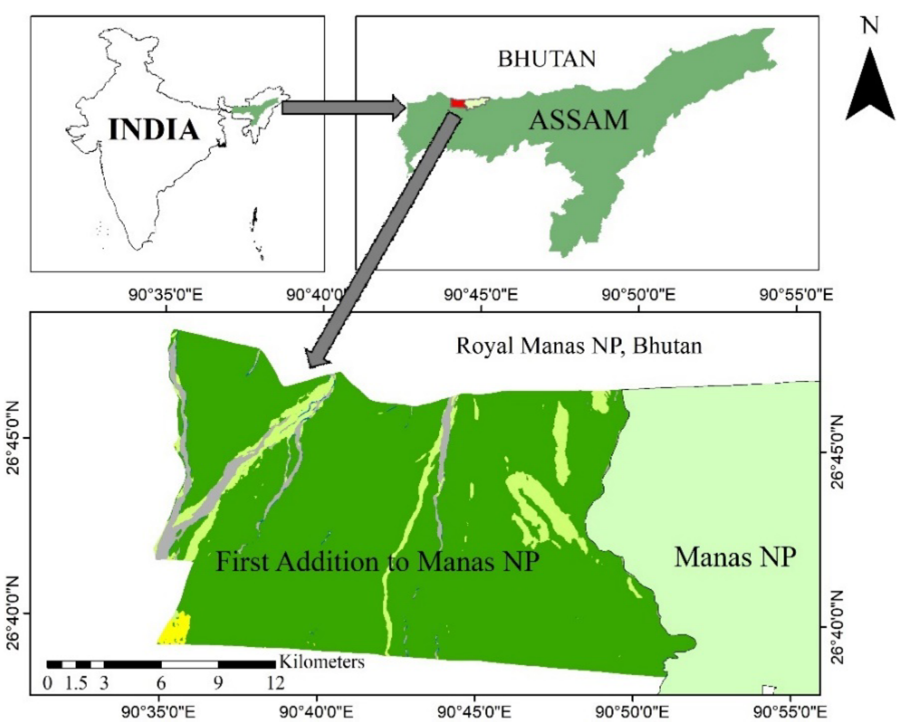

Fig.1. Location map of First Addition to Manas NP in Assam, India

Materials and Methods

Study Area

The First Addition to Manas NP (26^{0}38′-26^{0}48′ N, 90^{0}35′-90^{0}51′ E) lies in the Chirang district of north-western Assam, India. It is embedded on the west of the existing Manas NP and contiguous with the Royal Manas NP (1,023 sq. km) of Bhutan in the north (Fig. 1). Around a total of 53 thickly populated villages are present on the south and western sides of the study area. Sukhanjan River forms its eastern boundary and it extends up to the Sukanteklai River in the west. The landscape represents the Eastern Dooars or Assam Dooars and is typical *Bhabar* consists of gravelly deposits covered by an alluvial apron of sand and clay (Champion and Seth, 1968a). The landscape has a gentle regular slope towards the south within a range of 57-373 meters above mean sea level. Sukanteklai, Kanamakra and Kuklung are three major rivers of the study area. Owing to *Bhabar* formation, rivers and streams are mostly seasonal or subterranean though a few of them are perennial too. The mean annual rainfall is about 3,330 mm with most of it being received from the south-west monsoon (Bhattacharjee *et al*., 2014). The mean maximum and minimum temperatures are 37°C and even more during summer and 5°C in winter respectively (Nath *et al*., 2010). The sub-Himalayan semi-evergreen forests are found in the northern part, whereas Himalayan mixed-moist and dry deciduous forests including the grassland habitats are dominant in the remaining part of the study area (Champion and Seth, 1968b).

Data Collection

The entire study area was divided into 2x2 km^2 sampling grids for data collection e.g., sign survey and systematic deployment of camera traps. Three belt transects, each of a minimum 1 km length and 10 m width were walked following the forest paths and animal trails in each sampling grid covering all the representative habitat types (Fig. 2). The presence of different mammalian fauna was ascertained through their indirect signs *e.g*., scat, dung, pellet, hoofmark and pugmark inthe transects. The camera trapping method (O'Connell *et al*., 2010) was applied to collect occurrence information of mammals.

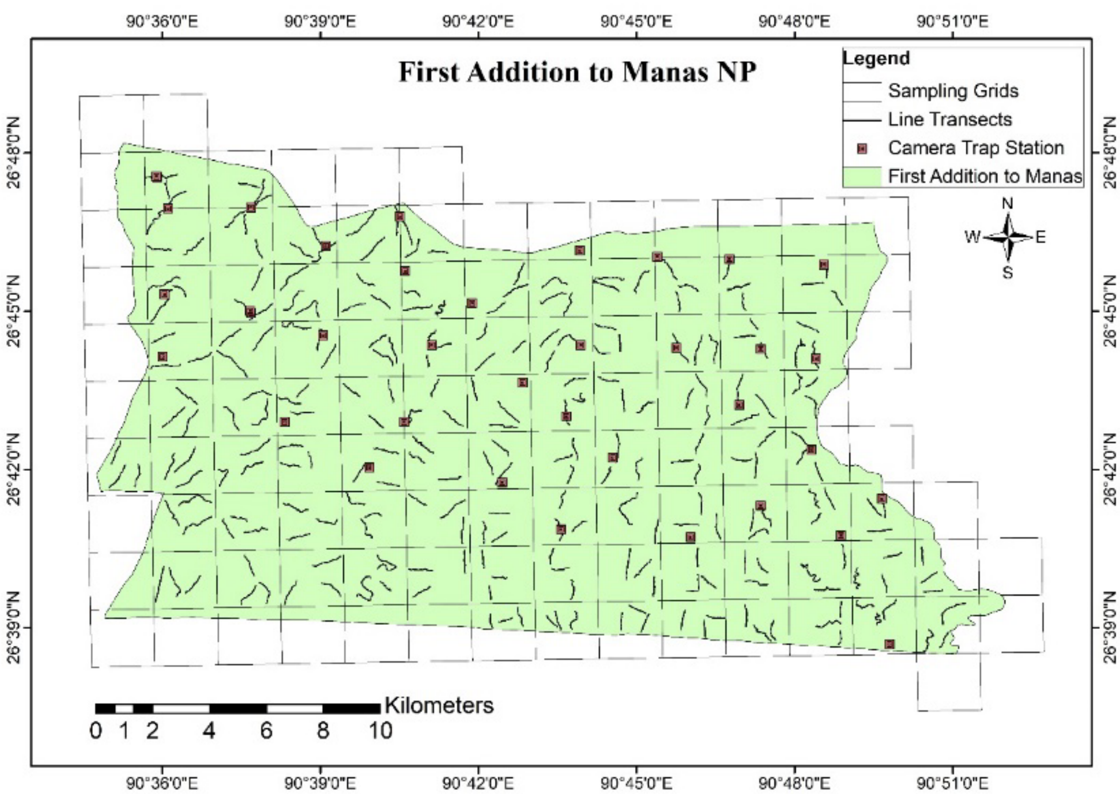

Fig.2. Map showing the sampling efforts in the First Addition to Manas NP

Data Analysis

Relative Abundance

Both direct sighting and indirect evidence including camera trap photographs of three predator species *viz*., tiger (*Panthera tigris*), leopard (*Panthera pardus*) and dhole (*Cuon alpinus*); and five prey species *viz*., Indian bison (*Bos gaurus*), sambar (*Rusa unicolor*), barking deer (*Muntiacusmuntjak*), hog deer (*Axis porcinus*) and wild boar (*Sus scrofa*) were used to calculate the relative abundance indices (RAI), which is the number of photographs of the focal species per trap night across the sampled area (Carbone *et al*., 2001; O'Brien, 2011).

Species Occupancy

The presence of the three predator species tiger, leopard and dhole recorded in the sampling grids was used for their occupancy analysis. All the analyses were performed in the PRESENCE software (version 10.9) and occupancy maps were prepared using QGIS (version 3.22). In occupancy, single season-single species analysis, vegetation classes, disturbance factors and distance to human settlement from each sampling grid were used as covariates to account for variation in detectability and occupancy. Model selection was performed using Akaike's Information Criterion (AIC) and model weights. Model averaging was performed and weighted parameter estimates and unconditional standard errors were calculated for model parameter estimates from the best-ranked models (Burnham and Anderson, 1998). Naive estimates of habitat occupied were calculated as the proportion of grid cells where the evidence of the species was recorded. Because occupancy methods explicitly estimate and account for the probability of detection (which is always<1) and generated occupancy estimates are always greater than or equal to the naive estimate. Occupancy analysis focuses on two parameters, *Psi* (Y) is the probability of a site is occupied by the target species, and *p* is the probability of detecting the species during the survey (Mackenzie *et al*., 2017).

Results

Relative Abundance

A total of 85 grids (67 complete grids and 18 broken grids) were surveyed among the total 90 sampling grids present in the study area. A total of 225 km walked in transects searching for direct observation of mammalian species as well as their indirect evidence in different habitat types following the existing forest paths and animal trails in the entire study area. We deployed camera traps in 35 random stations keeping a minimum 1 km distance between each other and left the southern part of the study area to avoid the risk of camera trap damage by hunters/poachers. Among the total captured images (8177) in all the 35 camera trapstations, 78% were mammalian fauna, avian fauna 6%, human crossing 7% and 9% of livestock population. Tiger, leopard and dhole were considered among the predator species for relative abundance and occupancy analysis and Indian bison, sambar, barking deer, wild boar and hog deer were considered among the prey species for analysis of their relative abundance only in the study area.

It is evident from the table (Table 1) that the relative abundance of all three predator species has in-

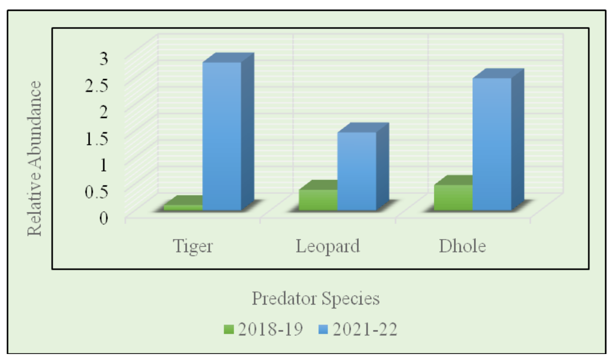

Fig. 3. Relative abundance of predator species in First Addition to Manas NP

Table 1. Relative abundance of predator and prey species in First Addition to Manas NP (comparison of two survey data: 2018-19 &2021-22)

Relative Abundance Index (RAI)	Predator Species			Prey Species				
	Tiger	Leopard	Dhole	Indian Bison	Sambar	Barking Deer	Wild Boar	Hog Deer
2021-22	2.79	1.47	2.49	15.84	21.26	14.22	5.13	2.93
2018-19	0.10	0.39	0.48	6.27	4.44	21.62	16.11	1.06

creased with the tiger (2.79) as highly abundant followed by dhole (2.49) and leopard (1.47) while the density of tiger was 2.29 individuals per 100 sq. km in the study area (Fig. 3). Among the prey species, though the relative abundance of Indian bison, sambar and hog deer has increased but barking deer and wild boar have shown population depression (Table 1). Among the prey species, sambar (21.26) was the highly abundant followed by Indian bison (15.84), barking deer (14.22), wild boar (5.13) and hog deer (2.93) in the study area (Fig. 4).

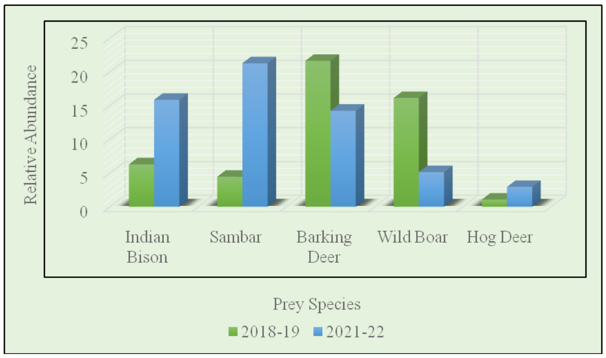

Fig. 4. Relative abundance of prey species in First Addition to Manas NP

Occupancy of Predator Species

As per the best model for occupancy *Psi*estimation of predators' anthropogenic disturbances, livestock grazing pressure, vegetation classes and distance to human settlements were considered as co-variates (Table 2) and for detection probability *p* was constant.

Tiger

The naïve occupancy (*Psi*) that is generated without using the capture-recapture framework, was found to be 0.3412 of the sampled area detected to have tiger. By correcting for the non-detection final parameter of occupancy (*Psi*) was estimated to be 0.5482 (SE = 0.046). From the coefficients of the best model (Table 3), it is clear that distance to human settlement, anthropogenic disturbance and livestock grazing had a negative effect on the presence of tigers while the abundance of grassland habitat and me-

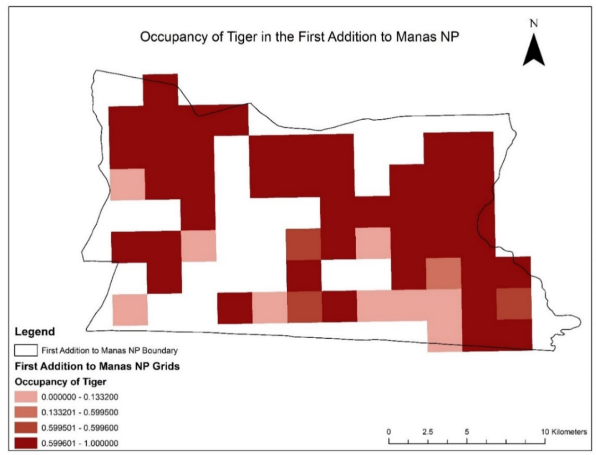

Fig. 5. Predicted occupancy model of tiger presence in the First Addition to Manas NP

Table 2. Different co-variates considered for occupancy analysis of predator and prey

Assigned No.	Co-variate Type	Assigned No.	Co-variate Type
1	Disturbance: Anthropogenic	6	Vegetation: Grassland
2	Disturbance: Grazing	7	Vegetation: Riverbed
3	Vegetation: Dense Forest	8	Settlement: Distance Less
4	Vegetation: Medium Dense Forest	9	Settlement: Distance Medium
5	Vegetation: Open Forest	10	Settlement: Distance Far

Table 3. Coefficient of the best model explaining occupancy of tiger in the study area

Variables	Estimate	Standard Error (SE)
A1 psi	-154.64	2.18
A2 psi.Disturbance_Anthropogenic	23.37	7.79
A3 psi.Disturbance_Grazing	26.70	7.60
A4 psi.Vegetation_Class_Dense_Fores	2.28	4.15
A5 psi.Vegetation_Class_Medium_Dens	103.68	2.90
A6 psi.Vegetation_Class_Open_Forest	2.28	2.98
A7 psi.Vegetation_Class_Grassland	144.35	3909.88
A8 psi.Vegetation_Class_Riverbed	73.87	50987.91
B1 P [1]	-0.95	0.20

dium canopied forest habitat had a positive effect. The conditional occupancy model of tiger presence in the study area is shown in the figure (Fig. 5). Here the occupancy is predicted based on the attributes of covariates for each sampled grid and capture histories, the model predicts occupancy estimates as shown.

Leopard

The naïve occupancy (*Psi*) that is generated without using the capture-recapture framework, was found to be 0.1647 of the sampled area detected to have leopard. By correcting for the non-detection final parameter of occupancy (*Psi*) was estimated to be 0.2320 (SE = 0.051). From the coefficients of the best model (Table 4), it is clear that human disturbance has a negative relation with the presence of leopards in the study area. The conditional occupancy model of leopard presence in the study area is shown in the figure (Fig. 6). In this map, the grid where the leopard was detected was assigned a score of 1. In grids where the leopard was not detected the occupancy is considered as the *Psi* value estimated by the occupancy model. The map uses predictive values for un-detected grids. The map helps in understanding the status of associated covariates in the undetected grids.

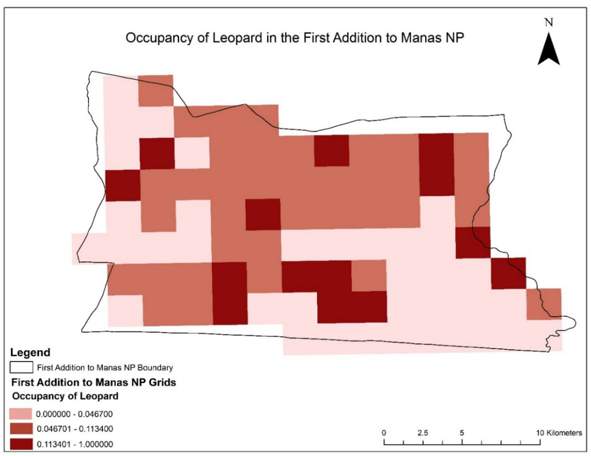

Fig. 6. Predicted occupancy model of leopard presence in the First Addition to Manas NP

Dhole

The naïve occupancy (*Psi*) that is generated without using the capture-recapture framework, was found to be 0.1765 of the sampled area detected to have dhole. By correcting for non-detection, the final parameter of occupancy (*Psi*) was estimated to be 0.3986 (SE = 0.1856). From the coefficients of the best model (Table 5), it is clear that anthropogenic disturbance and open forest has a negative relation with the presence of dhole, while the riverbed and dense canopied forest habitat had positive effects on it. The conditional occupancy model of dhole presence in

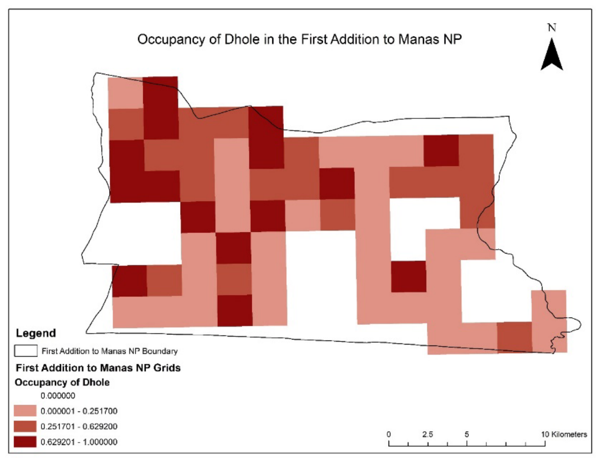

Fig. 7. Predicted occupancy model of dhole presence in the First Addition to Manas NP

Table 4. Coefficient of the best model explaining occupancy of leopard in the study area

Variables	Estimate	Standard Error (SE)
A1 psi	-0.82	0.48
A2 psi.Disturbance_Anthropogenic	-0.96	0.69
B1 P [1]	-0.67	0.45

Table 5. Coefficient of the best model explaining dhole occupancy in the study area

Variables	Estimate	Standard Error (SE)
A1 psi	-0.50	0.88
A2 psi.Vegetation_Class_Open_Forest	-25.77	112685.36
A3 psi.Vegetation_Class_Riverbed	1.62	1.59
B1 P [1]	-1.54	0.60

the study area is shown in the figure (Fig. 7). In this map, the grid where the dhole was detected was assigned a score of 1. In grids where the dhole was not detected the occupancy is considered as the *Psi* value estimated by the occupancy model. The map helps in understanding the status of associated covariates in the undetected grids.

Discussion

Our study interprets the results of predator relative abundance where their population has increased from the results obtained in 2018-19. Unique tiger photo-capture has increased from one individual in 2018 to eight in the present study. The pattern of relative abundance of the prey species also showsa population increase of Indian bison, sambar and hog deer in contrast to barking deer and wild boar only. Further, the study also reveals that distance to human settlement, anthropogenic disturbance and livestock grazing had a negative impact on the presence of both predator and prey populations in the study area. The multifaceted protection measures and conservation strategies implemented by the forest department, eco-development committees and local community-based organizations including the other conservation organizations working in that area have collaboratively contributed to improving the population status of the predator and prey species; and havethe potential for further growth with some scientific and managerial inputs especially improved enforcement in the First Addition to Manas NP.

Currently, improved enforcement and habitat improvement plans are very crucial in recovering the population status of the highly threatened greater one-horned rhino (*Rhinoceros unicornis*), eastern swamp deer (*Rucervusduvauceliiranjitsinhi*), pygmy hog (*Porculasalvania*), hispid hare (*Caprolagushispidus*) and Bengal florican (*Houbaropsis bengalensis*) in the First Addition to Manas NP. The spectacular scenic beauty already exists in the landscape like the Manas NP. The habitat of the area has a very good potential for harboring tiger population. It is evident from our results that the density of tigers was 2.29 individuals per 100 sq. km in the First Addition to Manas NP while as per the 2022 country-level assessment of tigers, the density was assessed as 11.4 tigers per 100 sq.km. in Manas NP and 13.06 tigers per 100 sq. km. in Kaziranga NP of Assam (Qureshi *et al*., 2023). Hence, the improvement of the top predators and their prey species as well as other wildlife population and their habitats will enable the area to serve as an extension of the existing Manas World Heritage Site in the near future for its integrity and long-term viability of the property as suggested by the UNESCO World Heritage Committee (UNESCO, 2011).

Of the five wild ungulate species found in the park, large-sized ungulates *viz*., Indian bison and sambar were more abundant which are known to contribute greatly to the diet of tigers (Hayward *et al*., 2012). Goswami and Ganesh (2014) reported a very low density of the predatorand prey species immediate aftermath of ethno-political conflict in Manas NP. However, with the focused conservation strategies, strengthening law enforcement, community engagement and transboundary initiatives with Bhutan have contributed in the recovery of the population status of both top predators and their prey species in the park (Lahkar *et al*., 2020; Islam *et al*., 2022; Qureshi *et al*., 2023). It is also very important that conservation initiatives targeting the recovery of tigers should be preceded by careful examination of interspecific interactions with sympatric carnivores. Maintaining population viability and resilience will depend upon a landscape approach to manage tigers as a metapopulation. Thus, both site-level protection and landscape-scale interventions to secure habitat corridors are simultaneously very essential (Wikramanayake *et al*., 2011). Furthermore, proper practices of grassland habitat management and their regular burning will arrest succession and will provide quality foods to sustain a sufficient stock of prey species and particularly the grazers in the First Addition to Manas NP (Moe and Wegge, 1997; Lahkar *et al*., 2020).

There is another scope of species' migration and transfer of gene pool from the contiguous Royal Manas NP of Bhutan as it is a hot spot of wild felids (Tempa *et al*., 2013; Tshering and Nidup, 2017). Our focus of any conservation action must be towards a balanced ecosystem with its ecological functionality in the landscape. Long-term ecological monitoring and gathering information is extremely useful for implementing such focused and effective conservation actions for improvement in the conservation strategies, ecosystem restoration and sustainable management of natural resources in a landscape (Jones *et al*., 2013; Stephenson *et al*., 2022). Each natural World Heritage site is unique and so too is the range of ecosystem services and benefits it delivers to people at different scales in terms of carbon sequestration, water provision, soil stabilization, flood prevention, recreation and tourism, employment generation, and more significantly biodiversity conservation of being outstanding universal values (Osipova *et al*., 2014). Therefore, the UNESCO World Heritage Committee recommends the States Parties of India and Bhutan to further strengthen their cooperation for better protection of the flagship species moving across national boundaries between the property and the adjacent Royal Manas NP. The committee also reiterates the importance of the conservation of the larger landscape for the integrity and long-term viability of the property, notably to increase its adaptability to climate change (UNESCO, 2021).

Conclusion

Our analysis shows that the establishment of a protected area and the subsequent multifaceted conservation strategies and protection measures have been successful in conserving biodiversity in general and particularly improving the population status of predator and prey species in the First Addition to Manas NP. Recovery of the population status of both top predators and their prey including other wildlife species and enhancement of their habitat conditions with the focused conservation strategies, strengthening law enforcement, community engagement and transboundary initiatives with Bhutanwill definitely improve ecosystem functionality in the First Addition to Manas NP and will maintain the integrity of the landscape with the existing Manas WHS in the east and Royal Manas NP of Bhutan in the north. The UNESCO World Heritage Committee reiterates conducting a joint feasibility study on a possible transboundary extension of the Manas WHS with the State Party of Bhutan realizing the importance of the conservation of this larger landscape for the integrity and long-term viability of the property as well as to increase its resilience to the climate crisis.

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Author Contributions

NI, RB, SD, SKS and RK conceived the ideas and designed the methodology; NI collected the data; NI and SKS analyzed the data; RB and RK led the writing of the manuscript. All authors contributed critically to the drafts and gave final approval for publication.

Conflict of Interest

The authors have no conflicts of interest to declare.

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