Transboundary Tiger Conservation in Indo-Bhutan Barnadi-Jomotshangkha Forest Complex.

[Final Technical Report]

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Executive Summary

The Transboundary Manas Conservation Area (TraMCA) between India and Bhutan is one of the significant tiger conservation landscape in the tiger range countries. It is part of the global 'Tiger Conservation Landscapes' (TCL #37: Northern Forest Complex-Namdapha-Royal Manas) for securing metapopulation of tigers in the long run. The TraMCA constitutes of over 6500 sq km of forests protected conservation areas on either side of the international boundary of India and Bhutan, spreading from River Sankosh on the west to the River Dhansiri on the east. On the western edge, starting from Ripu and Chirang Reserve Forest, through First Addition to Manas National Park (notified as National Park in 2016), Manas National Park, extend to the Barnadi Wildlife Sanctuary and Khalingduar Reserve Forest along with several smaller reserve forests flank on the Indian side, while on Bhutan side, Phipshoo Wildlife Sanctuary, Royal Manas National Park, Jomotsangkha Wildlife Sanctuary and network of designated Biological Corridors constitutes TraMCA. Both the Manas National Park (MNP) in India and Royal Manas National Park (RMNP) in Bhutan hold significant tiger source population (See Figure-1) while information on other sites is being generated.

The transboundary core areas are being evaluated for tiger conservations by tranboundary institutions lead by government and nongovernment through joint scientific monitoring of tigers initiated since 2010 between RMNP and MNP. However, this is the first attempt in which we explored the Indo-Bhutan Jomotsangkha-Barnadi forest complex comprising contiguous protected areas falling on the eastern edge of TraMCA. The results of the present study bring significant baseline information for future study and evaluation of the conservation efforts in the forest complex. Apart from that, the present study would help in preparing revise management plan for the Jimotsangkha Wildlife Sanctuary on Bhutan counterpart and Dhansiri division on Indian counterpart.

During 2017 and 2018 followed by two camera trapping sessions and combined efforts of 6270 trap–days, we obtained 16152 photographs of mammals from which, 27 are ground doweling mammal species belonging to 14 families. These include one Critically Endangered, three Endangered, six Vulnerable, four near threatened and 13 Least Concern as per IUCN RedList (IUCN, 2017). The study, among carnivores, recorded six species of Felides (Common Leopard *Panthera pardus*, Clouded Leopard *Neofelis nebulosa*, Marbled Cat *Pardofelis marmorata*, Leopard Cat *Prionailurus bengalensis*, Jungle Cat *Felis chaus*and Golden Cat *Catopuma temminckii*), and one species of Canidae (Wild Dog *Cuon alpinus*). Three species of Cervidae (Sambar *Cervus unicolor*, Hog Deer *Axis porcinus* and Barking Deer *Muntiacus muntjak*), three species of Bovidae (Gaur *Bos gaurus*, Himalayan Serrow *Capricornis thar* and Goral *Naemorhedus goral*) were recorded during the study period that comprises prey animals. The study also recorded relative abundance of the species photo-trapped signifying outstanding biodiversity and richness of the forest complex.

The study observed that the Barnadi-Jomotsangkha forest complex could be flagged as a core area on the eastern part of the TraMCA to strengthen conservation of tigers and prey animals. However it would requires considerable improvement of law enforcement along with community engagement to achieve such a goal in the long term. Strategic cooperation and collaboration between the government institutions of Bhutan and India would hold key to desired success of conservation in the forest complex.

The Bhutan government has strongly committed for conservation of the Jomotshankha WLS by expanding the area of the protected area by 925 sq km to the existing 335 sq km. We strongly recommend that Government of Assam also take similar actions to notify Khaling and

Bhairabkunda Reserve Forests as Wildlife Sanctuary on Indian side to ensure better law enforcement and protection of these forest complexes as one unit of transboundary forest.

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1. Introduction

Over the last 100 years, Tiger (*Panthera tigris*) has lost their 93% population in Asia (Wolf & Ripple 2017) and population is continued to be decline despite of massive conservation initiatives throughout its range countries. Exploring potentiality of tiger conservation across landscape, connectivity between two source sites and measuring threats are the key for any management intervention.

The Transboundary Manas Conservation Area (TraMCA) across the international boundary of India and Bhutan, is a significant tiger habitat that has potential to double its tiger population within a decade (Ahmed *et al.* 2016). The TraMCA with an area of over 6500 sq km spans from the river Sankosh, the western boundary of Manas Tiger Reserve, India to the Jomotsangkha Wildlife Sanctuary, Bhutan to the east. To the south it extends to the southern boundary of the Manas Tiger reserve (MTR) in India and to the north, the northern extend of the Royal Manas National Park (RMNP) in Bhutan.

A combined record of the TraMCA indicate the local species composition includes more than 65 species of mammals, over 500 species of birds and more than 1000 species of plants(Ahmed *et al.* 2016). Key species include Tiger, Elephant, Pigmy Hog, Bengal Florican, Clouded Leopard, Common Leopard, Gaur, etc.

Recognizing the importance of transboundary level approach in protecting the biodiversity in these highly diverse ecosystems across the international boundary between India and Bhutan, TraMCA was conceptualised in the years 2011 under the 'Living Himalayas Initiative'. The joint transboundary tiger monitoring study which started in 2011 is a paradigm of a successful transboundary conservation effort to safeguard tiger population across TraMCA. Studies carried out on tigers, co-predators their prey animals, between 2011-2018 reveals that a total cumulative number of minimum 70 individual tigers have been identified in the TraMCA (Manas and Royal Manas NP) (Unpublished data from TraMCA landscape)..

While, transboundary tiger conservation focuses the Manas National Park and the Royal Manas National Park core, this study was designed to explore the status of tigers and habitats in a new underexplored area on the eastern part of the TraMCA, the Barnadi-Jomotsangkha transboundary area that has strong potential to be another core tiger habitat in the landscape. This study would significantly assist the protected area managers and government of the two countries to strengthen tiger and habitat conservation in areas beyond the Manas National Park-Royal Manas National Park core of the TraMCA. This study was a part of the initiatives of Transboundary Biodiversity Management (TBM) approach includes management of two or more contiguous protected areas across International political boundaries. It is also a global Tiger Conservation landscape (TCL # 37) (Northern forest Complex-Namdapha-Royal Manas) entity (Sanderson *et al.* 2006).

There was little systematic effort to study on tigers, co-predators and prey animals in this forest complex of the TraMCA except the Manas National Park and RMNP. With the photo-capture of an adult male tiger in 2016, confirmed record of tiger presence was established in the sanctuary. However, this study was the first opportunity to bring these transboundary conservation sites to the attention of conservationist and policymakers as another transboundary tiger conservation core area. Considering potential of doubling the tiger population in the TraMCA landscape, this study has helped in setting baseline and would significantly contribute in conservation of tigers in the landscape.

2. Study Area

2.1 TransboundaryManas Conservation Area (TraMCA)

TraMCA with an area of over 6500 sq.km is one of the three transboundary landscapes across the Eastern Himalayas that connect Bhutan with North East India (Figure-1). This transboundary landscape having unique biological significance, straddles the forest areas across the Indo-Bhutan international border. It spans from the River Sankosh, the western boundary of Ripu Reserve Forest as well as the Assam state on the west in India to the Jomotsangkha Wildlife Sanctuary in Bhutan to the east. To the south it extends to the southern boundary of the Manas Tiger reserve in India and to the north, the northern extent of RMNP in Bhutan. Thus, the TraMCA encompasses the whole of the Manas Tiger Reserve in India and the group of protected areas in southern Bhutan including the RMNP. The area is one of the richest biodiversity zones in the entire tropical Asia. The long term vision of conserving TraMCA landscape is to ensure better management of the ecosystems for the benefit of wildlife and people both in Bhutan and India.

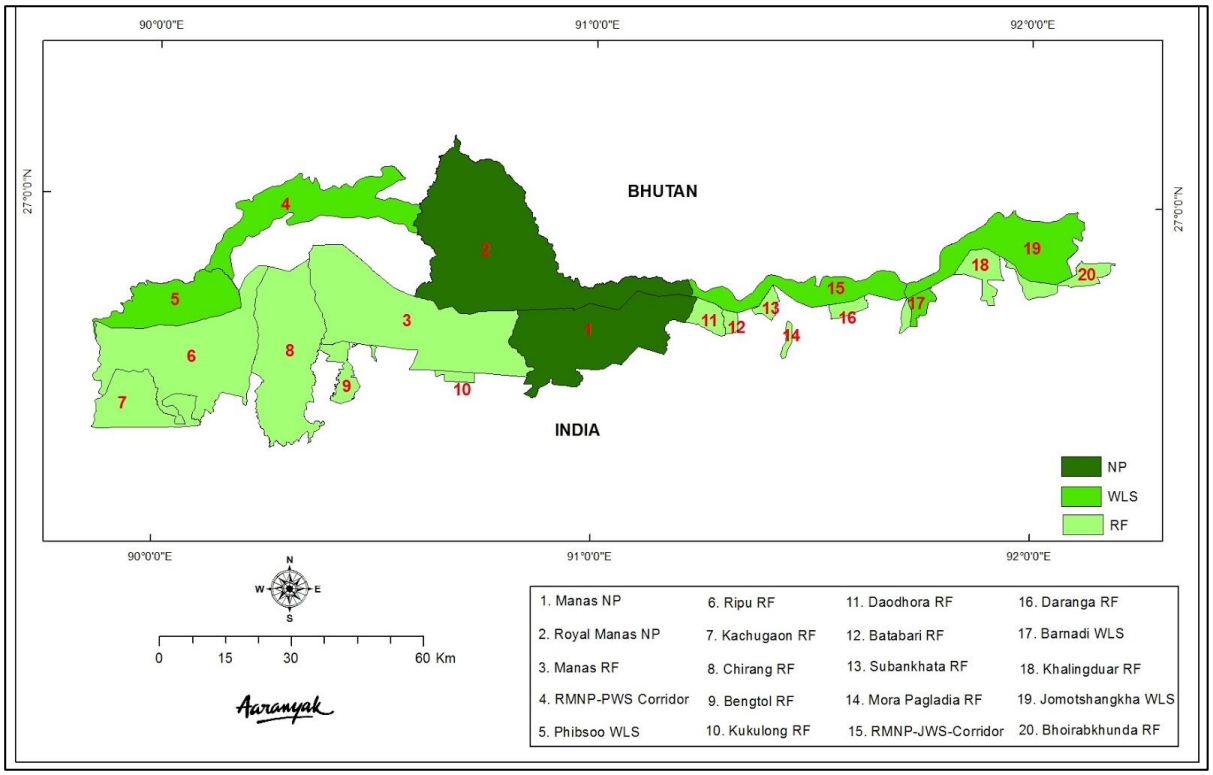


Figure-1: Map of the Transboundary Manas Conservation Area (TraMCA).

2.2 Jomotsangkha Wildlife Sanctuary (JWS), Bhutan

Jomotshangkha Wildlife Sanctuary (JWS) earlier known as Khaling Wildlife Sanctuary is one of the ten protected areas in Bhutan (Figure-2). The Sanctuary covers an area of 335sq.km and is situated in the south-easternmost part of the country. It is bordered by Udalguri district of Assam in the south and Arunachal Pradesh in the east. The altitude of the sanctuary ranges from 184 m to 2300 m above sea level.

The Sanctuary forms an important part of the Himalayan subtropical broad-leaved forest ecosystem which is an important element in the Himalayan Eco-region. The Sanctuary which encompasses only 3 types of vegetation as classified in viz., subtropical forest, warm broad leaved forests and cool broadleaved forests, classification along the altitudinal gradient houses a wide variety of plant species.

As the Sanctuary lies within the Indo-Bhutan border, it provides critical habitat for survival of several threatened species in both the countries. The sanctuary harbors a wide array of the endangered wildlife species such as the Royal Bengal Tiger (*Panthera tigris*), Common Leopard (*Panthera pardus*), the Himalayan Black Bear (*Selenarctos thibetanus*), Gaur (*Bos gaurus*), and Asiatic Wild Elephant (*Elephus maximus*). The Sanctuary is said to be the only habitat for the rare and endangered Pygmy hog (*Porcula salvania*) and the hispid hare (*Caprolagus hispidus*).

2.3 Barnadi Wildlife Sanctuary (BWS), India

Barnadi Wildlife Sanctuary (BWS) one of the protected areas falls under the TraMCA. It is located in the Baksa District of Assam (Figure-2). It was declared a wildlife sanctuary in 1980. It has a designation of an Important Bird Area (IBA). The river Barnadi forms the western boundary and Nalanadi River forms the eastern boundary of the sanctuary. The sanctuary lies in a *Bhabar* zone. So the area is mainly composed with sediments deposited by the river flowing through Bhutan (Sharma & Sharma 2008).

The vegetation is tropical semi-evergreen, tropical moist and dry deciduous type. The altitude ranges from 150– 200 m. Average annual rainfall is 400mm. Khalingduar RF, (70.33 sq.km 26052’14”N & 91053’01”E) is located in the Udalguri District. The altitude ranges from 250–450 m. The average annual temperatures range from about 80C in January to 300C in July. The vegetation is moist deciduous, semi-evergreen and mixed deciduous type. Neoli (11.48 sq.km) is a proposed reserve forest and lies between Barnadi WS and Khalingduar RF.

2.4 Khalingduar Reserve Forest (KRF), India

Khalingduar Reserve Forest (KRF) was notified on dated 17th October 1878 as reserve forest located in the Udalguri district of Assam under Dhansiri forest division, India. Total area of the KRF is 70.3 sq.km. The forest type of the reserve is semi evergreen forest.

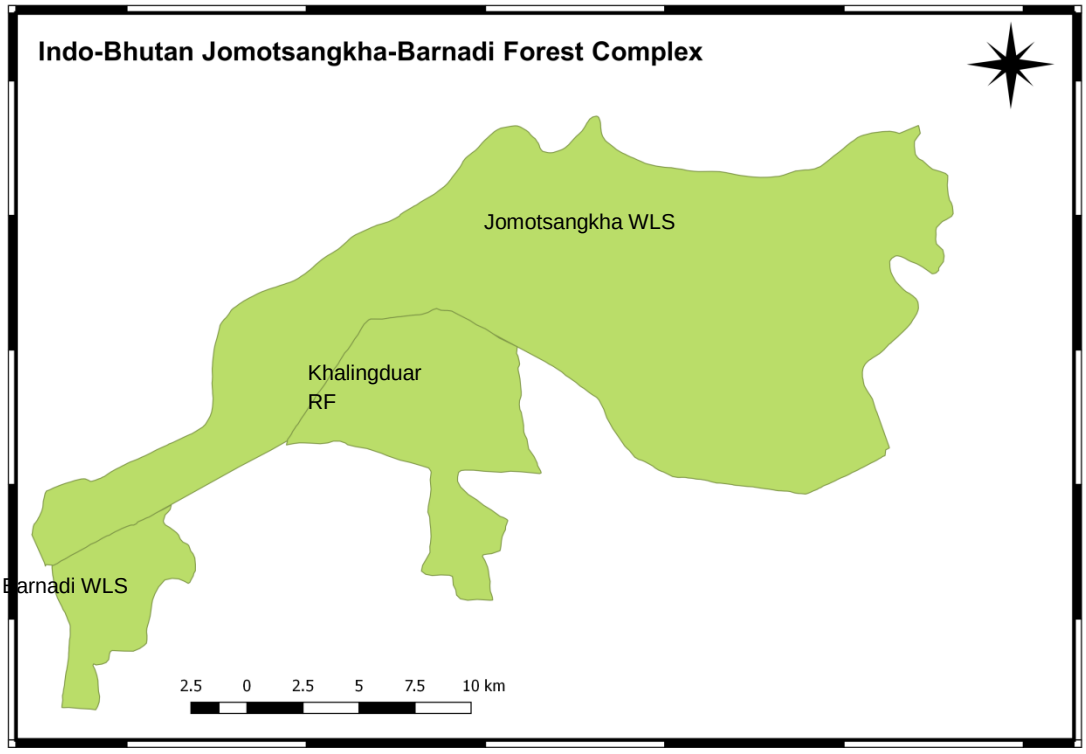


Figure-2: Map of the Study Area (Indo-Bhutan Jomotsangkha-Barnadi Forest Complex).

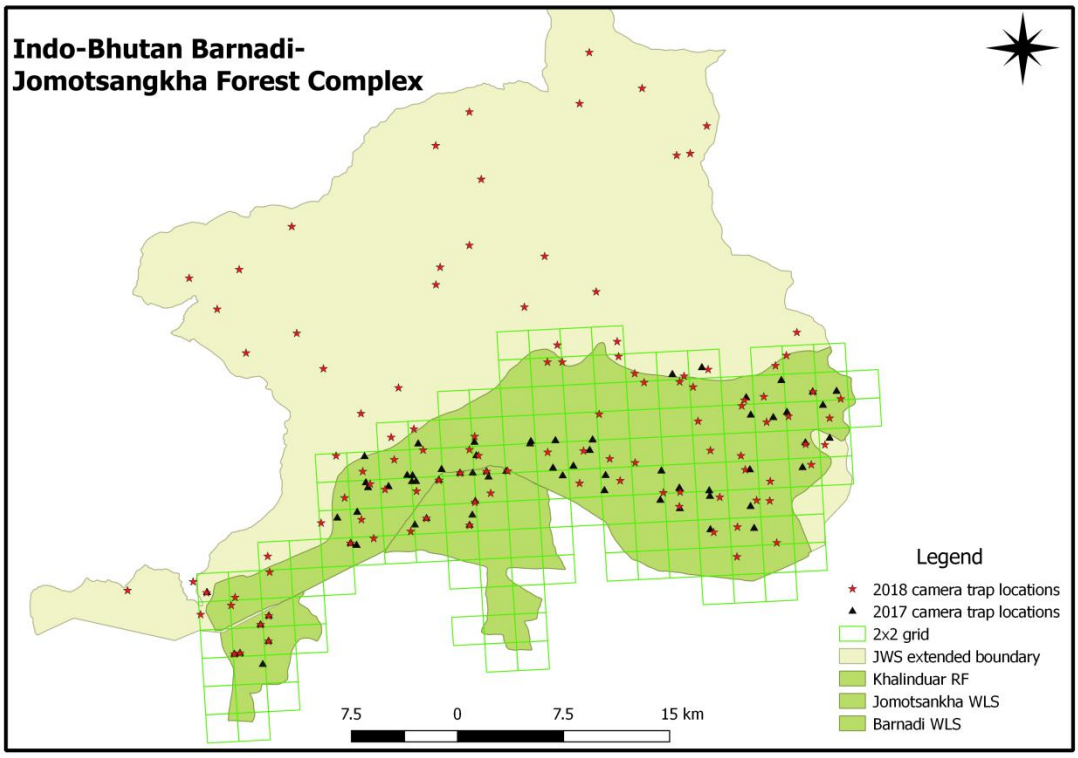


Figure-3: Map showing the camera trap locations (Indo-Bhutan Jomotsangkha-Barnadi Forest Complex) the red stars represented the camera trap locations for 2017 and black stars represented the camera trap locations for 2018.

3. Justification of the study

The existing collaboration between India and Bhutan partners in the TraMCA has helped in understanding the status of tigers, co-predators and prey animals in the transboundarycore are of the landscape, Manas National Park (MNP) and Royal Manas National Park (RMNP). While, transboundary tiger conservation focuses MNP-RMNP core, this study was designed to explore the status of tigers and habitats in a new underexplored area on the eastern part of the TraMCA, the Barnadi-Jomotsangkha transboundary forest complex that was believed to have strong potential to be another core tiger habitat for the landscape. This study has generated the much needed baseline to strengthen conservation approaches and would significantly assist the protected area managers, governments and NGO partners of the two countries to strengthen tiger and habitat conservation in areas beyond the MNP-RMNP core of the TraMCA.

4. Objectives of the Study

1. Understand status of Tigers, co-predators and prey animals in both the transboundary sites.

2. Assess habitat status and its connectivity across Transboundary conservation sites.

3. Evaluate threats to the tigers, co-predators and prey animals in the sites to recommend appropriate protection and conservation measures.

5. Methodology

5.1 Camera Trapping

5.1.1 Field Method

We conducted camera trapping survey in 2017 (17-03-2017 to 27-06-2017) and 2018 (27-01-2018 to 30-05-2018) covering the three study sites viz. Barnadi Wildlife Sanctuary and Khalingduar Reserve Forest in India and Jomotsangkha Wildlife Sanctuary in Bhutan. We used 4 sq. km 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.

We searched all possible animal trails, forest roads, dry river beds for the animal sign, and camera traps were placed at best location where animal concentration was high. On the hills we chose ridges to placed camera traps. The cameras were placed in steel cages customised specifically for the cameras to minimise the damage from wild animal. In 2017, camera traps were placed at 57 locations (Barnadi WLS= 06, Khalingduar RF= 09 and JWS= 42) and in 2018, camera traps were placed at 82 locations (Barnadi WLS= 05, Khalingduar RF= 09 and JWS= 68) (Figure-3). In 2018, we covered the extension areas of JWS with ad hock camera trapping (Figure-3).

We first downloaded photographs from all the trap stations across the park at regular intervals (usually once in a week in India and once in a month in Bhutan) 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.

5.1.2 Analytical method

5.1.2.1 *Photographic Capture Recapture Index$_1$ (PCRI$_1$)*

To calculate the Photo–Capture Rate Index (PCRI) of all species captured we first enumerated the number of independent captures (over 30-minutes apart for each station) of each species at each trap-location and estimated the capture rate given by the number of independent captures obtained divided by trap-effort standardized to 100 trap-days (Carbone *et al.*, 2001). We then divided the number of independent captures obtained at each trap by trap–specific effort 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).

5.1.2.2 *Photographic Capture Recapture Index $_2$ (PCRI$_2$)*

Photo–Capture Rate Index$_2$ (PCRI$_2$) was calculated to know number of trap-days required to get a single photo capture of a species. We first enumerated the number of independent captures (over 30-minutes apart for each station) of each species at each trap-location. To obtained PCRI$_2$ we divided total trapping efforts with the number of independent events for each species (Carbone *et al.*, 2001). Here we present PCRI$_2$ for major predators and their prey animals.

5.1.2.3 *Activity pattern of major prey and predators and their temporal overlap with threats*

Finally, To calculate the Photo–Capture Rate Index (PCRI) of all species captured we first enumerated the number of independent captures (over 30-minutes apart for each station) of each species at each trap-location and estimated the capture rate given by the number of independent captures obtained divided by trap-effort standardized to 100 trap-days (Carbone *et al.*, 2001). Then using package overlap (Meredith & Ridout 2014) in R (Team 2010), we generated the probability density function for each of the species and referred to them as the activity pattern (Ridout & Linkie 2009; Linkie & Ridout 2011). As we were interested in understanding how temporal activity patterns of major prey and predator species responded to anthropogenic activity within the study area, we measured overlap between two estimated probability density functions (e.g. threat−sambar). We estimated the coefficient of overlap (Δ_4 and Δ_1), ranging from 0 (no overlap) to 1 (complete overlap). Confidence intervals at 95% were obtained as percentile intervals from 1000 bootstrap samples.

5.2 *Assessing Habitat Connectivity Across Transboundary Landscape*

To evaluate potential connectivity between tiger populations in the region, we implemented an analysis using CIRCUITSCAPE v.4. Circuit theory, unlike least-cost path modelling procedures, identifies more than one movement route across a landscape imposing differential costs of movement. We used Human Footprint Index (http://wcshumanfootprint.org/) to map the permeability of tigers across the landscape.

6. Results

6.1 *Camera Trapping Efforts*

Camera traps were deployed mainly during the winters in both 2017 and 2018. As the study was a joint initiative of teams from Bhutan and India, we synchronise the study on both the years on either side of the international border. A cumulative of 57 and 82 locations were camera trapped during 2017 and 2018 respectively (Table-1). In 2018, we placed camera traps in the newly extended areas in the JWS. The total survey effort was calculates 2816 and 3197 trap-days in 2017 and 2018 respectively (Table-2).

Table-1: Trans-boundary camera trapping effort in 2017 and 2018 in Indo-Bhutan Barnadi-Jomotsangkha Forest complex

Catagory	**2017**	**2018**
Grid size	4 sq km	4 sq km
Duration	103 days	124 days
Efforts	2816 trap-days	3197 trap-days
Area Sampled	348 sq.km	451 sq.km
Type of Camera trap used	Panthera (V4 and V5)	Panthera (V4 and V5)
Total camera trap stations	57	82
Teams Involved	4 teams	6 teams
Total camera trap used	68	82
Total camera trap stollen	5	9

Table-2: Site wise camera trapping efforts in Indo-Bhutan Barnadi-Jomotsangkha Forest complex during 2017 and 2018.

Category	**Barnadi WLS**		**Khalingduar RF**		**JWS**	
	2017	**2018**	**2017**	**2018**	**2017**	**2018**
Duration	52	63	52	64	103	124
Total camera trap stations	06	05	09	09	42	68
Efforts	298	260	357	379	2161	2617

6.2 *Camera Trapping Activity*

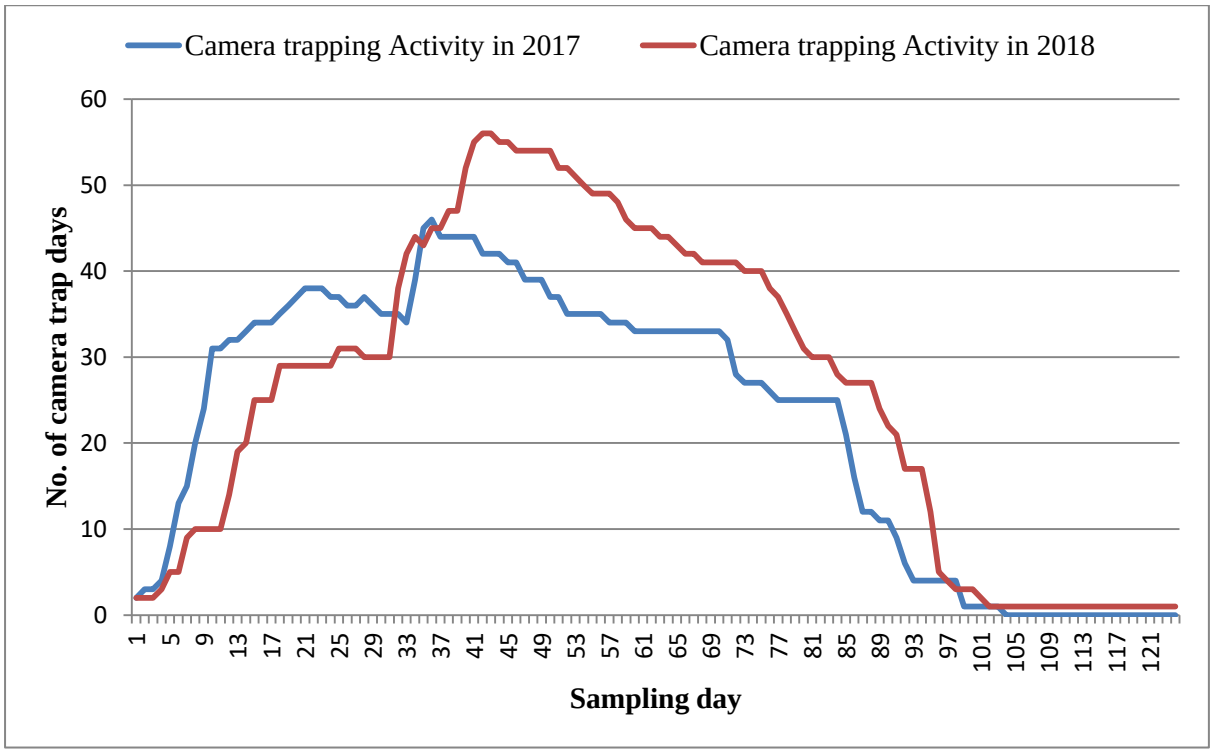


Figure-4: Graph showing activities of different camera trap stations in Indo-Bhutan Barnadi-Jomotsangkha Forest complex.

Figure-5: A Panther V4/V5 model Camera traps used during the study.

6.3 *Species Assemblage*

Following a camera trapping effort of 6270 trap–days in both 2017 and 2018 across the study area, we obtained 16152 photographs of mammals (6162 mammal images in 2017 and 9990 mammal images in 2018) from which, we identified 27 mammal species belonging to 14 families. Of these one is Critically Endangered, three are Endangered, six are Vulnerable, four near threatened and 13 Least Concern (IUCN 2018). The species diversity is presented in Table-3.

Among carnivores, six species of Felides (Common Leopard *Panthera pardus*, Clouded Leopard *Neofelis nebulosa*, Marbled Cat *Pardofelis marmorata*, Leopard Cat *Prionailurus bengalensis*, Jungle Cat *Felis chaus*and, Golden Cat *Catopuma temminckii*), one species of canidae (Wild Dog *Cuon alpinus*). In addition, among prey animals, three species of Cervidae (Sambar *Cervus unicolor*, Hog Deer *Axis porcinus* and Barking Deer *Muntiacus muntjak*), three species of Bovidae (Gaur *Bos gaurus*, Himalayan Serrow *Capricornis thar* and Goral *Naemorhedus goral*) were photo captured during the study.

In addition to that four species of primates viz Rhesus Macaque (IUCN status: Least Concern), Capped Langur (IUCN status: Vulnerable), Arunachal Macaque (IUCN status: Endangered) and Assamese Macaque (IUCN status: Near Threatened), one species of deer, Himalayan Musk Deer (IUCN status: Endangered), Spotted Linsang (IUCN status: Least Concern) and Himalayan Giant Squirrel (IUCN status: Near threatened), were also photo captured during the study (IUCN 2017).

The results of Photographic Capture Rate Index (PCRI) show that among the ungulates PCRI of Sambar *Cervus unicolor* was found highest followed by Barking deer *Muntiacus muntjak* and Gaur *Bos gaurus*. In carnivores, the PCRI of Common Leopard *Panthera pardus* was highest follow by Leopard Cat *Prionailurus bengalensis*. In general photographic capture rate of Sambar was found highest in both the years followed by Gaur, Barking Deer, Indian Elephant and Wild Pig.

In addition to that we also mapped the spatial variation in photo-capture rates across the study area (Figure-6a-e). We did not fine much difference in the spatial capture pattern in any of the recorded species.

Table-3: Summary of mammal species recorded using camera trap in Indo-Bhutan Barnadi-Jimotsankha Forest complex.

Sl. No.	Family	Common Name	Scientific Name	IUCN category	PCRI (CI 95%) 2017	PCRI (CI 95%) 2018
1	Bovidae	Goral	*Naemorhedus goral*	NT	0.19 (0.0-0.51)	0.18 (0.00-0.54)
2	Bovidae	Himalayan Serrow	*Capricornis thar*	NT	0.40 (0.15-0.67)	0.61 (0.26-1.0)
3	Bovidae	Gaur	*Bos gaurus*	VU	6.31 (4.04-8.59)	8.21 (4.17-12.25)
4	Canidae	Dhole	*Cuon alpinus*	EN	0.16 (0.01-0.31)	2.26 (0.00-5.04)
5	Cervidae	Barking Deer	*Muntiacus muntjak*	LC	6.58 (4.12-9.03)	8.6 (7.4-9.9)
6	Cervidae	Hog Deer	*Axis porcinus*	EN	0.06 (0.0-0.16)	0.17 (0.00-0.35)
7	Cervidae	Sambar	*Cervus unicolor*	VU	11.34 (3.87-18.7)	13.28 (0.00-28.6)
8	Elephantidae	Elephant	*Elephas maxima*	EN	4.53 (2.49-6.57)	3.67 (2.05-5.29)
9	Felidae	Marbled Cat	*Pardofelis marmorata*	NT	0.10 (0.0-0.23)	N/A
10	Felidae	Clouded Leopard	*Neofelis nebulosa*	VU	0.14 (0.01-0.27)	0.12 (0.03-0.22)
11	Felidae	Leopard Cat	*Prionailurus bengalensis*	LC	1.06 (0.53-1.58)	
12	Felidae	Common Leopard	*Panthera pardus*	VU	1.64 (0.84-2.44)	1.17 (0.13-2.21)
13	Felidae	Golden Cat	*Catopuma temminckii*	NT	0.04 (0.0-0.12)	N/A
14	Felidae	Jungle Cat	*Felis chaus*	LC	N/A	0.07 (0.0-0.21)
15	Herpestidae	Crab-eating Mongoose	*Herpestes urva*	LC	1.09 (0.38-1.81)	0.25 (0.0-0.50)
16	Hystricidae	Brush-tailed porcupine	*Atheurus macrourus*	LC	0.07 (0.0-0.21)	N/A
17	Hystricidae	Crestless Porcupine	*Hystrix brachyura*	LC	1.07 (0.49-1.66)	0.64 (0.13-1.14)
18	Leporidae	Indian Hare	*Lepus nigricollis*	LC	0.10 (0.0-0.25)	
19	Manidae	Chinese Pangolin	*Manis pentadactyla*	CR	1.07 (0.49-1.66)	N/A
20	Mustelidae	Large-toothed Ferret Badger	*Melogale personata*	LC	0.04 (0.0-0.12)	N/A
21	Mustelidae	Yellow-throated Marten	*Martes flavigula*	LC	0.51 (0.19-0.84)	0.17 (0.02-0.30)
22	Suidae	Wild Pig	*Sus scrofa*	LC	3.49 (2.07-4.89)	5.26 (1.01-9.55)
23	Ursidae	Himalayan Black Bear	*Urus thibetanus*	VU	0.65 (0.27-1.01)	0.22 (0.05-0.40)
24	Viverridae	Large Indian Civet	*Viverra zibetha*	LC	0.23 (0.0-0.48)	0.14 (0.00-0.33)
25	Viverridae	Binturong	*Arctictis binturong*	VU	0.26 (0.0-0.5)	N/A
26	Viverridae	Common Palm Civet	*Paradoxurus hermaphroditus*	LC	1.65 (0.36-2.94)	0.19 (0.00-0.44)
27	Viverridae	Himalayan Palm Civet	*Paguma larvata*	LC	N/A	0.10 (0.00-0.22)

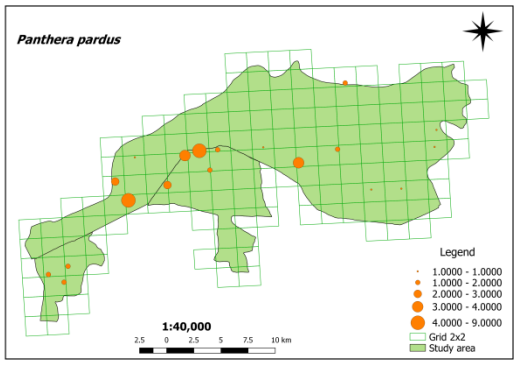
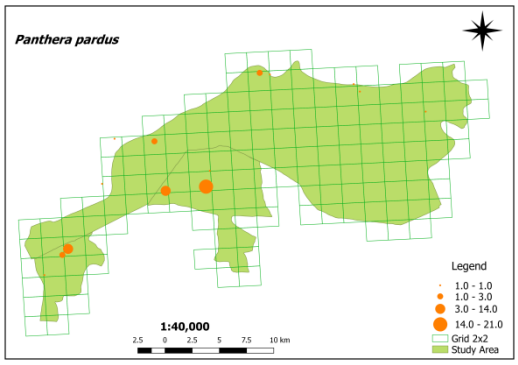
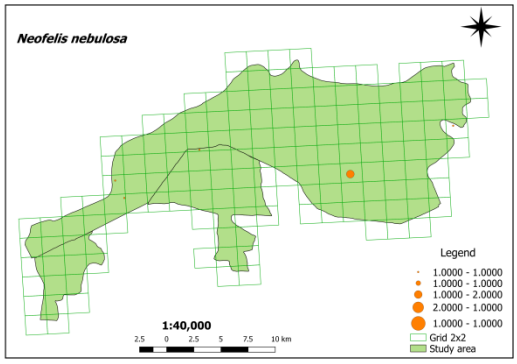
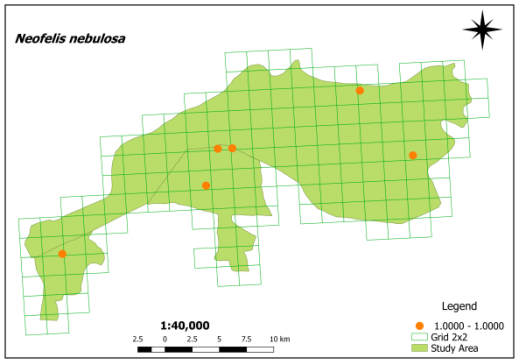
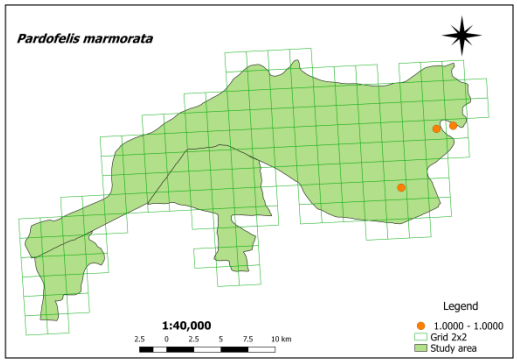
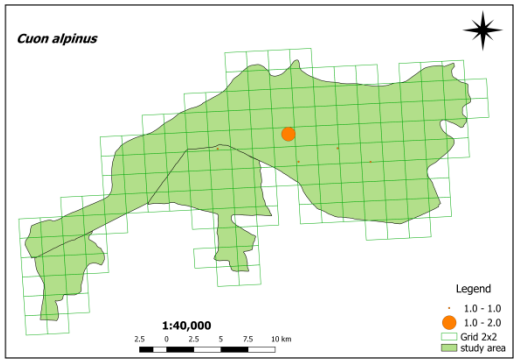
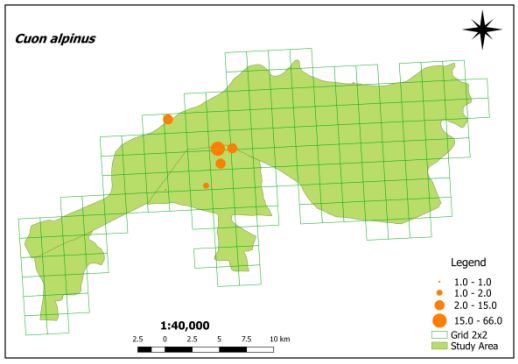
Session 2017	Session 2018
	
	
	
	

Figure-6a: Photographic capture rate index of the mammalian prey species of Indo-Bhutan Barnadi-Jomotsangkha Forest complex.

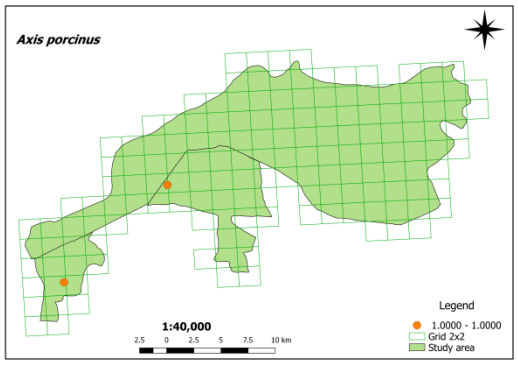
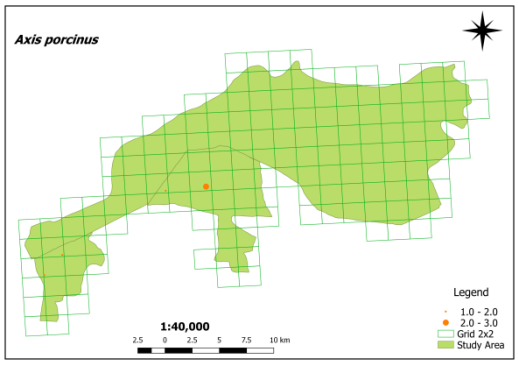
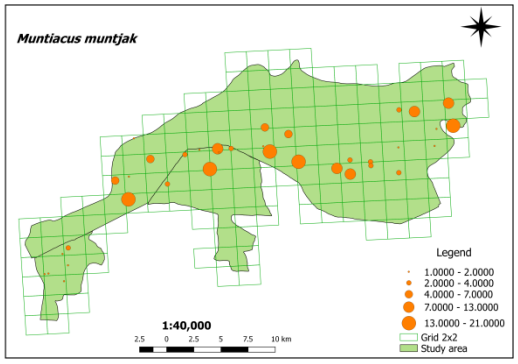
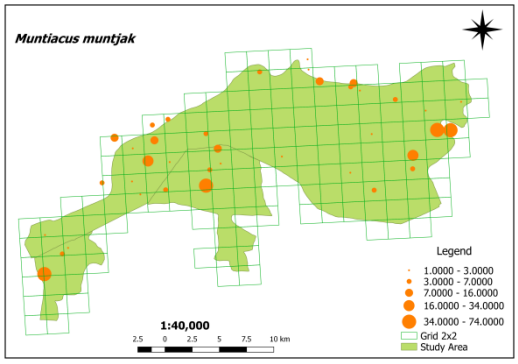
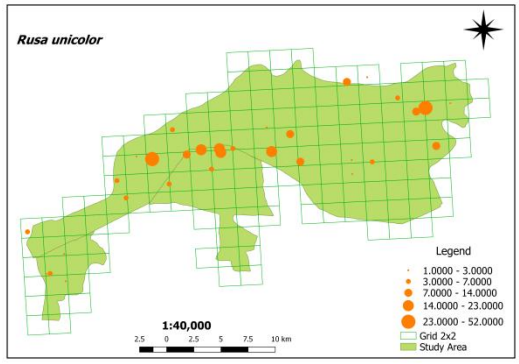
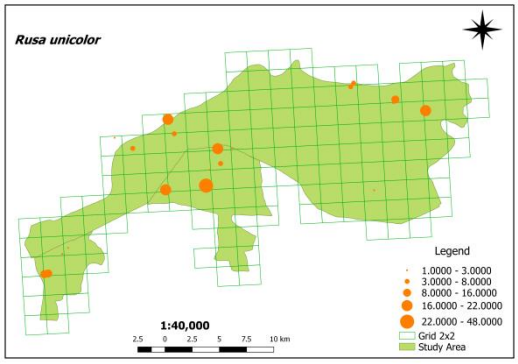
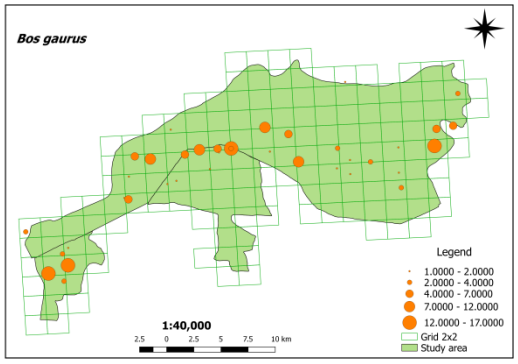
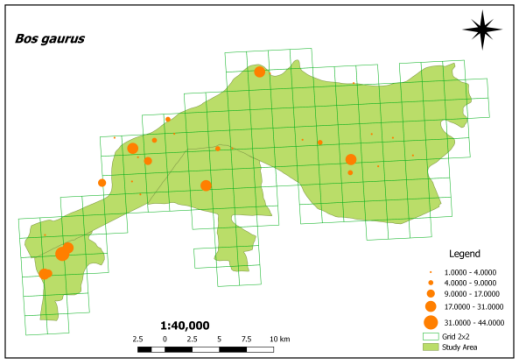
Session 2017	Session 2018
	
	
	
	

Figure-6b: Photographic capture rate index of the mammalian prey species of Indo-Bhutan Barnadi-Jomotsangkha Forest complex.

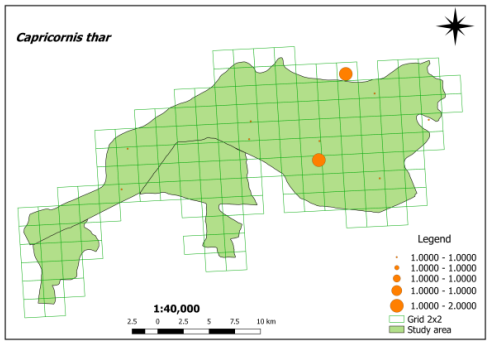
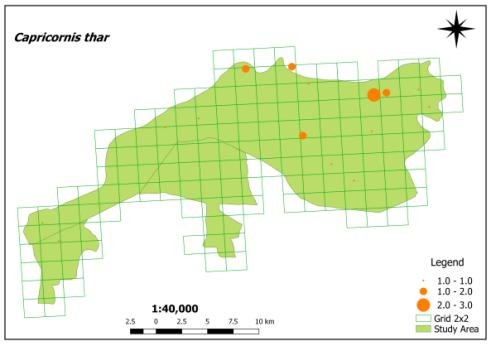
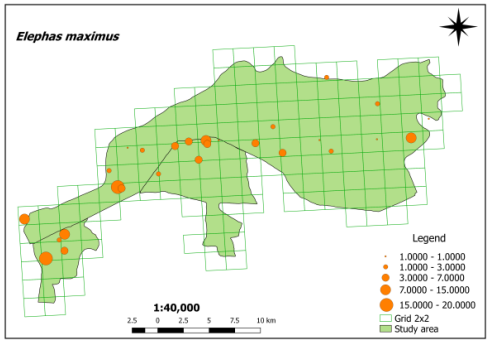
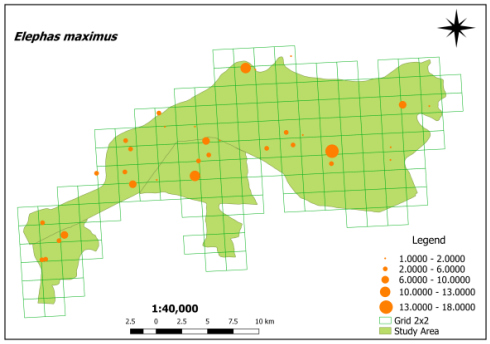
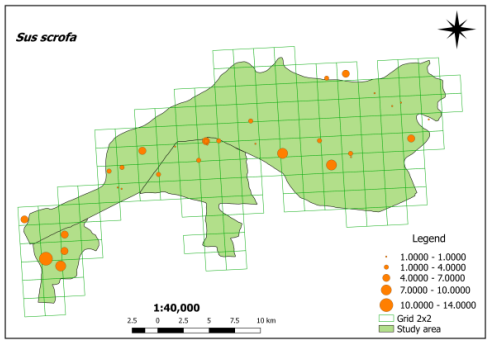
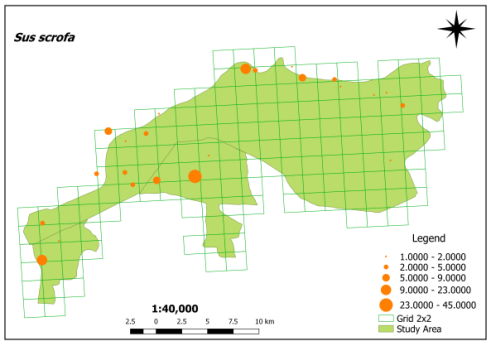
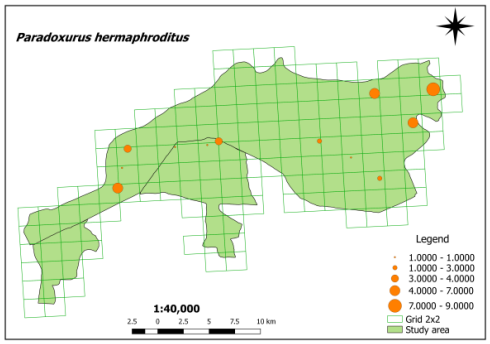
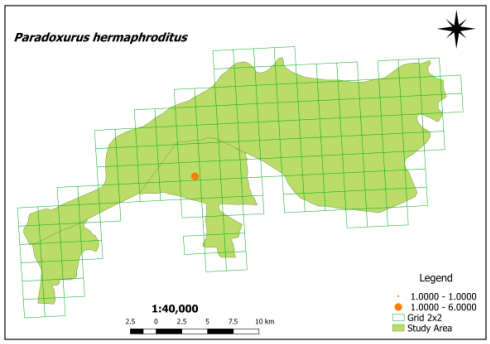
Session 2017	Session 2018
	
	
	
	

Figure-6c: Photographic capture rate index of the mammalian prey species of Indo-Bhutan Barnadi-Jomotsangkha Forest complex.

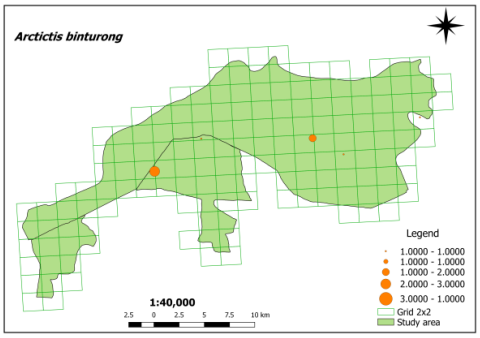
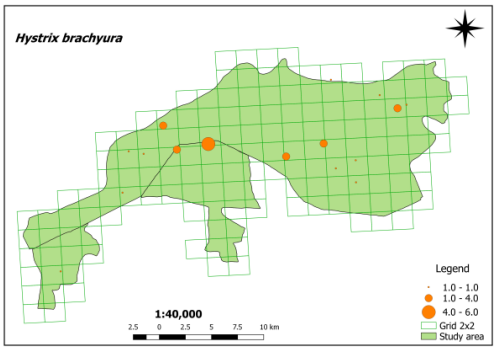
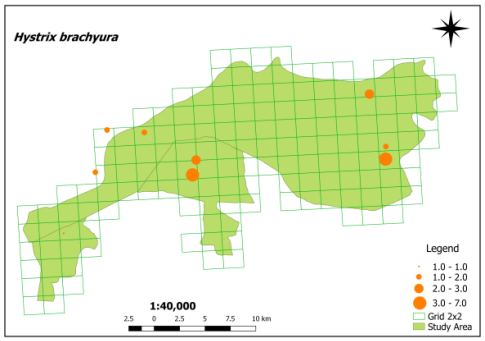
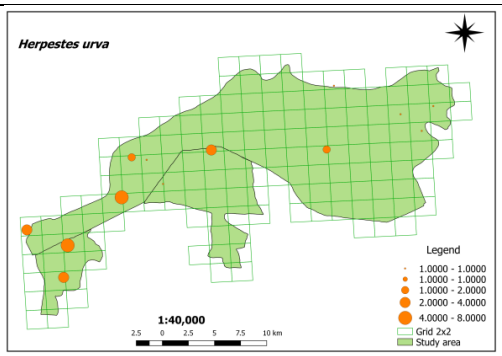
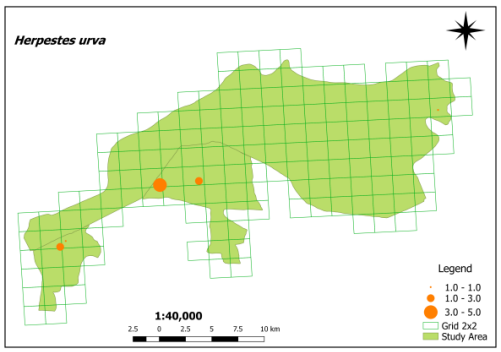
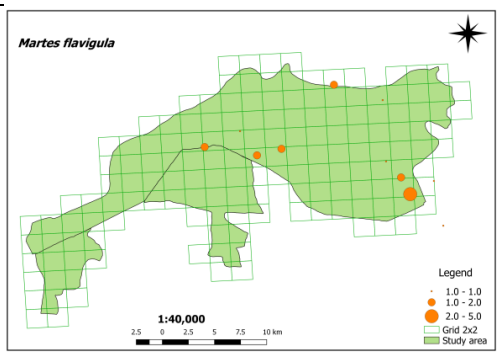
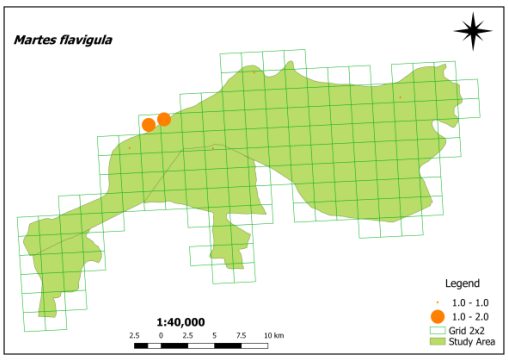
Session 2017	Session 2018
	
	
	
	

Figure-6d: Photographic capture rate index of the mammalian prey species of Indo-Bhutan Barnadi-Jomotsangkha Forest complex.

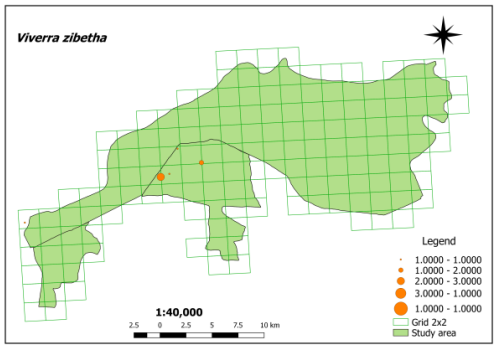
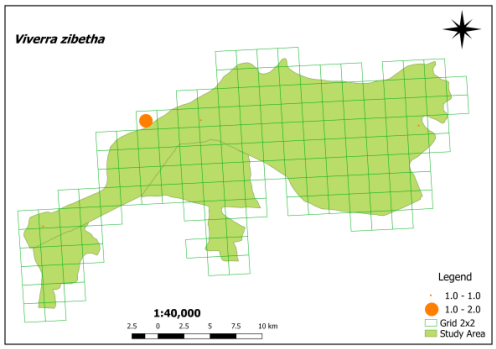
Session 2017	Session 2018
	

Figure-6e: Photographic capture rate index of the mammalian prey species of Indo-Bhutan Barnadi-Jomotsangkha Forest complex.

6.4 *Photographic Capture Recapture Index $_2$ (PCRI$_2$)*

In case of prey animals, Barking deer, Gaur and Wild pig the estimated RAI_2 was reduced to 7, 11 and 21 respectively in 2018, but did not get significant charges over two years ($p<0.05$) (Figure-7). The estimated RAI_2 of Common leopard and Leopard cat was increased from 52 to 56 and 83 to 86 respectively, but we did not get significant changes over two years ($p<0.05$) (Figure-7). The estimated RAI_2 of sambar was significantly reduced from 49 to 14 between the two years.

6.5 *Temporal Activity Pattern*

The seven prey species (Barking Deer *Muntiacus muntjak*, Hog Deer *Axis porcinus*, Sambar *Rusa unicolor*, Wild Pig *Sus scrofa*, Gaur *Bos gaurus* Elephant *Elephus maximus* and Himalayan Serow) were considered for Kernel density and trigonometric sum estimates of activity patterns with anthropogenic disturbances. Barking deer, Hog deer, Red serow and Wild pig were found active during the daylight hours (Barking deer and Hog deer was found active between 06:00 to 11:00 hrs. Red serow and Wild pig was found active between 07:00 to 16:00 hrs), while Sambar was found active during the crepuscular period (18:00 to 05:00 hrs). The mega herbivores Gaur and Elephant were found active during daylight (06:00 to 11:00 hrs) and evening hours (15:00 to 18:00 hrs) (Figure-8).

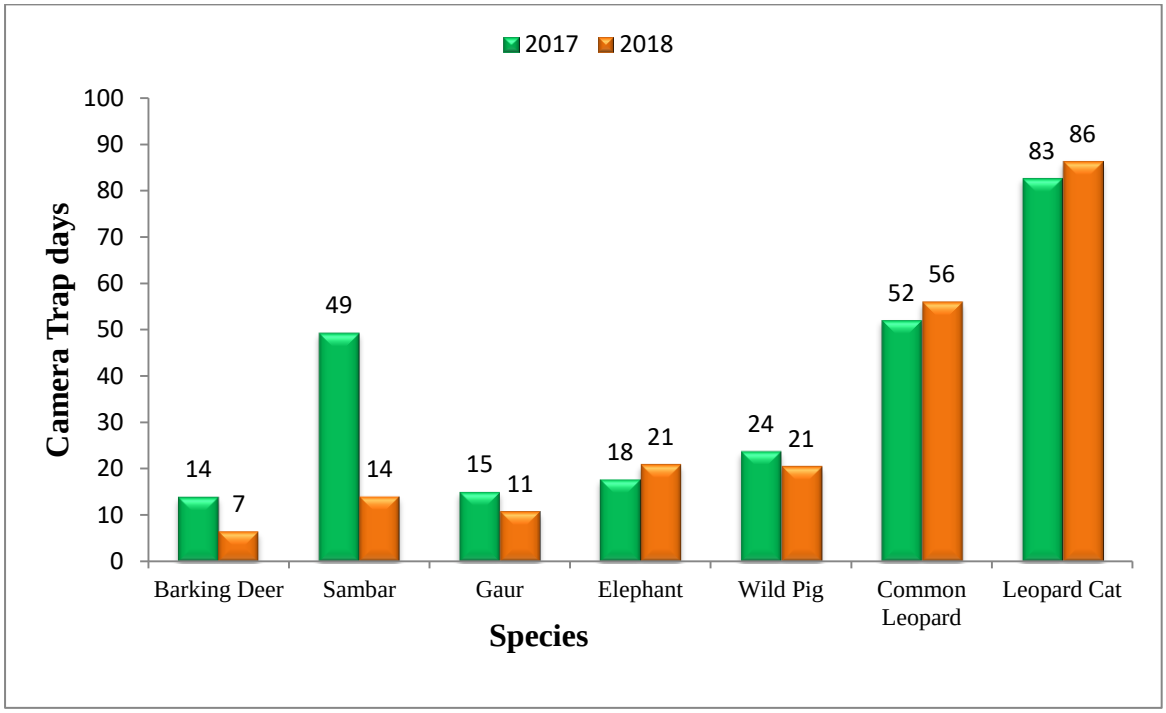
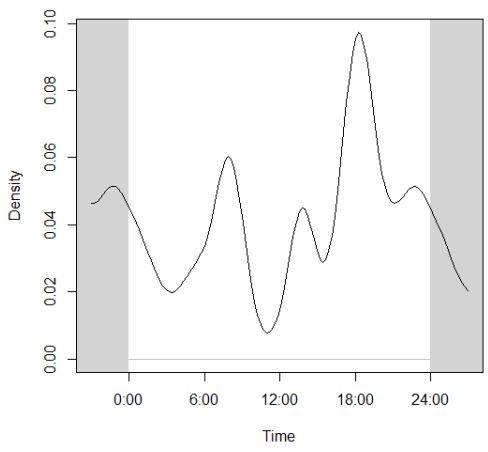
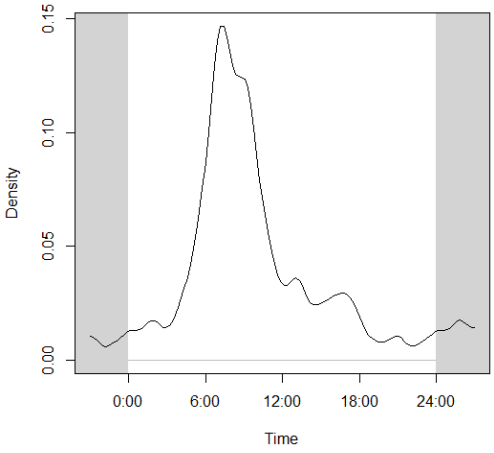


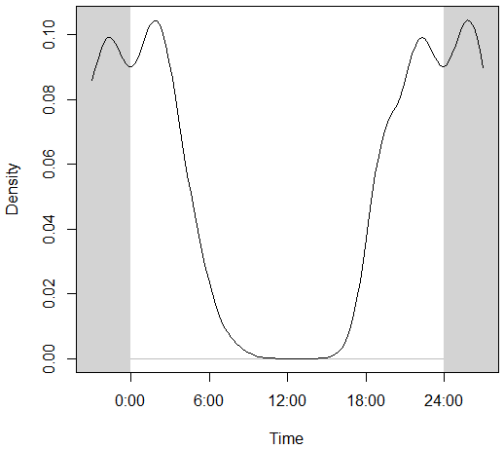
Figure-7: $PCRI_2$ for major prey and predator species in Indo-Bhutan Barnadi-Jomotsangkha Forest complex in 2017 and 2018.



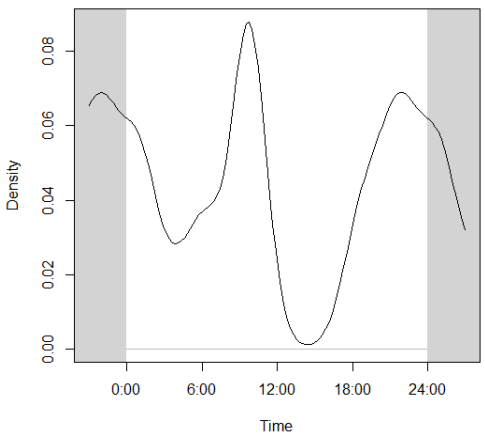
Common Leopard



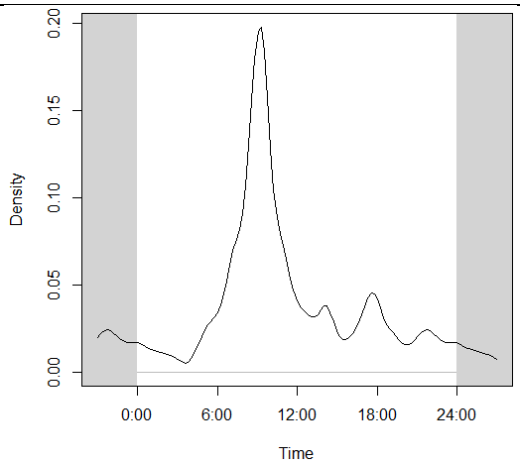
Wild Dog



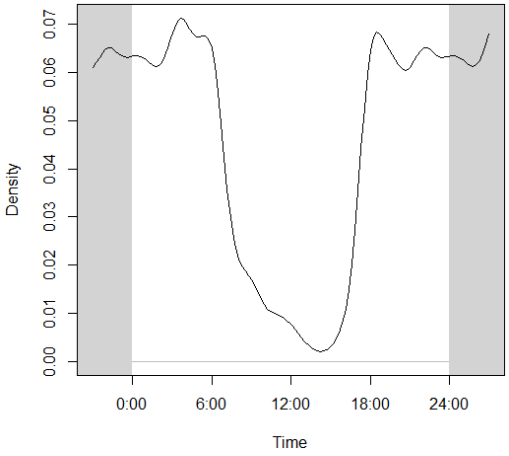
Leopard Cat



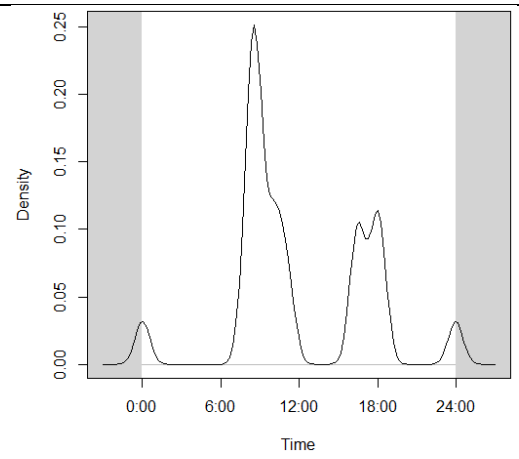
Clouded Leopard



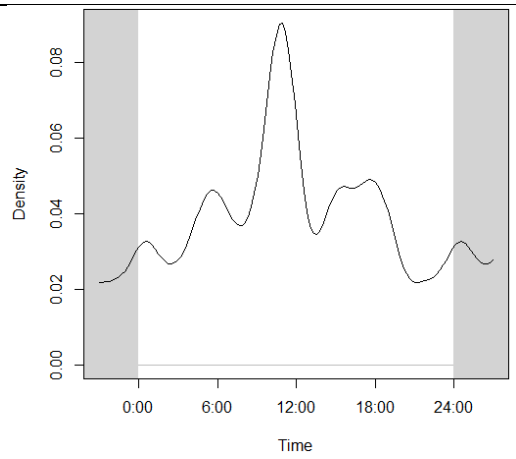
Barking Deer



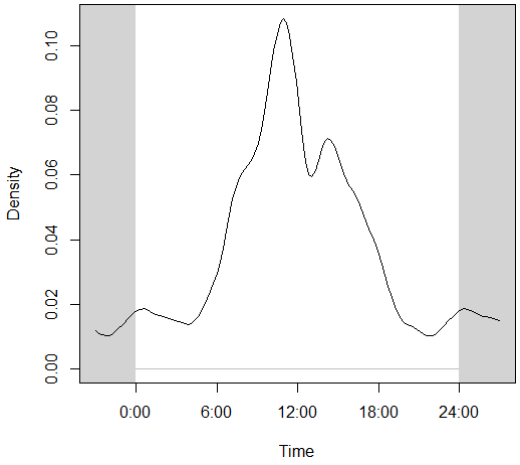
Sambar



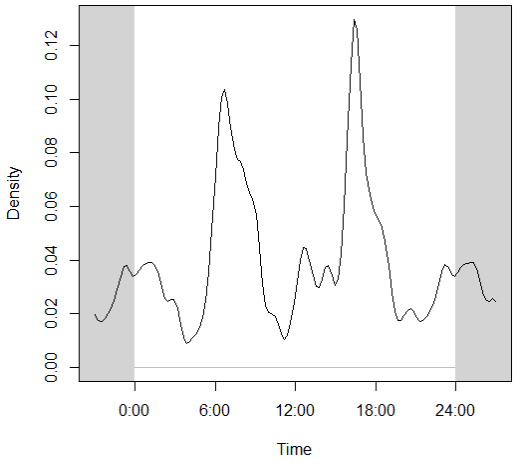
Hog Deer



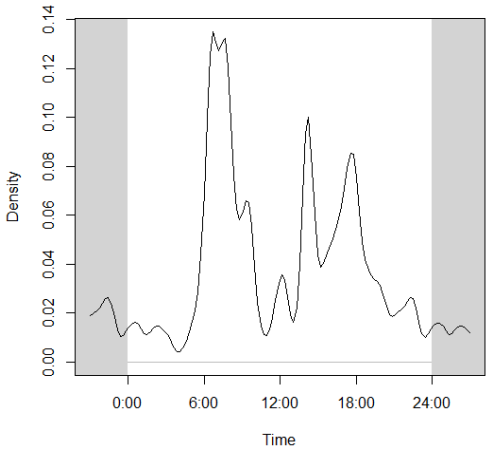
Himalayan Serrow



Wild Pig



Gaur



Elephant

Figure-8: Activity pattern of major prey and predator species in Indo-Bhutan Barnadi-Jomotsangkha Forest Complex.

6.6 *Human Use of Forests and Anthropogenic Threats*

The camera traps also detected different anthropogenic threats in the study area. The study across the Barnadi-Jomotsangkha forest complex obtained 1165and 545 photographs of human activities during 2017 and 2018 session respectively. From these photo−captures we identified 6 distinct categories of forest use and related anthropogenic threats. These were (Figure-9, provides a few examples):

(a) **Livestock Grazing**−domesticated ungulates (eg. cow, buffalo etc.)

(b) **Fishing –** people carrying fishing gear and/or fish

(c) **NTFP Collection**−people carrying bags with plant material

(d) **Unknown Person** – people photographs with no visible evidence indicating their purpose of entering into the forest

(e) **Cutting Tool**- people carrying Mantachie and other similar shape weapon.

(f) **Hunting**- people carrying gun, catapult etc.

Among all threat categories, livestock grazing was found to be highest, followed by unknown people and cutting tools in both 2017 and 2018 (Table-4). Percent capture of Hunting was reduced from 16 to 11 (Table-4). The concentrations of all threats were mostly found in the Indian counterpart of the Indo-Bhutan Barnadi-Jomotsangkha Forest Complex (Figure-10a-b).

Table-4: Number of independent photo−captures and percent capture (in parentheses) obtained across Indo-Bhutan Barnadi-Jomotsangkha forest complex during the study sessions in 2016−17 and 2017−18.

Forest use category	**2016−17**	**2017−18**
Livestock grazing	178 (59)	74 (32.3)
Fishing	05 (1.6)	0
NTFP collection	15 (5)	10 (4.3)
Unknown Person	**50 (16.8)**	**74 (32.3)**
Cutting tool	44 (14.8)	44 (19.2)
Hunting	**05 (16)**	**27 (11.8)**
Overall	297	229

	
Cutting Tools	**Livestock**
	
Hunting	**Unknown Person**
	
NTFP Collection	**Fishing**

Figure-9: Photographic representation of different categories of forest uses. (a) Livestock grazing, (b) Fishing, (c) NTFP collection, (d) unknown, (e) cutting tool and (f) hunting.

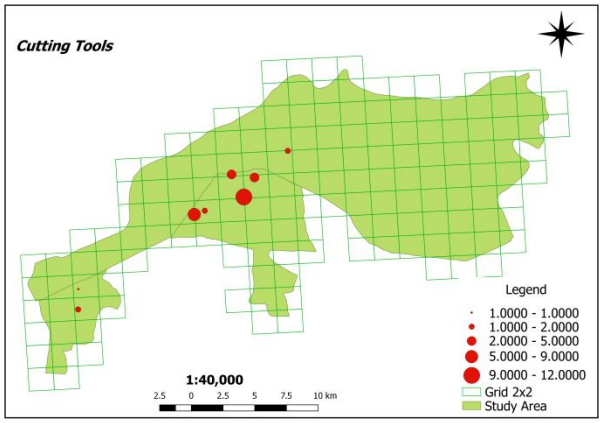
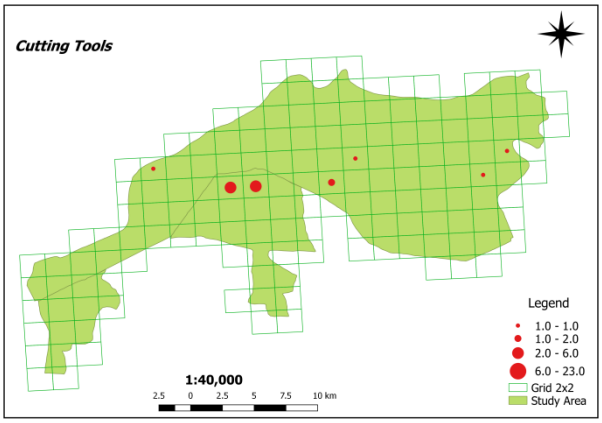
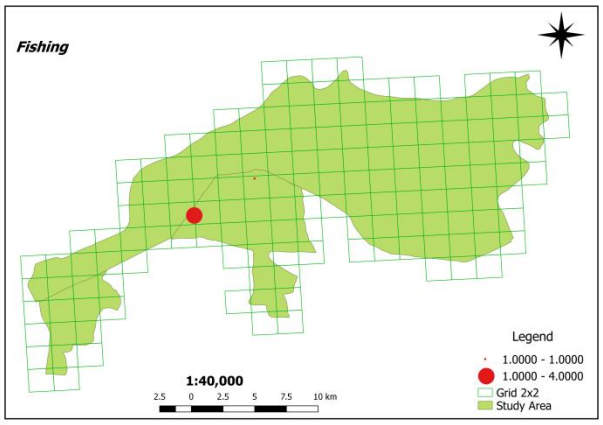
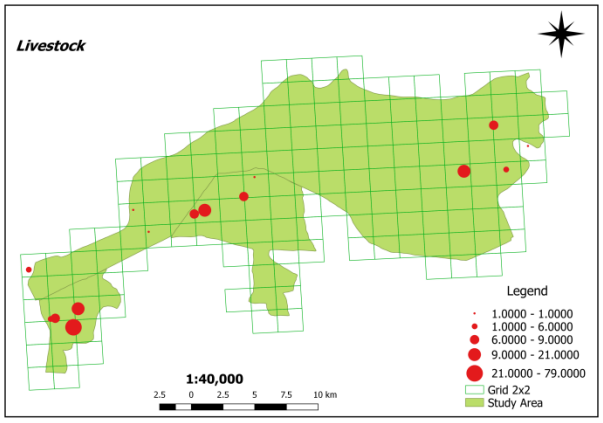
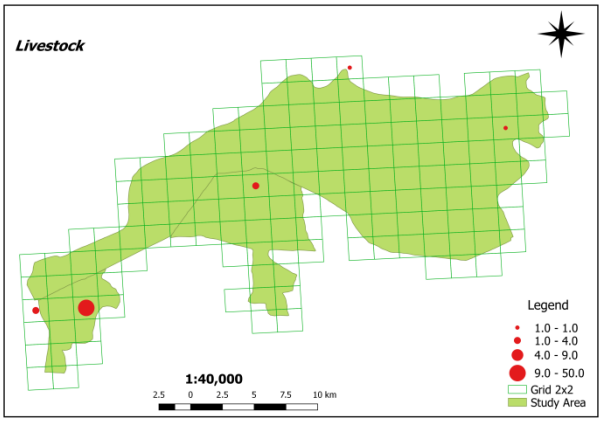
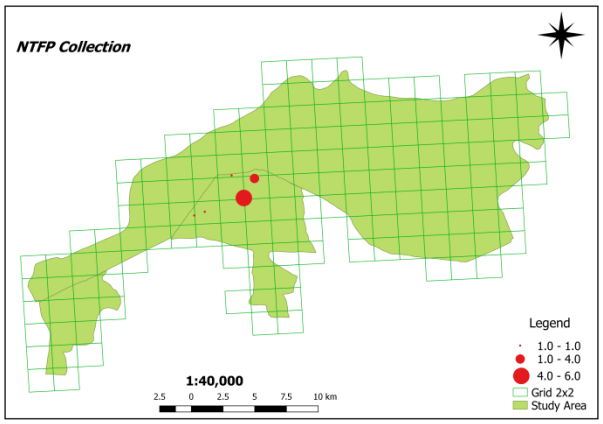
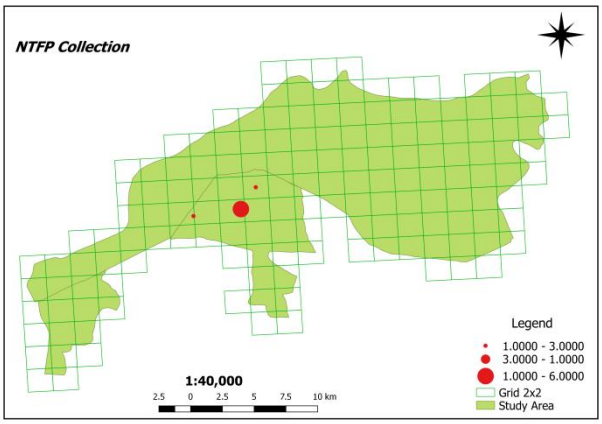
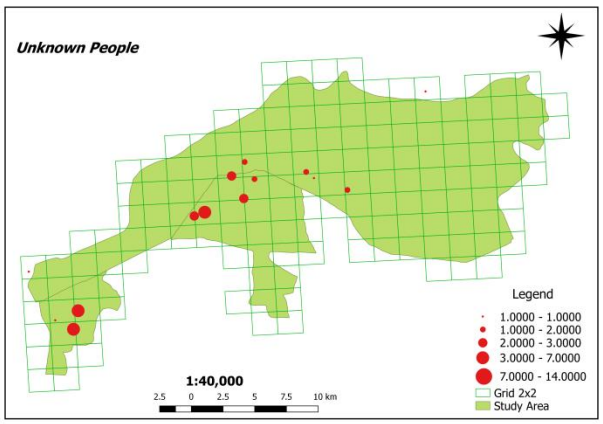
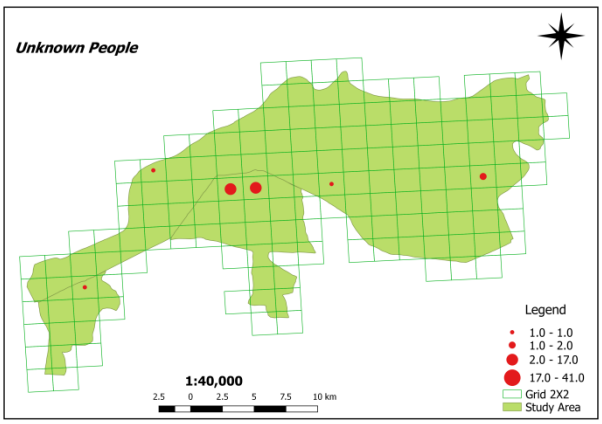
2017	2018
	
	
	

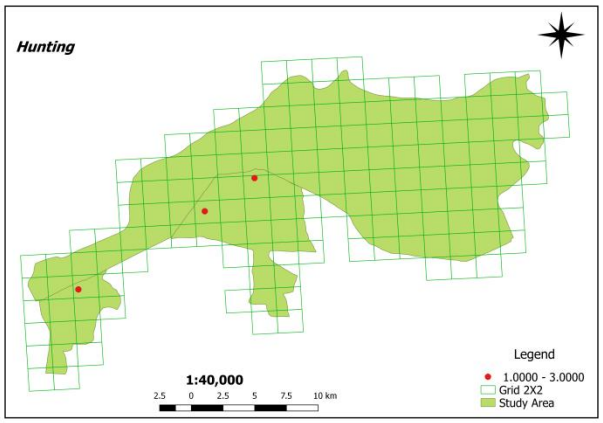
Figure-10a: Spatial variance of different threat categories recorded in Indo-Bhutan Barnadi-Jomotsangkha Forest complex in 2017 and 2018.











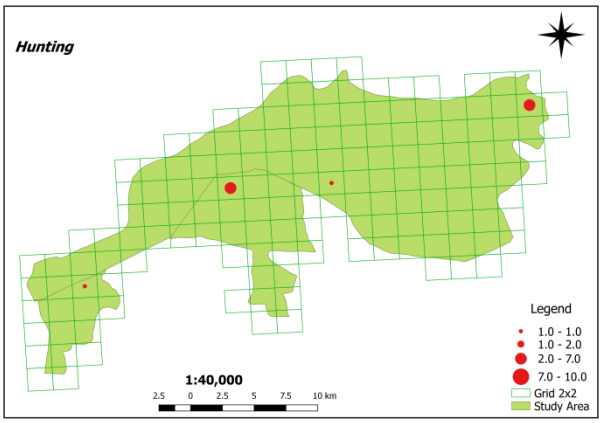
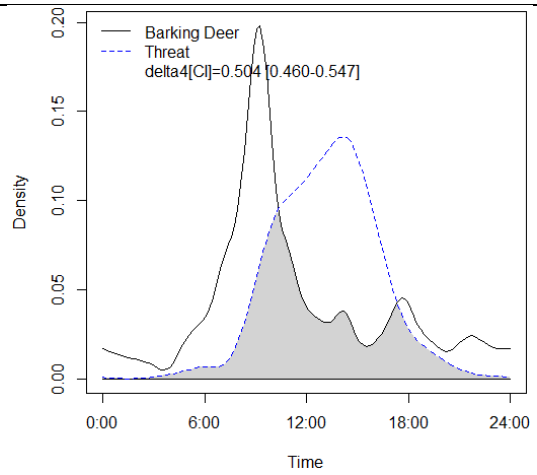


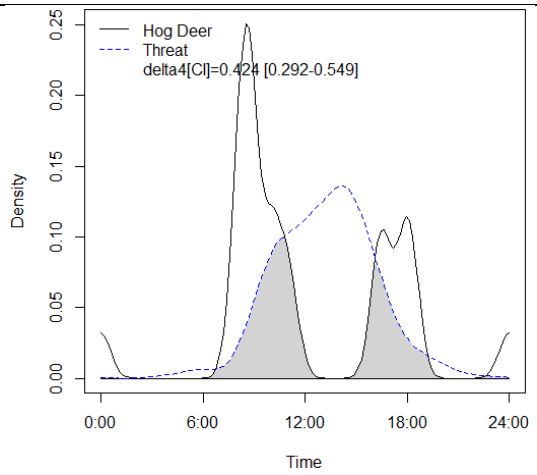
Figure-10b: Spatial variance of different threat categories recorded in Indo-Bhutan Barnadi-Jomotsangkha Forest complex in 2017 and 2018.

6.7 *Temporal overlap between major prey and predators with threats*

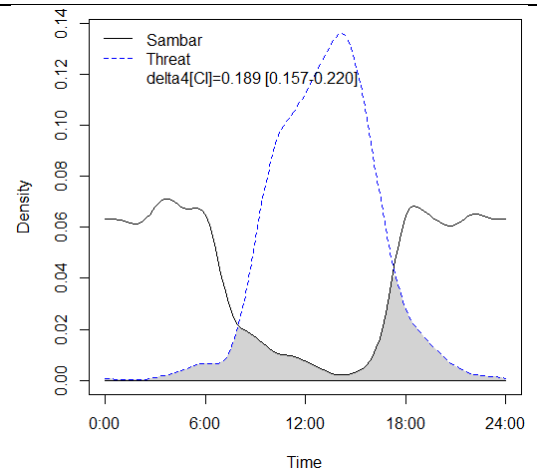
We obtained all captured images of anthropogenic disturbances between ~7:00 to ~15:00 hrs.The coefficient of overlap of Kernel density between all ungulate species except sambar and anthropogenic disturbances was found high (Figure-11). Among the wild ungulates the overlap between wild pig ($\Delta_4$0.73) and anthropogenic disturbances was found highest followed by Himalayan serrow and Barking deer (Figure-11). The coefficient of overlap of kernel density between carnivores and anthropogenic disturbances was found less (Figure-11). Among the carnivores the coefficient of Kernel density overlap was found highest in Wild dog ($\Delta_4$0.40) and lowest in Leopard cat ($\Delta_4$0.08) (Figure-11).



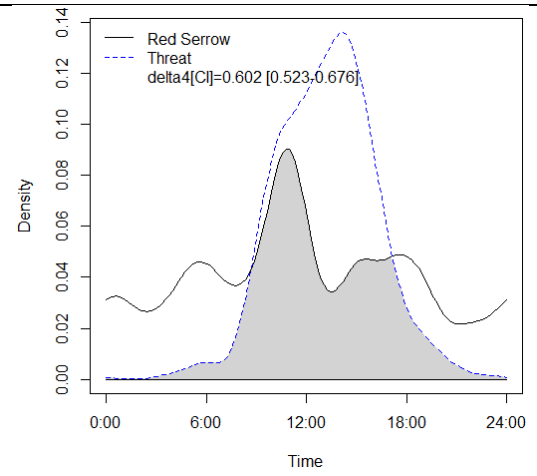
Barking Deer + Threats



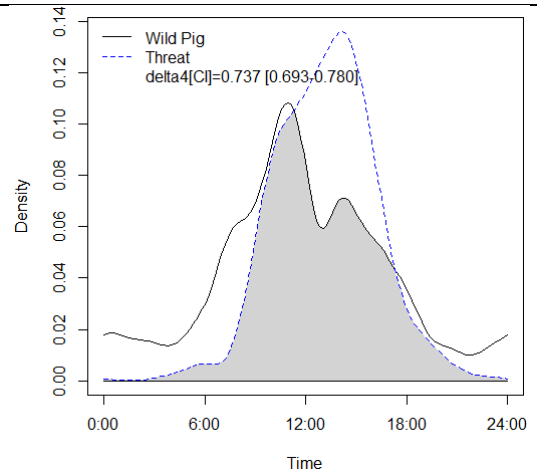
Hog Deer + Threats



Sambar+Threats

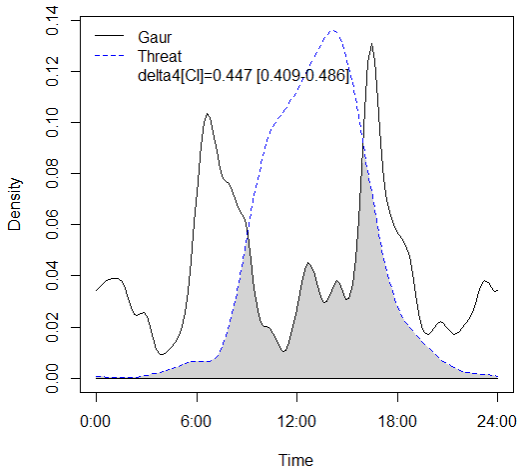


Himalayan Serrow + Threats

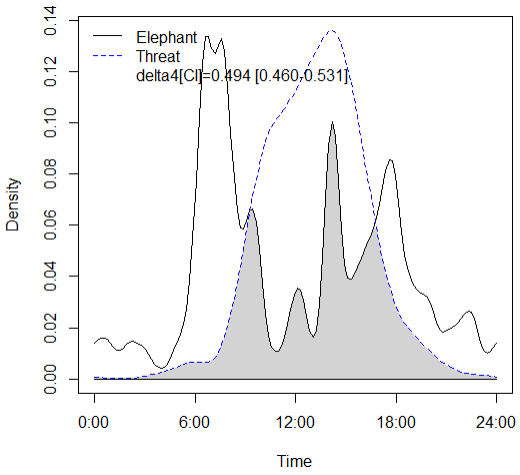


Wild Pig + Threats

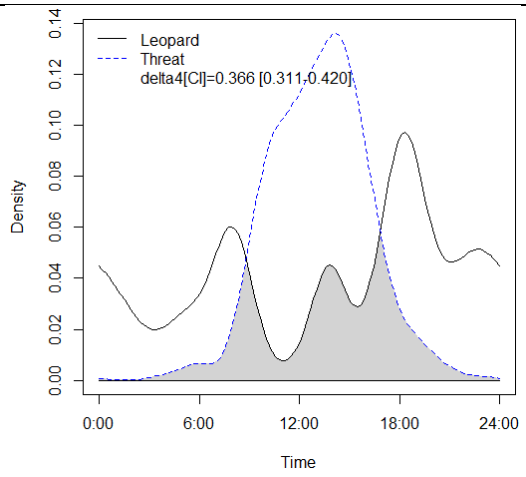
Figure-11a: Coefficient of Kerneldensityoverlap between potential preys and predators in Indo-Bhutan Jomotsangkha-Barnadi Forest Complex.



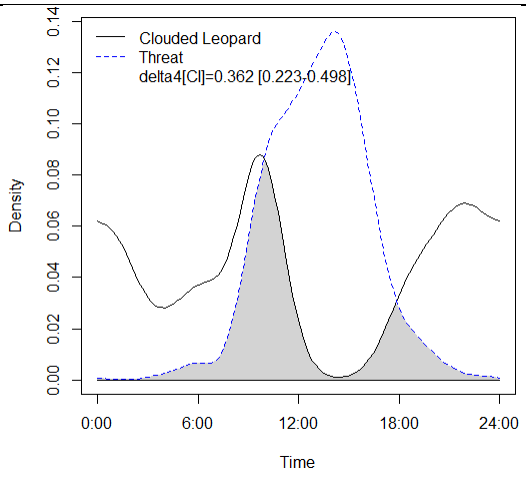
Gaur + Threats



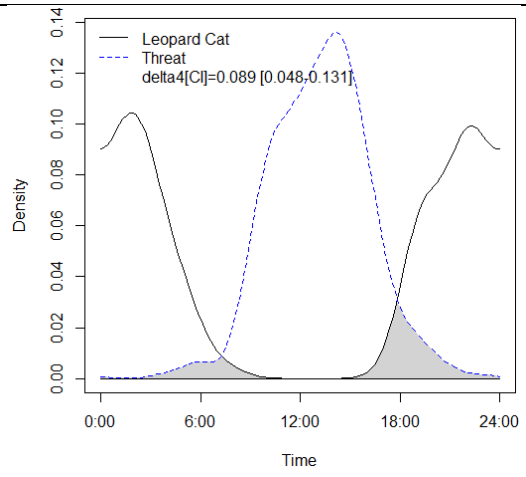
Elephant + Threats



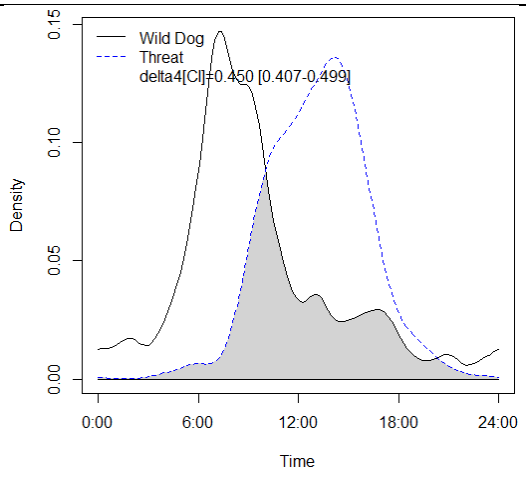
Leopard + Threats



Clouded Leopard + Threats



Leopard Cat + Threats



Wild Dog + Threats

Figure-11b: Coefficient of Kerneldensityoverlap between potential preys and predators in Indo-Bhutan Jomotsangkha-Barnadi Forest Complex.

6.8 *Habitat Connectivity*

Our map of cumulative current flow shows the sum of currents when all patch pair are iteratively connected and highlights areas with high centrality, i.e. areas important for keeping the entire network of patches connected. Cumulative current flow was highest in Nameri Tiger Reserve and Barnadi-Jomotsangkha forest complex on the east and on the west Buxa Tiger Reserve and Trans-boundary Manas Conservation Area (TraMCA). Compare to Barnadi-Jomotsangkha forest complex and Nameri Tiger Reserve, current flow across Kaziranga and Orang Tiger Reserve located on the southern part of the River Brahmaputra was relatively low. Patterns of high flow were present along the Buxa-TraMCA-Nameri, we observed a 'halo' effect around many small patches reflecting high current flow around their perimeter.

Our map of habitat patch centrality revealed different protected areas located in both north and south of the river Brahmaputa that may be important for keeping the overall network of habitat patches connected. Estimates of cumulative current flow highlighted those patches most important for maintaining relatively high current flow between other patches. Area-weightage estimates of centrality revealed patches that provided more connectivity value across the network than would be expected by their size alone. On the whole the map (Fig 12) indicated a well connectivity across the conservation sites in the transboundary area.

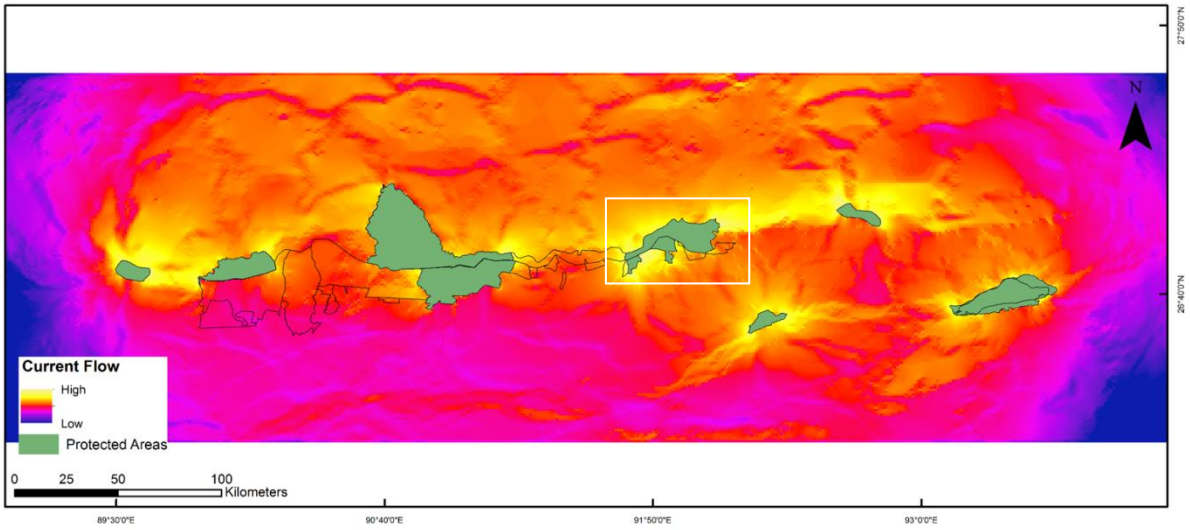


Figure-12: Model of cumulative current flow used to estimate connectivity for Tiger (*Panthera tigris*) across the entire network of habitat patches of TraMCA and neighbouring landscapes. The study area Barnadi-JomotshankhaTransboundary Forest Complex is shown within the box with white boundary.

7. Conservation Outcomes and Recommendations

7.1 Conservation Outcome:

a. This project, for the first time has created the much required baseline towards planning and scientific monitoring of long term conservation interventions in the Barnadi-Jomotshankha forest complex.

b. The results shows presence of good diversity of animals and this can now be used for monitoring and evaluation of performances of any future investment for conservation in the forest complex.

c. The knowledge gathered has helped and would help the project team and forest manager in immediate future to assess future needs and set priorities to ensure long term conservation of tigers.

d. The outcome will help in drafting the indicative conservation plan for the entire forest complexes managed through transboundary approach by both India and Bhutan as single unit of forest.

e. The project has helped in understanding the habitat connectivity within in the larger landscape called TraMCA along with the Barnadi-Jomotshankha Forest Complex. The information would be used for future ground assessment and conservation planning for biological corridors.

f. The project has helped in establishing the relationship between the two transboundary forest management units (Dhansiri Forest Division in India and Chief Forestry Officer of Jomotshankha WLS in Bhutan) the most primary need to ensure long term conservation of this forest complex and ensure long term conservation of Tigers across the transboundary PAs.

g. Further, the project would help in re-evaluating the conservation status of the forest complex and consolidate the entire forest complex through improved protection and law enforcement which is crucial for ecosystem services for a large number of people in the watershed.

7.2 Recommendations

a. It is very pertinent that the Barnadi-Jomotshankha forest complex across the international border of India and Bhutan is considered and managed as a single forest unit.

b. The many anthropogenic threats that the forest complex faces needs to be minimized and eliminate completely to ensure that number of prey animals are increased to eventually have a resident population of tigers and co-predators.

c. A transboundary tigers, co-predators and habitat conservation and management plan should be developed and accepted jointly by the forest managers across the boundary and jointly work to achieve the goal of the same. We also recommend that the progress of the plan is evaluated through regular and periodic joint meetings of the managers.

d. We would also like to recommend the governments of Bhutan and India to give priority to such sites for tiger conservation as these forest complex has potential to add to the global tiger numbers in the next decade or so.

e. While Bhutan government has added an area of 925 sq km to the existing 335 sq km area of Jomotshankha WLS, we strongly recommend that Government of Assam also decides in the similar line to notify Khaling and Bhairabkunda Reserve Forests as Wildlife Sanctuary on India side of the border to ensure better law enforcement and protection of these forest complexes as one unit of transboundary forest.

f. We would also like to recommend that the Forest Department BTC prepares effective community engagement plan to ensure their participation in the conservation process and reduce their dependency on forest resources through appropriate skill development and livelihood options.

8. References

Ahmed, M. F., S. Wangmo, D. Lahkar, P. Chakraborty, A. Sarmah, J. Borah, D. Wangchuk, T. Nidup, T. wangchuk, H.K. Sarma, A. Harihar & R. Pickles.(2016). Tigers of Transboundary Manas Conservation Area. Technical Report, 50pp.

Carbone, C., S. Christie, K. Conforti, T. Coulson, N. Franklin, J.R. Ginsberg, M. Griffiths, J. Holden, K. Kawanishi, M. Kinnaird, R. Laidlaw, A. Lynam, D.W. Macdonald, D. Martyr, C. McDougal, L. Nath, T. O'Brien, J. Seidensticker, D.J.L. Smith, M. Sunquist, R. Tilson and W.N. Wan Shahruddin (2001). The use of photographic rates to estimate densities of tigers and other cryptic mammals. *Animal Conservation* 4: 75–79.

IUCN (2017). The IUCN Red List of Threatened Species. Version 2017.<www.iucnredlist.org>. Downloaded on 20 January 2018.

Linkie, M. & M.S. Ridout (2011). Assessing tiger–prey interactions in Sumatran rainforests. *Journal of Zoology* 284: 224–229.

Menon, V. (2014). *Indian mammals– a field guide*. Hachette Book Publishing India Pvt. LTD, India, 528pp.

Meredith, M. & M. Ridout (2014). Overlap: Estimates of coefficient of overlapping for animal activity patterns. *R Package. version 0.2* 4.

Olliff, E.R.R., C.W. Cline, D.C. Bruen, E.J. Yarmchuk, R.S. A. Pickles & L. Hunter (2014). The Pantheracam− a camera−trap optimizied for monitoring wild felids. *Wild Felid Monitoring* 7: 21−23.

QGIS Development Team (2012). *QGIS Geographic Information System.* Open Source Geospatial Foundation Project.

Ridout, M.S. & M. Linkie (2009). Estimating overlap of daily activity patterns from camera trap data. *Journal of Agricultural, Biological, and Environmental Statistics* 14(3): 322−337.https://doi.org/10.1198/jabes.2009.08038.

Sanderson, E., J. Forrest, C. Loucks, J. Ginsberg, E. Dinerstein, J. Seidensticker, P. Leimgruber, M. Songer, A. Heydlauff, T. O'Brien, G. Bryja, S. Klenzendorf & E. Wikramanayake (2006). Setting Priorities for the Conservation and Recovery of Wild Tigers: 2005-2015. The Technical Assessment. WCS, WWF, Smithsonian, and NFWF-STF, New York – Washington, D.C.

Team, R.D.C. (2010). R version 2.11.1.

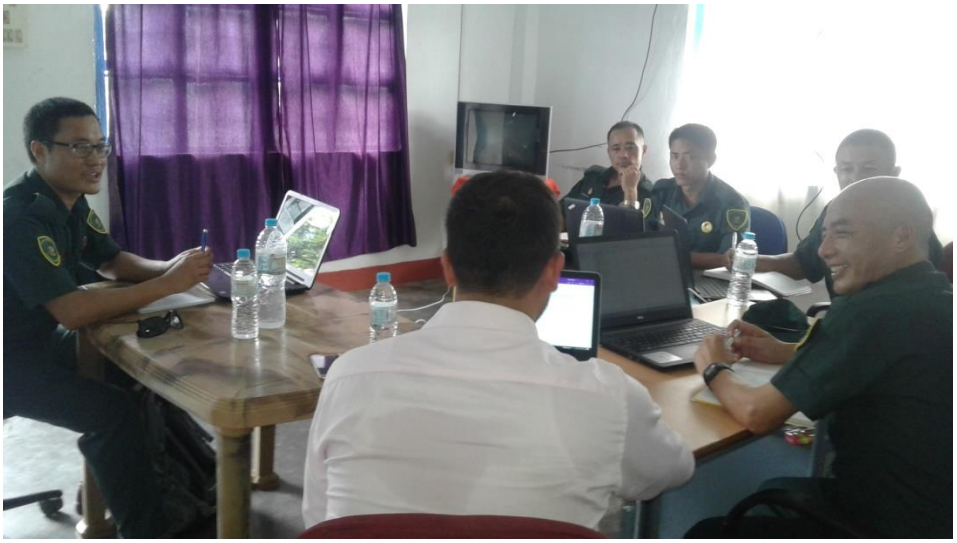
Wolf, C. & W.J. Ripple (2016). Prey depletion as a threat to the world's large carnivores. *Royal Society Open Science* 3(8): 160252.http://dx.doi.org/10.1098/rsos.160252

Wolf, C. & W.J. Ripple (2017). Range contractions of the world's large carnivores. *Royal Society open science* 4(7): 170052.

9. Training and outreach activities

9.1 *Hands on training on Camera trapping and GPS*

On 27th August, 2017 a daylong workshop was organized in the Divisional office, JWS, Bhutan on camera trapping data analysis and use of GPS/GIS to train study teams of JWS.



On 25 and 26th September, 2017, a two days' workshop was conducted on Camera trapping and GPS/GIS at the Divisional office, JWS, Bhutan for the staff of JWS.

On 9 to 11 July, 2018, a three days in-house workshop on joint data analysis and report preparation was organised at Aaranyak, Guwahati, India. A detail of the workshop is reported in Appendix 2.

Appendix-1: Photographs of species recorded in camera traps in the Indo-Bhutan Barnadi-Jomotsankga Forest Complex in 2017 and 2018.

Tiger: captured in JWS in 2016

* Tiger (*Panthera tigris*) (JSW 2016)

Common Leopard (*Panthera pardus*)

Common Leopard (*Panthera pardus*)

Clouded Leopard (*Neofelis nebulosa*)

Leopard Cat (*Prionailurus bengalensis)*

Golden Cat (*Catopuma temminckii*)

Marbled Cat (*Pardofelis marmorata*)

Jungle Cat (*Felis chaus)*


Wild Dog (*Cuon alpinus)*


Himalayan Black Bear (*Ursus thibetanus)*


Barking Deer *(Muntiacus muntjak)*


Hog Deer *(Axis porcinus)*


Sambar *(Rusa unicolor)*


Mask Deer (*Moschus chrysogaster*)


Himalayan Serrow (*Capricornis thar*)


Himalayan Goral (*Naemorhedus goral*)

Gaur *(Bos gaurus)*

Elephant *(Elephas maximus)*

Wild Pig *(Sus scrofa)*

Arunachal Macaque (*Macaca munzala*)

Assamese Macaque (*Macaca assamensis*)

Capped Langur (*Trachypithecus pileatus*)

Rhesus Macaque (*Macaca mulata*)

Spotted Linsang (*Prionodon pardicolor*)

Large Indian Civet *(Viverra zibetha)*

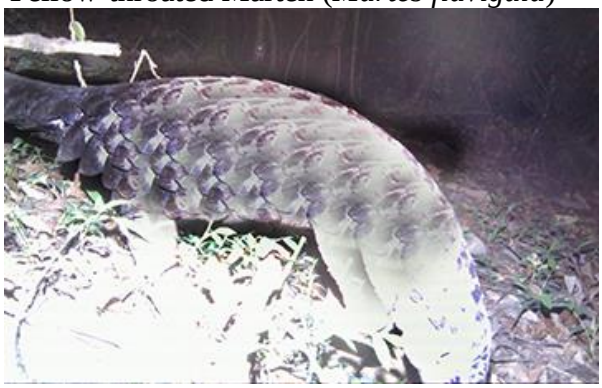
Mask Palm Civet *(Paradoxurus hermaphrodites)*

Himalayan Palm Civet (*Paguma larvata*)

Large-toothed Ferret Badger (*Melogaleper sonata)*

Yellow-throated Marten (*Martes flavigula*)

Binturong (*Arctictis binturong*)



Chinese Pangolin (*Manis pentadactyla*)

Himalayan Giant Squirrel (*Ratufa bicolor*)

Porcupine *(Hystrix brachyuran)*

Brush-tailed Porcupine (*Atherurus macrourus*)

Crab-eating Mongoose *(Herpestes urva)*

Indian Hare *(Lepus nigricollis)*

Appendix-2: Trans-boundary Jomotsangkha-Barnadi Wildlife Sanctuary Data Sharing and Data Analysis Workshop

Workshop Report on

Trans-boundary Jomotsangkha-Barnadi Wildlife Sanctuary Data Sharing and Data Analysis Workshop

Dated: 9th to 11th July, 2018

Convenor

M. Firoz Ahmed, M.Sc., PhD

Workshop Instructor

Dipankar Lahkar, M.Sc

Organiser

Aaranyak

Partner

Jomotsangkha Wildlife Sanctuary, Bhutan

Brief Outline

The Transboundary Manas Conservation Area covers approximately 6500 sq km across the International Boundary between India and Bhutan. Tiger conservation potential of this large landscape is very high and offers an opportunity to double tiger population within 2025. The Bornadi-Jomotsangkha forest complex on the eastern edge of the landscape offers an opportunity to replicate Transboundary tiger conservation model being implemented in Manas-Royal Manas forest complex. This project aims to create baseline for a long term research and conservation action required to secure tigers and habitats in this unexplored forest complex.

To arrange the data in a systematic manner for analysis for a comprehensive report, this workshop was organised with the active participation of the partnering agencies.

1. Aim of the Workshop

- ✓ To compile the camera trap data collected during the study period.
- ✓ Interpretations of the camera trap data into different format for analysis.
- ✓ Share the compile data with the project partners in a systematic format.
- ✓ Train data interpretation and analysis among the project partners aim to skilled personnel in our study sites.
- ✓ Introduce a common format of data sharing and analysis.
- ✓ To introduce new methods and related software programs for data analysis to the project partners.
- ✓ Formulate a timeline for further project related activities.
- ✓ To understand the challenges and prospects for future studies in this landscape.

2. Member with designation of the participants

Sl. No.	Name	Designation
1.	Dr. M Firoz Ahmed	HOD, Tiger Research and Conservation Division (TRCD), Aaranyak
2.	Dipankar Lahkar	Manager (Research), TRCD, Aaranyak
3.	Aprajita Singh	Trainee Biologist, TRCD, Aaranyak
4.	Nibir Medhi	Volunteer, Aaranyak
5.	Ugyen Tshering	Chief Forest Officer, Jomotsangkha WLS, Bhutan
6.	Chaten Zara	Sr. Forestry Officer, Jomotsangkha WLS, Bhutan
7.	Lekey Chaida	Sr. Forestry Officer, Jomotsangkha WLS, Bhutan
8.	Sonam Dendup	Sr. Forestry Officer, Jomotsangkha WLS, Bhutan
9.	Tashi	Sr. Forestry Officer, Jomotsangkha WLS, Bhutan

3. Venue: Conference Hall, Research Division Office, Aaranyak, 12, Kanaklata Path, bye lane 3, Ajanta Path, Beltola Survey, Guwahati, India-781028

4. Workshop Agenda

08-07-18	Welcome Bhutan forest officials and accommodate them in the hotel	
09-07-18	**First day of the workshop**	
First Session	**10:00 to 13:00 IST**	**Camera Trap data Visualization** 1. Create grid wise raw data folder 2. Prepare segregated species wise data folders 3. Prepare segregated threat category wise data folders 4. Species wise XMP and meta-data output 5. Camera trap effort calculation 6. List out captured species 7. List out new species records 8. Basic profiling related to camera trap study
	13:00 to 14:00 IST	**Lunch break**
Second Session	**14:00 to 16:00 IST**	**Mapping related data visualization** 1. Boundary layers of each study sites in .kml format 2. Grid and centroid layers in .kml format 3. Camera trap locations in .kml format
Third Session	**14:15 to 18:00 IST**	**Data Sharing** 1. Raw camera trap data in grid wise format 2. Segregated species wise data 3. All .kml files
10-07-18	**Second day of the workshop**	
First Session	**10:00 to 13:00 IST**	**Basic Mapping** 1. Preparing matrix for PCRI maps 2. Create PCRI maps with QGIS 3. Final study area map 4. Camera trap effort map
	13:00 to 14:00 IST	**Lunch break**
Second Session	**14:00 to 16:00 IST**	**Basic Analysis** 1. Preparation of matrix for PCRI calculation and analysis. 2. Preparation of matrix for Occupancy estimation. 3. Preparation of matrix for time analysis
Third	**14:15 to 18:00 IST**	**Matrix generation and occupancy analysis**

Session		1. Preparation of matrix for Occupancy estimation. 2. Preparation of matrix for time analysis 3. Generate overall information on camera trapping 4. Demonstration on Occupancy estimation

11-07-18 Third day of the workshop

First Session	**10:00 to 11:30 IST**	**Compile results of the analysis for report preparation** 1. Basic PCRI estimates 2. All threat XMP and meta data and PCRI matrix 3. Threat mapping
Second Session	**12:00 to 13:00 IST**	**Report outline**
	13:00 to 14:00 IST	**Lunch break**
Third Session	**14:00 to 17:00 IST**	**Report outline**
Fourth Session	**17:00 to 17:30 IST**	**Valedictory function and future planning**

12-07-18 Exposure trip to Assam State Zoo, Guwahati, Assam, India

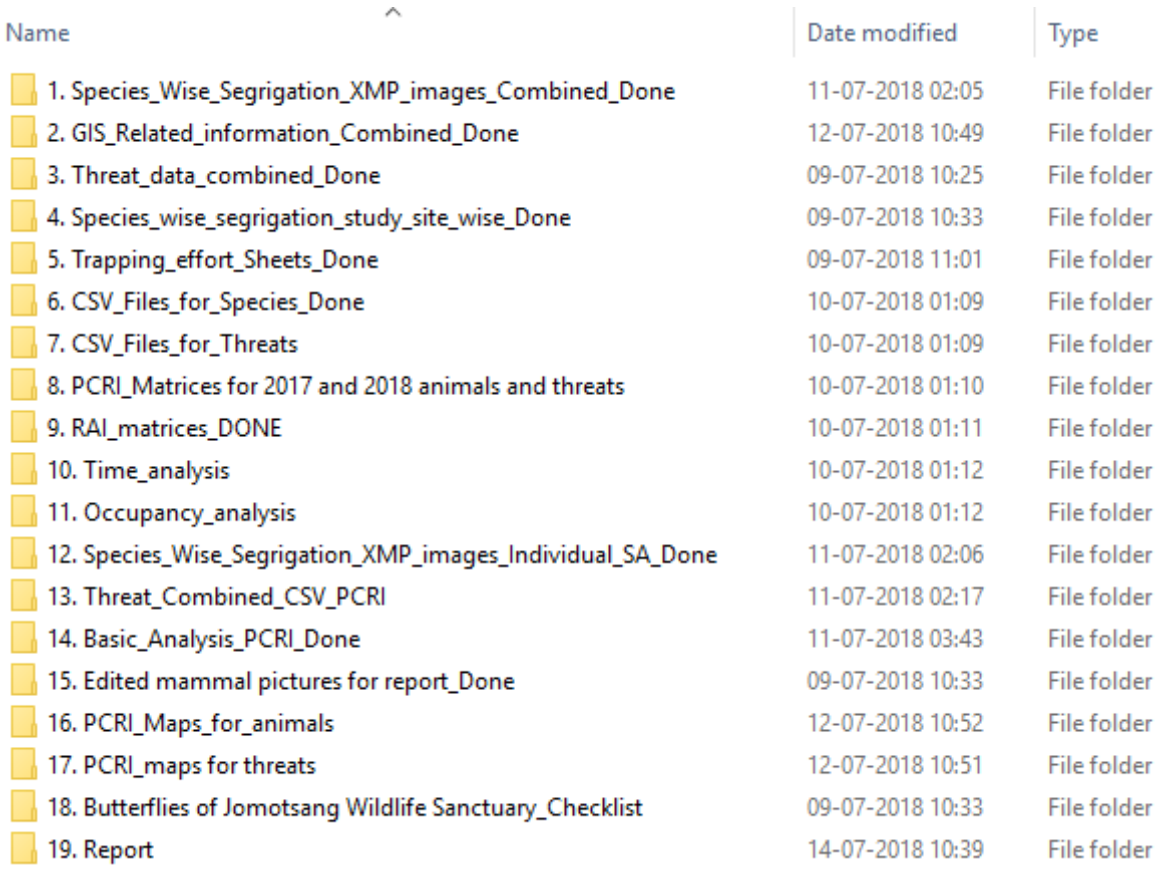
5. Outcome of the workshop

- Successfully compiled all camera trap raw data into grid wise folders for both 2017and 2018 session
- Produced species wise folders for both 2017and 2018 session.
- Produced threat category wise folders for both 2017 and 2018 session.
- Generated XMP data for both species and threat types for both 2017 and 2018 session.
- Calculated camera trapping efforts for both 2017 and 2018 session.
- Export .CSV files for each species and threat types for both 2017 and 2018 session.
- Generated PCRI matrices for threat and animal species for both 2017 and 2018 session.
- Calculated RAI with CI at 95% of all captured species for both 2017 and 2018 session.
- Edited all captured mammal pictures for report.
- Created PCRI maps for species for 2018 session.
- Generated all basic GIS layers.
- List out all basic camera trap results.
- Discussion and taken resolution on future studies and fund raising.
- Delegates from both the countries agreed to continue this study in future.

6. Acknowledgements

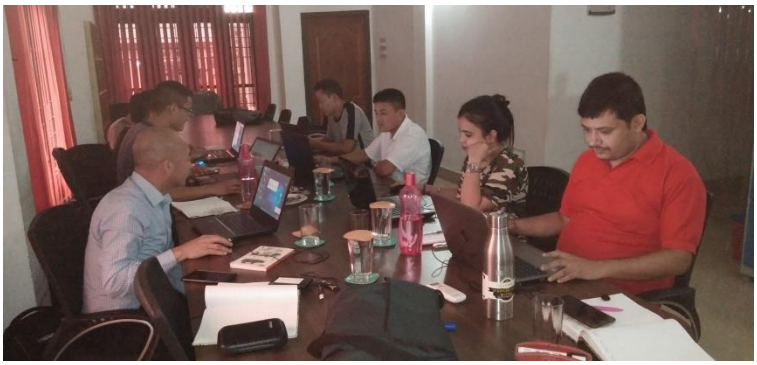
We would like to extend our deep gratitude to Zoological Society of London (ZSL) for funding. We acknowledge Administrative division and Finance division of Aaranyak for their help in logistics during the workshop. We extend our thanks to Mr. Gauranga and Mr. Krishna for helping actively in food arrangement. Thanks to Ms. Aprajita Singh for arranging cab for the participants and Dr. Kalloli Dutta for helping in valedictory function. Last, but not the least, we thank all participants of Jomotsangkha Wildlife Sanctuary, Bhutan for their active participation which made it possible to achieve common goal of the workshop.

Plate-1: Workshop output folders



Name	Date modified	Type
1. Species_Wise_Segrigation_XMP_images_Combined_Done	11-07-2018 02:05	File folder
2. GIS_Related_information_Combined_Done	12-07-2018 10:49	File folder
3. Threat_data_combined_Done	09-07-2018 10:25	File folder
4. Species_wise_segrigation_study_site_wise_Done	09-07-2018 10:33	File folder
5. Trapping_effort_Sheets_Done	09-07-2018 11:01	File folder
6. CSV_Files_for_Species_Done	10-07-2018 01:09	File folder
7. CSV_Files_for_Threats	10-07-2018 01:09	File folder
8. PCRI_Matrices for 2017 and 2018 animals and threats	10-07-2018 01:10	File folder
9. RAI_matrices_DONE	10-07-2018 01:11	File folder
10. Time_analysis	10-07-2018 01:12	File folder
11. Occupancy_analysis	10-07-2018 01:12	File folder
12. Species_Wise_Segrigation_XMP_images_Individual_SA_Done	11-07-2018 02:06	File folder
13. Threat_Combined_CSV_PCRI	11-07-2018 02:17	File folder
14. Basic_Analysis_PCRI_Done	11-07-2018 03:43	File folder
15. Edited mammal pictures for report_Done	09-07-2018 10:33	File folder
16. PCRI_Maps_for_animals	12-07-2018 10:52	File folder
17. PCRI_maps for threats	12-07-2018 10:51	File folder
18. Butterflies of Jomotsang Wildlife Sanctuary_Checklist	09-07-2018 10:33	File folder
19. Report	14-07-2018 10:39	File folder

Plate-2: Workshop Pictures (Event Photographs)



Appendix-3: Field activity photographs

Research scholar along with the forest officials in Barnadi Wildlife Sanctuary

Sessonal river flowing down from Bhutan are the important corridors/paths for tigers and their pery animals

Landscape view of Barnadi-Jomotsangkha transboundary area

Forest officials of Jomotsangkha Wildlife sanctuary installing a camera trap

Forest officials of Jomotsangkha Wildlife sanctuary carrying logistics for field work

Implementing Partners

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