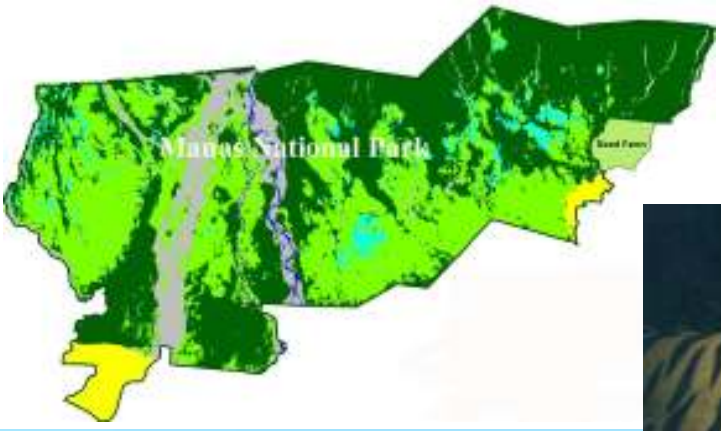
Conservation and Monitoring of Tiger Population in Manas National Park through field techniques and capacity building of local stakeholders



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FINAL REPORT

Conservation and Monitoring of Tiger population in Manas National Park through field techniques and capacity building of local stakeholders

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All Foresters, Forest Guards, Mahouts, Drivers, Boatmen, Casual labors and IB Care takers of Manas National Park

All Conservation Volunteers at Bansbari , Bhuyapara Range

List of figures and Appendix

CHAPTER-I

INTRODUCTION

The Royal Bengal tiger *Panthera tigris tigris* (Linnaeus, 1758) is the National Animal of India. It is an intimate part of the history and culture of this region. This species is the most threatened large carnivore in India. It has been used as the main flagship species in India to protect a wide diversity of other species. Despite this, the principal threat to its sustainability have been rapidly increasing mainly due to habitat destruction (Seidensticker, 1986), decline in prey base caused by over hunting (Karanth, 1991; Rabinowitz, 1991), commercial poaching (Rabinowitz, 1993; Plowden and Bowles, 1997; Shaharuddin, 1999) and poor tiger-human conflict management (Ajlan and Sharma, 2003). Development activities and alternation of habitat in throughout its range has resulted in forest fragmentation and rapid loss of its habitat.

Most of the existing tiger population data in India have been gathered from surveys based on pugmark technique carried out by the forest department all across India. But track survey or pugmark technique (Panwar, 1979) has been proven demonstrably failure prone (Karanth, 1987, 1988, 1993a, b) because the estimates based on pugmark census are neither reliable total counts nor statistical sample and very prone to human errors (Karanth, 1995). Population estimate based on the individual stripe patterns of each animal is proven to be more reliable as each tiger has its own unique coat (stripe) pattern (Schaller, 1967). This can be achieved by recording tigers photographically in dorsal or lateral position (Griffiths, 1993; Karanth, 1995). Besides individual's identification or population estimation (Karanth, 1995), camera trapping can also provide other biologically relevant information such as temporal variations (Laidlaw and Shaharudin, 1999), distance of travel, relative abundance in relation to environmental variables, abundance of prey species (Kawanishi, 2002) and other wildlife species in the area (Ajlan and Sharma, 2003). However, obtaining a total count of tigers using camera traps involves excessive resources and effort and there are possibilities of uncounted tigers (Karanth, 1995).

Population censuses are considered to be an important initial step in determining management and protective needs for tigers, which provides a basis for judging the success of tiger management programmes (Ajlan and Sharma, 2003). Despite the obvious reasons in monitoring tiger populations, a comprehensive population survey has yet to be implemented in Assam due to lack of resources and expertise.

Manas National Park is one of the key conservation areas in the entire north east India. It was declared as Tiger Reserves along with the initial 12 tiger reserves of India way back in 1973. The tiger population of this Park was estimated around 90 in the mid 80s. However, due to the civil unrest during mid 1980s till late 1990s caused considerable damage to the entire Park. There is no scientific research work for almost a decade and the flow of conservation information came to a standstill due to the socio-political instability. The impact of the unrest has completely devastated the infrastructure of the Park and information vacuum has further hampered the management of key lifelines that protects the sanctity of the National Park. After a series of negotiations, the political settlement of the civil unrest problem has come through and that has offered a favourable environment to initiate rigorous scientific research programmes in the area. Manas is now in the process of revival. People who disregarded Manas a few years back now have come forward to bring back the past glory of Manas again. The researchers, conservationists, nature lovers, politicians, teachers, lawyers, students and the local community have joined together in a common platform with a strong believes to save and restore Manas.

The current tiger population is around 65 based on 2002 official census, which was carried out following pugmark technique. The Manas tiger population has suffered a lot during the long civil unrest period in the region. During those years the habitat has been altered substantially. Most of the forest, grassland, wetlands and river-course are changing at ever accelerating rate. Almost everyone has seen these changes to their local environment but without a clear understanding of their impact. It is not until we study Manas landscape from a spatial perspective and the time scale that we can begin to measure the changes that have occurred and predict the impact of changes to come. Patterns of land cover change in most tropical developing countries relate significantly to anthropogenic impacts and are extremely complex, with change occurring across multiple spatial and temporal scales (Woods and

Skole, 1998; Duncan *et al.* 1999). An area of 20.05 sq. km has been deforested within the Park boundary within these years; out of which 15.33 sq. km. has been deforested in the southwestern part of the Park whereas 4.72 sq. km has been deforested in the eastern most part of the Park (Lahkar *et al*. 2006). During the civil unrest problem few smugglers took the opportunity and started illegal logging. Political pressure from this growing population, driven by feelings of deprivation and neglect, may become the greatest threat to the future of the Park (Deb Roy, 1991). The swampy grassland, which is a major habitat of many prey species of tiger reduced drastically (87.17 %) during last ten years (Lahkar *et al*. 2006). Grasslands play a vital role for many of the wildlife species including tiger in Manas. Their reduction in size caused serious concerns. The major causes of the decline are unscientific management of grasslands resulting in cutback of water holding capacity of the soil, massive invasion of few exotic weeds like *Eupatorium sp., Melastoma* sp., *Lea* sp. (fire resistant sp.) and marked augmentation of *Bombax ceiba* saplings. During the last decade two disastrous floods caused heavy damage, which carried vast silt from the upstream and spread and deposited all over the low-lying areas of the Park. Most of the low-lying areas being swampy grasslands, suffered most. Consequently, during the 90s there was no proper management step taken, possibly because of break down of law and order, which potentially stimulated to such habitat alteration. No studies till date have examined the influence of floods in this type of land cover alteration. These grasslands are naturally dynamic and subjected to altered flooding regime due to the change of the river course and are subjected to additional disturbances from fire, grass collection, grazing, encroachment and agricultural conversion (Lehmkuhl, 1989; Singh, 1965; Biswas *et al*, 2002). However since 2004 there was gradual raise in the swampy grassland area, possibly because of the heavy rainfall after a prolonged dry period in 2004. The 2004 imagery was taken during a dry period of March. There was a marked eastward shifting of four km of the river Beki and on the other hand the river Manas almost dried out from Mathanguri onwards. There is an urgent need to study the landmass dynamics of the Park, primarily because to understand the impact of different landscape elements over the changing landscape pattern. Heavy siltation along the riverbanks also resulted in increase in river sand area. Logging is primarily the cause for the siltation. The woodland area almost remained same during these years; however currently the area occupied by mixed moist deciduous forest is dreadfully trifling (65.61 sq. km). Species specific to this type of habitat may have some problems. The semi evergreen forest has a greater coverage of area (177.02 sq. km). Most of the semi evergreen forest are well

protected and intact lying in the northern part of the Park touching Indo-Bhutan border. These patches play a crucial role in trans-boundary movement of wild animals including tiger.

As by now, the civil unrest period is over in the Park area, there is an urgent need to find out the population status of tiger in Manas. In mid 80's Manas possibly has the highest density of tiger in the entire subcontinent. A reliable estimate of population size related to demography is important to planning for the conservation of a species, especially in a protected area that is under intensive management. Database information on its population status and dynamics often assist in proper management practice. A clear scenario of the demography of the population in Manas is needed for various reasons.

OBJECTIVES

The overall objective of the project is to find out the presence and absence data of tiger and possible level of density. In India, already camera trap is used for tiger estimation in many Parks, however in Manas this was for the first time the method is applied. This report presents the preliminary findings of the results of camera trapping of tigers and other wildlife species in the Park. Through this approach, a team of local young biologist would be trained to use camera trap method and this team can play a vital role in future tiger population study in the entire north east India. Publication of awareness materials in local language was another activities to be carried out during the project tenure.

CHAPTER-II

STUDY AREA

Location and geology

Manas National Park (Fig. 1) is located at the foothills of the Bhutan Himalayas in Baksa and Chirang districts of Assam (26°35'-26°50'N, 90°45'-91°15'E). It spans on both sides of the Manas River and is restricted to the north by the international border of Bhutan, to the south by thickly populated villages and to the east and west by reserve forests. Elevation ranges from 50 m MSL on the southern boundary to 250 m MSL along the Bhutan hills. The Manas National Park occupies an area of 500 sq. km., which forms the core area of the Tiger Reserve (2837 sq. km). The Tiger Reserve stretches over a length of 150 km. as a continuous belt of forests along the foothills between the rivers Sankosh in the west to the river Dhansiri in the east. It is contiguous with Royal Manas National Park (1023 sq. km.) of Bhutan. The Manas National Park is located at the junction of Indo-Gangatic, Indo-Malayan and Indo-Bhutan realms and is a key conservation area in the *Jigme Dorji-Manas-Bumdeling* conservation landscape in the eastern Himalayan eco-region (Wikramanayake *et al.* 2001). It is situated in the eastern *duăr* and has extensive *bhabar* and some *terăi* areas, typical of Himalayan foothills. These *terăi* like tracts are more or less flat. The natural gradient of the land is gentle sloping southward and area along the southern boundary is more flat and get water-logged during the rains. The river Manas, named *Dagme Chu* (in Bhutan) joined another stream *Mangde Chu*, floating down through Manas National Park and by splitting up into three major streams known as Manas, Hakuwa and Beki, to join the River Brahmaputra some 50 km further south. These and five small rivers running through the Park carry enormous amounts of silt and rock from the foothills as a result of heavy rainfall, steep gradients and friable bedrock upstream. Over the limestone and sandstone bedrock of the Bhabar savanna area in the north, this has formed shifting river channels and swamps and a soil of porous alluvial terraces of coarse detritus under layers of sandy loam and humus where the water level is very low. The terai grasslands in the south consist of deep deposits of fine alluvium with underlying pans where the water table lies very near the surface, making it potentially useful farmland. The Manas basin in the west of the Park is frequently flooded during the

monsoon but never for very long due to the sloping relief. Drowning of wildlife is negligible as animals are able to take refuge on islands of high ground (Deb Roy, 1991).

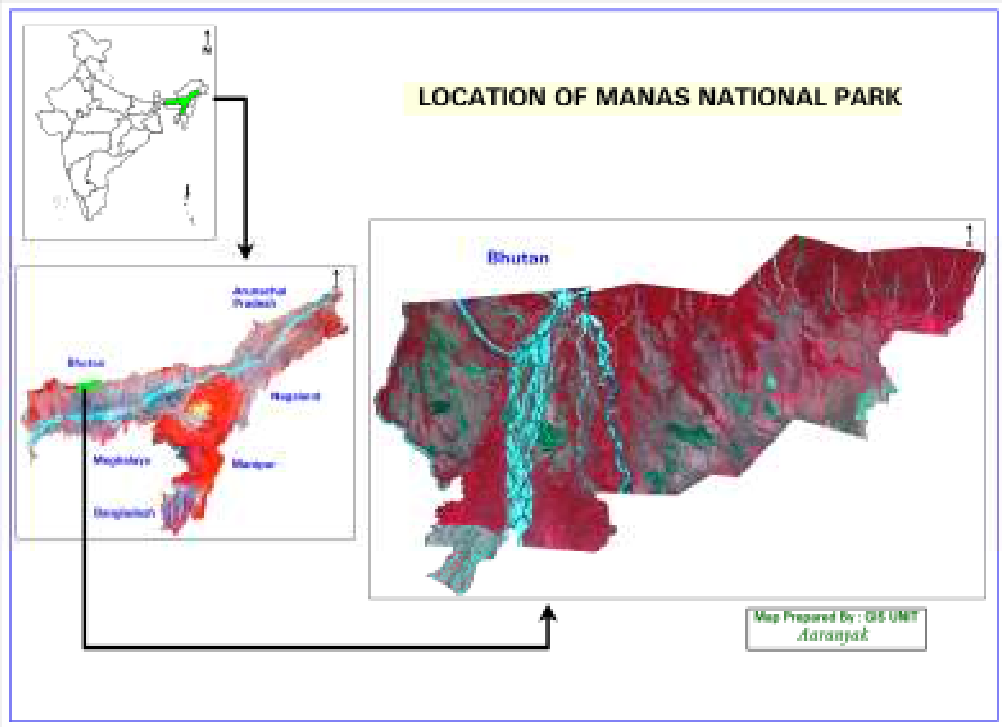

Fig. 1. Map of the study area

Climate

The climate is warm and humid with up to 76% relative humidity. It rains from mid-March to October with most rain falling during the monsoon months from mid-May to September, flooding the western half of the Reserve. The mean annual rainfall is 3330 mm. November to February is relatively dry when the smaller rivers dry up and large rivers dwindle (Deb Roy, 1991). The mean maximum summer temperature is 37°C and the mean minimum winter temperature is 5°C. The climate can be divided in four distinct seasons on the basis of variation in rainfall, temperature and winds (Borthakur, 1986). These are winter (December-February), pre-monsoon (March-May), monsoon (June-September) and retreating monsoon (October-November).

Vegetation

There are three main types of vegetation: sub-Himalayan alluvial semi-evergreen forest, east Himalayan mixed moist and dry deciduous forests, the commonest type, and

grasslands. Much of the riverine dry deciduous forest is an early successional stage, being constantly renewed by floods. It is replaced by moist deciduous forest away from watercourses, which is succeeded by semi-evergreen climax forest in the northern part of the Park. Its common trees include *Aphanamixis polystachya, Anthocephalus chinensis, Syzygium cumini, S. formosum, S. oblatum, Bauhinia purpurea, Mallotus philippensis, Cinnamomum tamala, Actinodaphne obvata;* Tropical moist and dry deciduous forests are characterized by *Bombax ceiba, Sterculia villosa, Dillenia indica, D. pentagyna, Careya arborea, Lagerstroemia parviflora, L. speciosa, Terminalia bellirica, T. chebula, Trewia polycarpa, Gmelina arborea, Oroxylum indicum* and *Bridelia spp*.

Two types of alluvial grasslands cover almost 42.84% of the Park: low alluvial savanna and semi-evergreen alluvial grassland (Lahkar *et al.* 2006). These are created and maintained by burning, and on a smaller scale, by elephants. The riparian grasslands are the best tiger habitat in India, and also well suited to the unique wild buffalo herds, gaur and swamp deer, elephants and waterbirds. There are 43 different grass species, *Imperata cylindrica, Saccharum narenga, Phragmites karka* and *Arundo donax* predominating (Menon, 1995) in eight major associations. There are also a variety of tree and shrub species such as *Dillenia pentagyna*, which dominates the swamp forest, silk cotton *Bombax ceiba,* a dominant of the savanna woodland, and *Phyllanthus emblica*, and shrub species of *Eupatorium, Clerodendrum, Leea, Grewia, Premna, Mussaenda, Sonchus, Osbekia* and *Blumera.* There is a wide variety of aquatic flora along riverbanks and in the numerous pools (Jain & Sastry, 1983). Some 374 species of dicotyledons, including 89 trees, 139 species of 6 monocotyledons and 15 species of orchid have been identified (Project Tiger, 2001).

Fauna

The Park supports an impressive diversity and biomass of large wildlife species. Herbivores density in the grassland ecosystems of Manas rivals that of some East African grasslands (Eisenberg & Seidensticker 1976). A total of 55 mammals, 50 reptiles and three amphibians have been recorded, several species being endemic (Project Tiger, 2001). Manas contains 22 of India's Schedule I (Wildlife Protection Act, 1972) mammals

and at least 33 of its animals listed as threatened, by far the greatest number of any protected area in the country. Many are typical of Southeast Asian rain forest and have their westernmost distribution there, while other species are at the easternmost point of their range. Before the tribal incursions, the populations of all the protected species were gradually increasing, including that of the indicator species, the Tiger (Deb Roy, 1992). Important fauna includes Tiger, Leopard, Elephants, Gaur, Wild buffalo, Sambar, Hog deer, Swamp deer, Pygmy hog, Golden langur, Bengal Florican, etc.

Over 450 species of birds including migrants have been recorded and about 350 breed in the area, 16 being endemic (Deb Roy, 1991) including the threatened Bengal Florican *Houbaropsis bengalensis*. The Bengal Floricans of the National Park were estimated at 80 individuals with 24 male territories in the Park in 1988 (Narayan *et al.*, 1989).

CHAPTER-III

Materials and methodology

Methods

This particular study is based on no sampling, protocol or design efforts and no particular planning. However it may be termed as random approach. The usage and placement of camera traps were completely arbitrary and the data collected from the study may be termed as 'opportunistic'. The result would point to the usability of camera trap in the Manas landscape and for future tiger study as well. This is mainly because of lack of sufficient resources and remoteness of the area (with no communication mechanisms to most of the park area). Approach of this study may be consider as the "stepping stone" on the new generation of tiger population estimate effort in Manas National Park.

The general sampling design and statistical analyses normally used to estimate tiger density based on photographic capture data following Karanth and Nichols (1998). In our case however, as there were only few camera traps some modifications to the sampling design were done so as to fit the local conditions. Two types of camera systems were used in this study: one system was designed by Centre for Electronics Design and Technology (CEDT), Indian Institute of Science (IISc), Bangalore. It consist of a motion detection circuit, a controller and a camera, all three packed in a weather and vermin-proof enclosure. The motion detection circuit uses a lens, a passive infrared detector and a amplifier and filter. The detector reacts to any moving body having a temperature different from ambient. The controller receives an input from the detector and then triggers the camera according to settings made by the user. And the other one was *Deercam*. This *Deercam* camera trap is however vulnerable to damage by wild animals as it has got a plastic cover, as in our case two cameras has been totally damaged by wild elephants

Preliminary survey and interviews with local field staff were carried out to maximize the possibility of getting more tiger photographs. Except the Panbari range on the western side of river Manas, the other two ranges Bansbari and Bhuyapara were covered encompassing an area of about 350 sq.km (Fig. 2). The area was sufficient enough to

cover home ranges of several tigers. The sampling duration was from November 2005 to January 2007 with few discontinuations. The ultimate goal of the camera-trapping was to maximize the capture probabilities of tigers, and camera systems were placed at strategic locations beside active game trails and waterholes. Care was taken not to leave a sufficiently larger area without camera traps where a tiger might have a zero capture probability. Trapping locations were, by default, not stationary throughout the sampling period and were moved regularly to nearby areas with fresh tiger sign or shifted to a new location if preliminary results revealed poor animal traffic at the particular site. GPS coordinates of all trap locations were recorded and plotted on maps. A total of 8 camera traps were used on 422 trap nights

The major constraint in this study was limited number of camera traps and limited mobility. Except for five months of dry period (November to March), all roads and trails were virtually inundated because of rain and making it inaccessible on foot or by vehicle. In some areas to install a camera trap the team had to walk through the deep forest for two days and obviously it was not possible to check the installed camera traps in a regular basis. Generally, each trap location was visited for maintenance and data retrieval only once or twice a month. This was a major difference between our study and that conducted by Karanth and Nichols (1998), where transportation by vehicles allowed traps to be checked daily. As the project team wants to cover more areas where the forest staffs reported tigers earlier and it had taken more resources than we planned and took much more time to complete the project. Another hurdle, which took additional resources and time, was the destruction of camera traps by wild elephants.

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Data analysis

As there was several limitations in the study as described above, no program could have been used for data analysis. Again the numbers of tiger captured were too small to be analyzed for density or abundance. However simple analyses were carried out using Microsoft Excel.

CHAPTER-IV

Results

Species photographed

A total of 13 species were photographed including three species belonging to carnivora order (Appendix 1). A total of 117 analyzable photographs were obtained, and of these, 4 included the target species. Of the remaining, 113 photographs showed non target species, predominantly elephants *Elephas maximus* (26.49 %) followed by Sambar *Cervus duvauceli* (19.68 %) and Wild boar *Sus scrofa* (12.82 %). There were around 500 photographs which were considered to be un-analyzable because of poor light or unrecognizable animals.

Trap rates (number of photographs per camera day) of the target species was estimated to be 0.0094 whereas that of the non target species was 0.26. The un-analyzable photographs were however excluded from this analysis. More than 10 nil photographs per trap effort were usually obtained because the sensor was affected by many factors. The changes in trap rates in each study month is shown in Fig. 3. The trap rate of three major species is also shown in Fig. 4. A total of 13 species were recorded with a trap rate of 0.03 (Fig. 5). The average trapping night per site was 12.05 (SE = ±0.52).

A total of four tiger photos, representing 3.41 % of all wildlife photos, were collected at the 35 trapping sites during a total of 422 trap nights between November 2005 to January 2007. The tiger photographs were obtained from Jungrang and Garuchara area (Fig. 6). During the study period camera trap was successful in detecting all medium to large animal in the Park (Appendix. I). The photograph of the wild dog was the first valid record of the species. The reason for failing to photograph more tigers during the study period is uncertain: perhaps the less number of camera traps contributed more, or may its activity may have been low during our study period, it might avoid cameras or trails with human smell. Or there may be very few tigers left in the study area.

The data collected from this study was inadequate for tiger density estimation analysis. However, the present study successfully able to photograph many species which were considered to be in threat because of decade long civil unrest in the region.

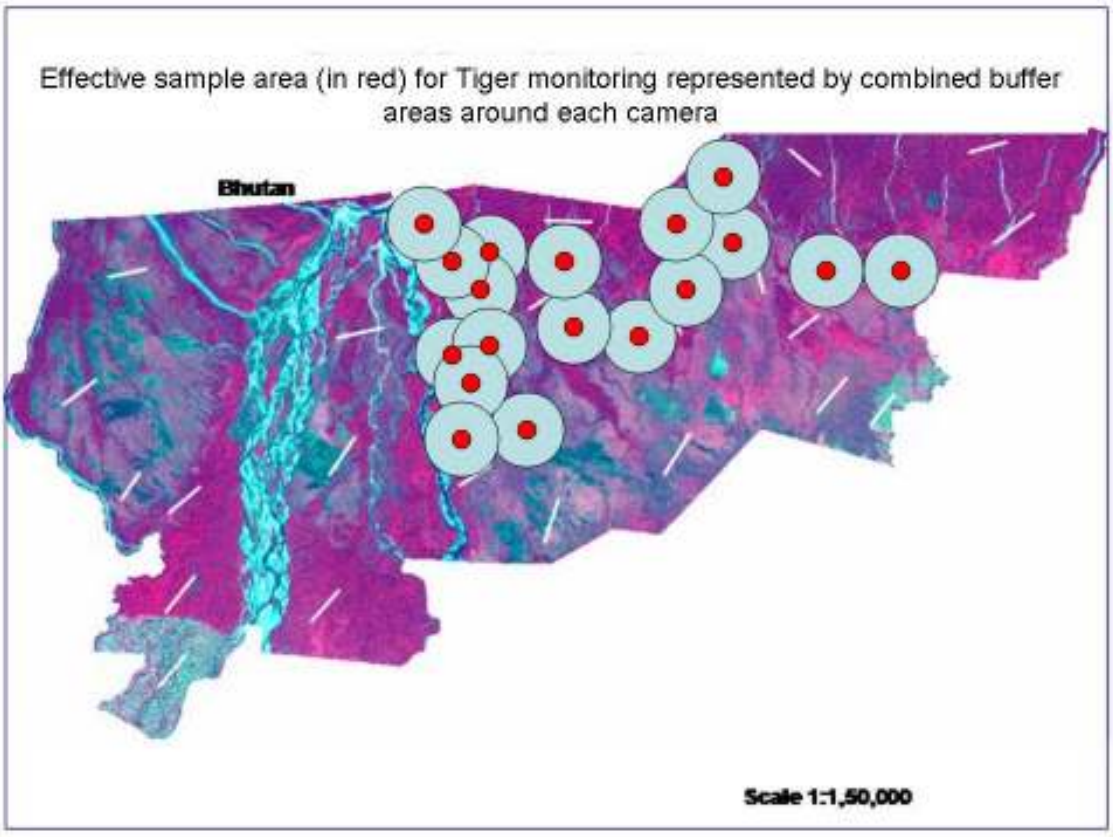

Fig. 2. The camera trap locations covering most of the Bansbari and Bhuyapara range. However certain locations were altered to a less distance hat can't be seen here.

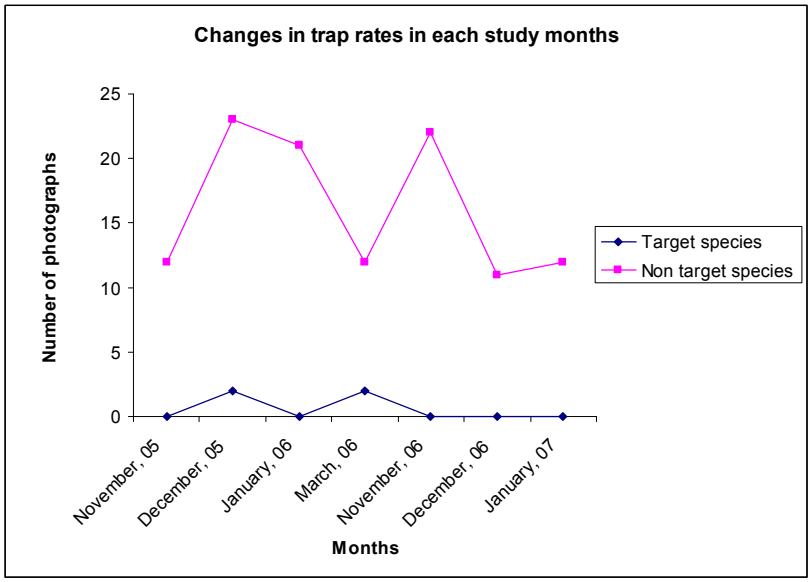

Fig. 3. Changes in trap rate during the study period. However the nil or un-recognizable photographs were excluded.

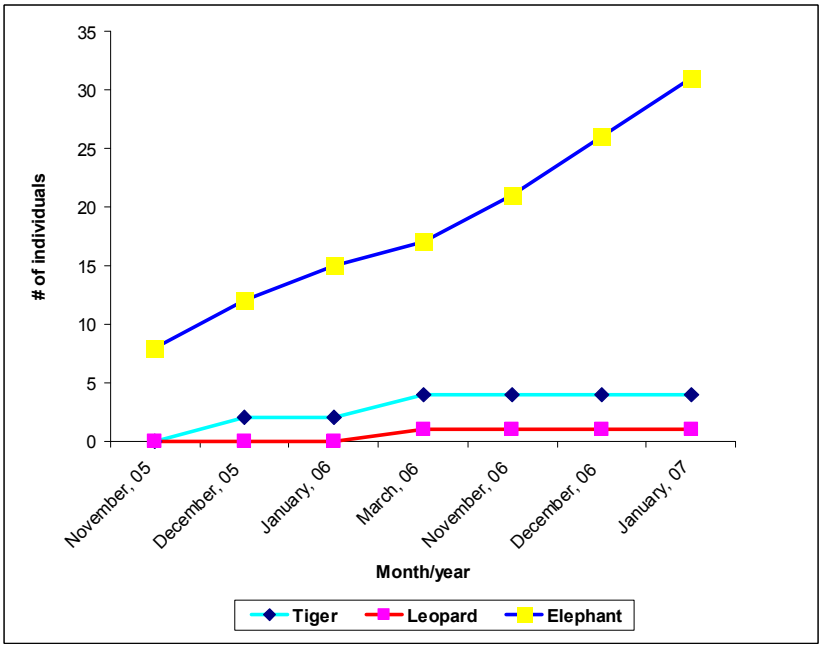

Fig. 4. Cumulative number of individuals of tiger, Leopard and Elephant

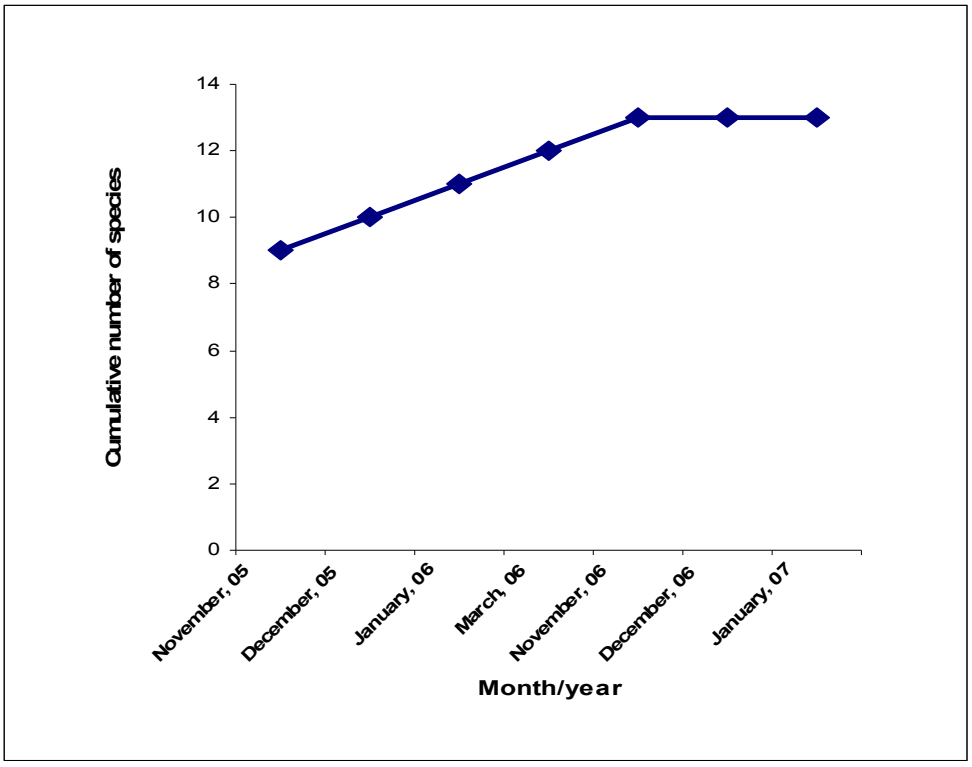

Fig. 5. Cumulative number of species recorded during the study period

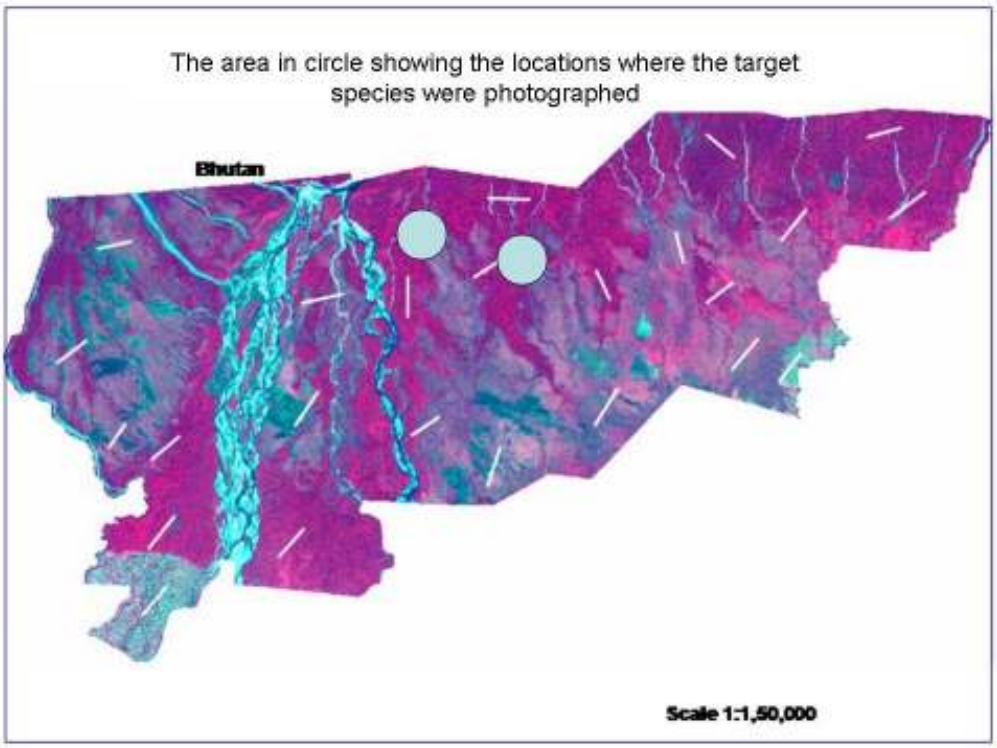

Fig. 6. The circles showing the area where tigers were photographed

Other activities during the Project:

A booklet on the tiger status and it needs for conservation in Manas National Park area was published in local language. One poster was also published in two local languages were treats to the species in Manas were highlighted in interesting sketch pictures. Both these awareness materials were distributed freely in the fringe areas of the Manas National Park.

Appendix.1 The species photographed and their numbers

Sl No	*Species*	*Number*
1	Tiger	4
2	Leopard	1
3	Elephant	31
4	Sambar	23
5	Hog deer	6
6	Barking deer	3
7	Wild dog	3
8	Crab-eating mongoose	3
9	Wild boar	15
10	Gaur	12
11	Wild Buffallo	14
12	Rhesus macaque	4
13	Capped langur	2
14	Lesser Adjutant Stork	1

CHAPTER-V

DISCUSSION

As mentioned earlier, the data obtained from the study is not sufficient to estimate tiger population in the Park. However, this study has provided all necessary stands for future study of tiger in the Park. Although it is understandable that the Park still holds a viable population of tiger, we think that relative and absolute density of tiger in the Park should be established immediately and are the two highest priorities for future research if we are to protect tiger in the Park. This study has revealed the utmost necessity of future research to ensure better management of the tiger and its prey base as well as to find out possible ways of reducing biotic pressure from the Park. Till date there is no accurate estimate of tiger density in the Park based on modern technique i.e. camera trapping, telemetry or DNA fingerprinting. We propose to follow capture-recapture model data derived from camera traps in future. However for that, a sufficient number of camera traps are needed to photograph (i.e., "capture") enough individuals of the target species to generate a statistical estimate of abundance.

The prime tiger habitats in Manas National Park have been under tremendous disturbance for over a long period. After a decade long unrest, human habitations around the Park have increased, along with grazing intensity and excessive movement of people at least in two ranges, causing severe disturbance. There are 61 fringe villages touching the southern boundary of the Park with a human population of over 10,000, and this has resulted in degradation and increased pressure on the Park. We propose to conduct a medium-scale motivation and awareness campaign in the schools, colleges, and other public gathering places in adjacent villages in order to make people aware about the importance of tiger conservation in the maintenance of ecosystem functioning and better livelihood for the local people. Seminars and slide shows should be regularly organized in order to inform and encourage the policymakers, intellectuals and other educated bodies in the BTAD (Bodoland Territorial Autonomous District) area.

Of the three ranges in Manas, only the Bansbari range has a high population of wild prey species. The rest of the ranges (Bhuyapara and Panbari) of the Park are under heavy biotic pressure from domestic livestock. Like many protected areas in India, Manas is also suffering from the problem of staff shortage. Unfortunately, the frontline staff is unmotivated, over aged, untrained and unfit for foot patrolling. Recently, however most of the poachers have surrendered and they are supporting the Park authority in patrolling. But this system also has to be managed in a sustainable manner eying for a long term viability.

Most parts of the study area become inaccessible during the monsoon, which leads to a concern for a specific protection strategy for the specific problems. Almost throughout the year, the Park is vulnerable to illicit grazing, felling of trees as well as poaching which necessitates surveillance at some sensitive places. The following measures have been proposed to undertake:

1. Establishment of Anti-poaching camps at sensitive locations inside the Park specially in the Southern boundary and the river side.
2. Regular patrolling mechanism by the forest staffs should be carried out effectively
3. Additional forest staff should join immediately to boost the protection mechanism of the park.
4. Control room of different range offices and camps should record systematically the animal sighting records.
5. Regular training camps should be organized for grass root forest staffs for effective patrolling and maintaining a systematic records of animal sightings.
6. Vehicles (jeep) in all ranges shall be provided and in case of emergency an additional vehicle with sufficient staff shall be provided at the control room so that the additional force can rush to the trouble spot.
7. All necessary protection infrastructures must be well maintained and replenished when necessary.

Lesson learnt by the research team

During the study, the research team has got adequate knowledge on the geography of the study area and ways of quickly accessing to monitor camera traps before they cease to function (because they have run out of either film or battery power). Beside this the team has acquired at least a rudimentary idea as to the topographic features of areas inhabited or sites visited by the study animal, and their travel routes. Along with the research team few local youths were also trained and this has created enough people familiar with the function and maintenance of camera traps to deploy and monitor the traps in a timely fashion. The study can provide a thumbnail idea of the capture rate of tiger. Another important fact gained by the team is the need of extra camera traps to act as replacements in the event of damage by wild animals or equipment failure.

Impact of the Project :

1. A group of local wildlife researchers have been trained for estimating tiger population using camera trap method.
2. First ever photograph of a tiger was taken using camera trap in Manas National Park.
3. Can be considered as a base line study for tiger population estimation in Manas using the camera trap method.
4. Policy makers at the local level were convinced that such attempts of tiger population estimation is possible in Manas using camera trap method.
5. Proect team is convinced that in Manas Tiger population is definitely less in number than it was estimated or assumed earlier.

Immediate follow up needed

An extensive programme of camera trap estimation of tiger in Manas using more camera and resources is an urgent need for understanding the tiger population status of Manas National Park.

PHOTO SECTION

Photo 1: Camera Trap Training and Testing

Photo 2: Installing Camera Trap

Photo 3: Camera Traps

Photo 4: Remains of a camera trap broken by wild elephant

Photo 5: Landscapes of Manas National Park

Photo 6: First Camera Trapped Tiger in Manas National Park

Photo 7: Another Camera Trapped Tiger

Photo 8: Camera Trapped Leopard

Photo 9: Camera Trapped Wild Buffalo

Photo 10: Camera Trapped Indian Gaur

Photo 11: Camera Trapped Wild Elephant

Photo 12: Camera Trapped Sambar

Photo 13: Camera Trapped Barking Deer

Photo 14: Camera Trapped Sambar

LITERATURE CITED

Ajlan, J. and S. K. Sharma (2003). Camera trapping the Indochinese Tiger, *Panthera tigris corbetti,* in a secondary forest in peninsular Malaysia. The Raffles Bulletin of Zoology, 51(2): 421-427.

Biswas, T., V. B. Mathur and V. B. Sawarkar (2002). A report on the current status and distribution of hog deer (*Axis porcinus*) in India. Survey report submitted to Wildlife Institute of India, Dehradun, India.

Borthakur, M. (1986). Weather and Climate of North East India. *The North east Geographer,* 18 (1&2): 20-27

Deb Roy, S. (1991). Manas - A monograph**.** *Tigerpaper,* 18: (1). 10 pp.

Deb Roy, S. (1992). *Manas - A World Heritage Site.* A report to the 4th World Congress on Protected Areas, Caracas, Venezuela

Duncan, B. W., S. Boyle, D. R. Breininger and P. A. Schmalzer. (1999). Coupling past management practice and historic landscape change on John F. Kennedy Space Center, Florida. *Landscape Ecology,* 14: 291-309.

Eisenberg, J. F. & J. Seidensticker, (1976) Ungulate in southern Asia: a consideration of biomass estimates for selected habitats. *Biol. Conserv.* 10: 293-308

Griffiths, M. (1993). Population density of Sumatran tigers in Gunung Leuser National Park. *Tiger Beat* (Newsletter of the tiger species survival plan), 6: 17-18

Jain, S. & A. Sastry, (1983). *Botany of Some Tiger Habitats in India*. Botanical Survey of India, Howrah. 71 pp

Karanth, K. **U. (1987).** Tigers in India: a critical review of field census. In: Tilson, R. L. and U. S. Seals (eds.) *Tigers of the world,* Noyes Pub, Park Ridge, New Jersey, USA, Pp-118-133

Karanth, K. **U. (1988).** Analysis of predator-prey balance in Bandipur Tiger Reserve with reference to census report. *JBNHS;* 85: 1-8

Karanth, K. **U. (1991).** Ecology and the Management of the tiger in tropical Asia. In: Maruyama, N., B. Bobek, Y. Yono, W. Reglin, L. Bartos and R. Ratcliffe (eds.)- *Wildlife Conservation: Present Trends and Perspective for the 21st century*, Tokyo, Japan Wildlife Research Center. p. 156

Karanth, K. **U. (1993a)**. How many tigers? Field censuses in India. *Hornbill*, 1; 2-9

Karanth, K. U. (1993b). The relevance of big cats numbers to their conservation. *Cat News* (Newsletter of the IUCN Cat Specialist Group), 19: 11-12

Karanth, K. U. (1995). Estimating tiger *Panthera tigris* populations from camera-trap data using capture-recapture models. *Biological Conservation*, 71: 333-338

Karanth, K. U., and J. D. Nichols. (1998). Estimation of tiger densities in India using photographic captures and recaptures. Ecology 79(8):2852-2862.

Kawanishi, K. (2002). *Population status of tigers (Panthera tigris) in a primary rainforest of peninsular Malaysia.* PhD Dissertation. University of Florida, Gainesville, USA. 150 pp.

Lahkar, B. P., J. P. Das, N. K. Nath, S, Dey, N. Brahma and P. K. Sarma (2006). Habitat evaluation of Asian elephant *Elephas maximus* and spatial aspects of human elephant conflict in Manas National Park using Remote Sensing/GIS. *in proceeding of International Elephant Conservation and Research Symposium 2006. Denmark.*

Laidlaw, R. K. and W. Shaharuddin, (1999). Activities patterns of the Indochinese tiger *(Panthera tigris corbetti*) and prey species in peninsular Malaysia. *The Journal of Wildlife and Parks,* 16: 127-134

Lehmkuhl, J. F. (1989). The Ecology of a South-Asian Tall Grass Community. Ph.D Dissertation. University of Washington, Seatle, USA. 195 pp.

Linnaeus, C. (1758). *Systema naturae*, 10th ed. Stockholm

Menon, V. (1995). Continuing concern about Manas Tiger Reserve. *Catnews 23*

Narayan, G., R. Sankaran, L. Rosalind, & A. Rahmani. (1989). The Floricans *Houbaropsis bengalensis* and *Sypheotides indica*. *Annual Report 1988-89. Bombay Natural History Society.* 39 pp

Panwar, H. S., (1979). A note on tiger census technique based on pugmark tracings, *Indian Forester,* Special issue: 70-77

Plowden, C. and D. Bowles, (1997). The illegal market in tiger parts in northern Sumatra, Indonesia , *Oryx*, 31: 59-66.

Project Tiger (2001). Project Tiger Status Report. Ministry of Environment & Forests. Unpublished report. 6 pp.

Rabinowitz, A. (1991). *Chasing the dragon's tail: the struggle to save Thailand's wild cats.* Doubleday, New York. 280 pp.

Rabinowitz, A. (1993). Estimating the Indo-chinese tiger *Panthera tigris corbetti* population in Thailand. *Biological Conservation*, 65: 213-217

Schaller, G. B. (1967). *The deer and the tiger*. University of Chicago Press, USA, 370 pp.

Seidensticker, J. (1986). Large carnivore and the consequences of habitat insularisation: ecology and conservation of tigers in Indonesia and Bangladesh. In: Miller, S. D. & D. D. Everett (eds), *Cats of the world biology, conservation and management*. National Wildlife Federation. Washington DC, Pp-1-41.

Shaharuddin, W. **N., (1999)**. Potential poaching threat to large mammals in Belum and Taman Negara. *The Journal of Wildlife and Parks*, 16: 135-139

Singh, L. R. (1965). *The Terai Region of U.P.: A Study in Human Geology*. Ram Narayan Lal Beni Prasad Publishers, Allahabad.

Wikramanayake, E. D., C. Carpentert, H. Strand, and M. McKnight, (2001). Ecoregion-based conservation in the Eastern Himalaya. Identifying important areas for biodiversity conservation. WWF and ICIMOD.

Woods, C. H. and D. Skole, (1998). Linking satellite, census, and survey data to study deforestation in the Brazilian Amazon. *In:* Liverman, D., E. F. Moran, R. R. Rindfuss and P. C. Stern (eds.), People and Pixels: Linking remote sensing and social science, National Academy Press, Washington, DC, USA, pp. 70-90.

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