Hornbills, hoolocks & hog badgers: monitoring threatened wildlife with local communities in Arunachal Pradesh, NE India

Aparajita Datta, Rohit Naniwadekar, M.O. Anand

nature conservation foundation

Suggested citation:

Datta, A., Naniwadekar, R. & Anand, M.O. 2008. Hornbills, hoolocks and hog badgers: long-term monitoring of threatened wildlife with local communities in Arunachal Pradesh, north-east India. Final report to the Rufford Small Grants Program (UK). Nature Conservation Foundation, Mysore, India. 80 pp.

Nature Conservation Foundation
3076/5, 4th Cross
Gokulam Park
Mysore 570002
Karnataka, INDIA
Email: aparajita@ncf-india.org
Website: www.conservation.in
Ph: +91-821-2515601
Fax: +91-821-2513822

Front cover: Misty forests in the Namdapha valley, and male Rufous-necked hornbill
Back cover: Setting up camera trap (Photo credit: Kalyan Varma), camp in Namdapha valley

Hornbills, hoolocks and hog badgers: long-term monitoring of threatened wildlife with local communities in Arunachal Pradesh, north-east India

Final report

February 2008

Project Investigator
Aparajita Datta

Research Affiliates
Rohit Naniwadekar, M.O. Anand

Project period: July 2006-June 2007

nature conservation foundation

Funded during 2006-2007

The Rufford Small Grants Foundation
www.ruffordsmallgrants.org

Funded by
The Disney Wildlife Conservation Fund (through WCS, NY from 2005 onwards)

Others involved in project

Advisory role: Dr. Charudutt Mishra

Collaborator (Remote sensing analysis): Dr. Harini Nagendra, ATREE
Mapping and GIS analysis: Somajita Paul, R. Raghunath
Volunteer, field wildlife monitoring program: Dr. Meghna Krishnadas

Local field staff:
Field co-ordinator: Akhi Nathany
Duchaye Yobin, Ngwa-akhi Yobin, Khichaye Yobin, Shekhar Subba (Namdapha)
Narayan Mogar, Rasham Barra, Late Taya Tayum, Kumar Tayum (Pakke)
Assistance of 10 more youth from the Lisu community in Namdapha

/

Funding support for wildlife monitoring program
Rufford Small Grants Program, UK (July 2006-June 2007)
Disney Wildlife Conservation Fund, USA (2005-ongoing)

Funding support for overall conservation program (2003-2008)
Wildlife Conservation Society, USA and WCS-India Program (2003-05)
National Geographic Society Conservation Trust Grant, USA (2003-04)
Ford Foundation, New Delhi, India (2005-ongoing)
Katha, New Delhi: primary education for tribal children (2003- ongoing)
Department of Science & Technology (2007-08)
Private donors

CONTENTS

Acknowledgements

We thank the Arunachal Pradesh Forest Department, chiefly S.K. Raha and K. Namchoom (both former PCCFs) and Pekyom Ringu (DCF, Itanagar) for their support, encouragement and positive attitude to this program. I thank the Field Directors (R. Modi, L.K. Pait), Research Officer (SS Chandiramani), and all office and field staff of Namdapha Tiger Reserve for help in various ways. I thank the DFO, Tana Tapi and his field staff in Pakke Tiger Reserve for all their assistance and help. Tana Tapi's dedication and interest in conservation of wildlife in Pakke has really made a difference to the park in recent years.

We thank the *Lisus* for their hospitality, help and support especially Akhi Nathany, Khiyohey Yobin, Phusa Yobin, Akhida Yobin, Ati Juniya Yobin, Sayefa Yobin, Sili Yobin, Duchaye Yobin, Ngwa-akhi Yobin and numerous others in all the *Lisu* villages for taking this forward. We are especially indebted to Akhi, Khiyohey, Duchaye and Ngwa-akhi and their family members for their assistance, wonderful company and memorable times in the forests of Namdapha and in Shidi (Gandhigram). The work with the community would not have been possible without Akhi's friendship, interest, advice and wisdom. There are just too many people among the *Lisu* to thank, so all we shall say is ***Akhe-Shamua*** to all.

At Pakke, we are indebted to Narayan Mogar, Taya Tayum, Rasham Barra for their untiring field work even in my absences that ensured the continued monitoring. We thank Taya Tayum's family members for their hospitality and warmth whenever we stayed at his house. Sadly, Taya Tayum passed away in car accident in December 2007 and roaming in the forests of Pakke, will never be the same again for us without his anecdotes, humour and laughter.

We thank Goutam Narayan and Nandita Hazarika for their friendship and help in so many crucial ways in Guwahati apart from the great company and food in Guwahati. We also thank Rupali, Ajay and others at the Pygmy Hog centre for their help in Guwahati. We thank Dr. Meghna Krishnadas for her assistance in the wildlife monitoring program.

At Miao, we thank Phupla Singpho, Huntu and the rest of his family for their hospitality and company, especially Phupla and several members of SEACOW for their assistance in Miao. We also thank the district administration in Miao, especially Shri Gautam Hazarika, EAC and Shri K. Riram, ADC for their assistance. We also thank Japang Pansa and his family for their company and hospitality in Miao. We thank Shekhar Subba, who apart from being a driver has also greatly assisted in the field work in both Pakke and Namdapha.

The work carried out under this program (2003-2007) was made possible by grants from the Wildlife Conservation Society, the National Geographic Society (Conservation trust grant), Disney Wildlife Conservation Fund and Rufford Foundation.

We thank Charudutt Mishra for the time and effort in discussions and spending time in Namdapha every year assisting and advising in field work as well as the work with the community. We thank TR Shankar Raman, MD Madhusudan, Divya Mudappa, Anindya Sinha and all other colleagues at NCF for their inputs. We are indebted to Rakhee Karumbaya, Viswanath, Naveen Raj, and Vena Kapoor (NCF administrative team) for various logistic and administrative support and help.

Aparajita also wishes to thank Ullas Karanth, AJT Johnsingh, Will Duckworth, Mahesh Rangarajan, NS Prashanth, Umesh Srinivasan, Ajith Kumar, Peter Clyne, Samba Kumar, Tim O'Brien, Margaret Kinnaird, Harini Nagendra, Jagdish Krisnaswamy and Kalyan Varma for their help and support in various ways.

Summary

As part of an ongoing research and conservation program, we are establishing a long-term wildlife monitoring program in order to generate ecological baselines for key faunal groups targeted by hunting in two important protected areas of Arunachal Pradesh, north-east India.

In the Namdapha National Park, a long-term wildlife monitoring program was set up as an important component of a conservation program that seeks to reduce hunting pressures and ensure recovery of wildlife populations threatened by hunting. Poor detectability and low abundance of terrestrial rainforest mammals precluded the use of standard density estimation techniques. We have established the long-term monitoring program with the assistance and the skills of erstwhile tribal hunters. These baselines are also important for future evaluation of the efficacy of welfare and other interventions with the community that seeks to bring about reduction in hunting. We used a variety of techniques (camera trapping, indirect signs to estimate occupancy) to assess status of several faunal groups. We used camera trapping to assess abundance of various terrestrial mammals (large carnivores, herbivores and small carnivores). Clouded leopard *Neofelis nebulosa* was the only large carnivore, and sambar *Cervus unicolor*, wild pig *Sus scrofa* and Indian muntjac *Muntiacus muntjak* were the only large prey detected during camera trapping. While indirect evidences indicated the presence of two other carnivores (wild dog *Cuon alpinus* and leopard *Panthera pardus*) and prey species (gaur *Bos gaurus* and serow *Nemorhaedus sumatraensis*), ***there was no evidence of tigers, strongly suggesting their possible extinction from the area***. Three other small cats (Golden cat *Catopuma temmincki*, Marbled cat *Pardofelis marmorata* and Leopard cat *Prionailurus bengalensis*) and the Himalayan black bear *Ursus thibetanus* and the rare Malayan Sun bear *Helarctos malayanus* were detected. However, relative abundance of most carnivores was considerably lower than estimates of these species from other tropical forest sites in SE Asia. We also examined the use of occupancy models for monitoring the status of four ungulate species that are targeted by hunting and examined the influence of habitat and anthropogenic factors on occupancy of these species. Occupancy estimates were high for Indian muntjac (1) and sambar (0.80) and their presence appear to be unrelated to habitat or anthropogenic factors. The occupancy estimate of wild pig (0.45) was low and negatively affected by disturbance, while occupancy of gaur (0.24) was low and was affected by disturbance as well as habitat factors. Our results suggest that future monitoring should focus on species (such as wild pig and gaur) that are patchily distributed. The rainforests here also harbour a diverse assemblage of mustelids, viverrids and herpestids, many of which are threatened by hunting, yet very little information exists on their status, distribution, abundance and ecology,. Most species are rare and several are nocturnal precluding observational studies, therefore camera trapping is a useful method to document species richness and estimate relative abundances. Relative abundances of small carnivores were estimated and compared to those obtained in several other tropical forests. Namdapha and Pakke are believed to harbour 14 species of terrestrial/arboreal forest-dwelling small carnivores We recorded seven species in 1656 trap nights in Namdapha, while at Pakke with a limited effort of 231 trap nights, we recorded four species. Direct sightings and indirect evidence confirmed the occurrence of some other species. Relative abundances of almost all seven species were high relative to that in tropical forest sites in south-east Asia; however rare species such as the binturong *Arctictis binturong*, spotted linsang *Prionodon pardicolor*, and stripe-backed weasel *Mustela strigidorsa* were not recorded by camera trapping at either of the two sites. Capture rates of the Large Indian civet *Viverra zibetha* was relatively high in Namdapha compared to other

species and along with the yellow-throated marten, they appear to be more common. Evidence of incidental or retaliatory hunting was recorded for most species; otters are highly threatened in Namdapha due to considerable hunting for its skin which has high market value. Based on our preliminary baseline data, most species appear to occur at very low abundances in Namdapha. An immediate conservation need is elimination of hunting. We argue that problems faced by local communities need to be addressed, in order to alter currently antagonistic relationships with park authorities. Our conservation program with the *Lisu* tribe has however, resulted in reduced hunting over the last 2 years and an opportunity now exists for using their skills and knowledge of the landscape for wildlife protection.

Although hunting is the most serious threat, habitat degradation is also an increasing threat to the park. We assessed the changes in forest cover from 1999 to 2005 to determine the impacts of the human settlements that have come up inside the park mainly from the late 1990s. Our preliminary results suggest a considerable decrease in dense tropical forest, although a majority of this change appears to be due to an increase in bamboo forest and natural open forest (regeneration in landslide areas) in 2005. About 16 km^2 of the park has been affected by anthropogenic pressures which is largely due to dependence of local communities on subsistence cultivation, limited availability of such land, lack of other livelihood opportunities and need for natural resources from the park. Decisions regarding relocation of *Lisu* families inside the park are pending for the last several years and unless alternate solutions are found, there is likely to be further influx into the park given perceived land shortage by the *Lisu* and weak administrative control over the area.

At another important PA in western Arunachal, the Pakke Wildlife Sanctuary & Tiger Reserve, continuous monitoring of hornbill nest and roost sites for about 10 years now has ensured that there are no hunting instances as well as provided valuable information on annual variations in nesting activity and success, turnover and loss of nest trees and patterns in use of roost sites. Here, we have also established long-term monitoring of important faunal groups such as arboreal mammals, pheasants, hornbills, and large herbivores to understand trends in status of wildlife populations in an area that has been under better management and protection than Namdapha and where hunting pressures have declined considerably over the last 10 years. Our preliminary analysis suggests that large terrestrial mammal abundances are much higher in Pakke than in Namdapha and this is possibly due to lower hunting pressures in the recent past.

About contributions to the report

The diverse activities carried out under the field monitoring program was undertaken by a team of skilled and trained tribal field staff (mostly erstwhile hunters) along with students and other interested volunteers. Two research affiliates were involved in data entry, analysis and partial writing up of some chapters. The remote sensing analysis was carried out in collaboration with Dr. Harini Nagendra of ATREE and students. Therefore, each chapter has had contributions of different sets of people, although I have collated and put together the full report.

Disclaimer: The data presented here in some sections of the report are preliminary findings, further compilation and analysis is underway and therefore assertions made here are tentative.

Chapter 1

Introduction

Arunachal Pradesh: biodiversity hotspot

The Eastern Himalaya and the hills of NE India are recognized as a global biodiversity hotspot. While NE India occupies 8% of the country's area, it harbors 56% of its faunal diversity. Within this region, arguably the most biodiversity-rich state (the largest among the seven in North-east India, covering 83,743 km^2) is the state of Arunachal Pradesh (26°28'– 29°30'N and 91°30'– 97°30'E). Arunachal is considered among the least developed and most remote.

Lying in the Eastern Himalayan region, AP has remained isolated from the rest of India by virtue of its geographical position and inaccessible terrain. It is situated in the north-easternmost part of India and is surrounded by international boundaries of Bhutan to the west, Tibet to the north and Myanmar to the east. To the south, it is bordered by Assam and Nagaland. Large forest areas still remain, in part due to its low human populations. About 82% of the geographical area is actually forested compared to the national average of 21%, albeit the recorded forest area is 62% of the total area (FS1 1999). The state has great biological significance as a result of its position at the confluence of the Palaearctic and Indo-Malayan biogeographical realms. It is among the 200 globally important ecoregions (Olson & Dinerstein, 1998). The state harbours the world's northernmost tropical rainforests and an estimated 7000-8000 species of flowering plants occur here (nearly 50 % of the total flowering plants in India). About 625 orchid species are reported from Arunachal (A.N. Rao, pers. comm.) Of the 1200 bird species in India, over 600 have been recorded here. Arunachal is also home to over 100 mammal species. The wide altitudinal range (100 to 6000 m) has resulted in a great diversity of forest types.

Of the recorded forest area, 9722 km^2 (12%) is classified as Reserved Forest (RF). Protected Forests, Anchal Reserve Forests, Village Reserve Forests and Unclassed State Forests (USF) constitute the remaining forests. The latter, where tribal people have customary rights, comprise the largest area of 30,965 km^2 (37% of the geographical area). Ten wildlife sanctuaries (7114 km^2) and two national parks (2468 km^2) (of which two are tiger reserves) covering an area of 9582 km^2 (11.44 % of the geographical area) have been established. Pioneering avifaunal surveys were first undertaken by Salim Ali along with Dillon Ripley. Floral and faunal inventorying has been undertaken by various Government-sponsored organizations, notably the State Forest Research Institute, Botanical Survey of India, Zoological Survey of India and the North-eastern Regional Institute of Science and Technology. Since the 1990s, several wildlife surveys and research projects have taken place. Recent herpetofaunal surveys have yielded new species, range extensions and first records for India. Mammal surveys have resulted in discoveries of three mammals (the leaf deer *Muntiacus putaoensis*, black barking deer *Muntiacus crinifrons*, Chinese goral *Nemorhaedus caudatus*) representing new additions to the large mammals of India, apart from a new primate species, the Arunachal macaque, *Macaca munzala*). These surveys and ecological studies have yielded important discoveries and information, but many areas remain unexplored. These discoveries also underline the importance of this region for wildlife and points to the fact that unless successful conservation efforts are undertaken, we may lose species without even knowing they existed. Apart from this, many species play a role in ecosystem functioning and processes and often the decline or extinction of certain species can lead to cascading effects. For instance, carnivores would be affected by prey depletion, while many large-seeded rainforest tree species would be affected by disappearance of large frugivores such as hornbills. There have been numerous examples of local extinction primarily due to hunting.

Cultural and socio-economic context of Arunachal Pradesh

The people are predominantly tribal, however, the percentage of the population that is Scheduled Tribe (ST) is steadily declining from 88% in 1961 to 64 % in 1991. There are 26 main tribes and 110 sub-tribes, each with specific geographic distributions and distinct linguistic, cultural, and social identities. Some major tribes are the *Monpa*, *Nishi*, *Adi*, *Apatani*, *Idu Mishmi*, *Miju Mishmi*, *Khampti*, *Tangsa*, *Wancho* and *Nocte*. In fact, it is a microcosm of the larger diversity within India; generalizations about the state fail to reflect the complexities. There are 15 districts in the state which are divided into numerous circles comprising of villages. Villages are homogenous (of one single community) unlike those in other parts of India. There is no demarcation of land into revenue lands or land records. Boundaries of agricultural lands and villages are determined by local communities based on traditional knowledge and rules. People have customary rights over community forests, most of which is classified as USF. Although Arunachal has the lowest human density compared to other states, its decadal growth rate (1991-2001) of 26% is higher than the national average of 21%. Population density varies from 3 per km^2 in Dibang Valley to 36 per km^2 in Tirap district. Agriculture is the main occupation (nearly 80%). Most tribes have traditionally subsisted on hunting and shifting cultivation, although many also practice settled rice cultivation in the valleys. There has also been considerable socio-economic transformation from zero urban population in 1961 to 26% urban population. Literacy has increased from 7% in 1961 to 55% in 2001. However, the lack of employment opportunities has resulted in continued dependence on subsistence agriculture and forest resources. Arunachalis have benefited from laws formulated first by the British and later by the Indian government, restricting the entry of non-tribals to the area. Indeed, in Arunachal Pradesh, people are proud of their tribal identity (although that seems to be changing somewhat in the youth now exposed to outside influences and frustrated by limited opportunities). They have not felt the marginalization/alienation with their own culture that has happened in other tribal societies. Government policies till date ensure preferential job reservation and other benefits. Increasingly, government positions (even at the top) are largely occupied by tribal people. Among all the north-east states, Arunachal is perceived to be a haven of peace (although inter-tribal disputes are increasing). However, there are numerous problems, chief among which is unemployment. The state largely depends on aid from the Union Government and there is hardly any industry generating revenue. Most people depend on Governments jobs which are few, with fierce competition between tribes, often decided through political connections. There are a large number of unemployed educated youth. In the present day, corruption (absent earlier) is pervasive in Arunachal, learnt from contact with non-tribals. The people are undergoing transition with increasing consumerism due to exposure to outside influences. Even their egalitarian society is changing with differences based on economic status, education level and between urban and remote rural communities.

Conservation problems

The NE region has 64% forest cover which is considerably higher than other areas of India. Fifty-six% of these forests are community forests with a predominantly tribal population and an area of 173,000 km^2 under *jhum* cultivation. From 1991 to 1999, estimates show a decrease of 1800 km^2 in forest cover in North-east India (FSI).

The conservation history of Arunachal is relatively recent. Though 12% of the geographical area has been brought under the PA network, the on-ground implementation of wildlife laws against hunting has not been successful. However, despite the imperfections of law enforcement and the prevalence of hunting even in PAs, they still afford a greater level of protection to wildlife than USF and RFs. 70% of the forests are community-owned. Although population density is the lowest in India, the growth rate is high at almost 3% per year, increasing from 10 per km^2 in 1991 to 13 per km^2 in 2001. Recent estimates suggest that dense forests cover only 16% of the area. People are primarily dependent on shifting cultivation, the only viable option in the hilly terrain. However, due to low population densities, in many areas, the *jhum* cycles are still relatively long compared to other states in the North-east. According to some estimates, shifting cultivation occupies 2300 km^2. Today, however, *jhum* is on the decline among many communities. The main sources of revenue for the state were forest-based industries till 1996, after which the Supreme Court banned logging. Combined with shifting cultivation, poorly regulated logging has resulted in loss of forest cover especially in the foothill forests of some districts. About 421 km^2 of dense forest has been lost over the last decade. Scientific studies have documented the detrimental impacts of logging on wildlife and forests. Moreover, hunting has led to the local extinction and rarity of several species of wildlife. Although, most hunting is for domestic consumption and sale, the extent of such hunting has resulted in population declines. With no proper land demarcation and cadastral surveys, there is encroachment of forest land for agriculture expansion. Other threats to this ecologically fragile region include fuelwood, non-timber forest produce and medicinal plant extraction from the wild. Several big dams are proposed in the region, while several have been opposed by local communities and environmental groups.

Background to current research and conservation program

Traditional hunting is often regarded as a serious threat to the wildlife of this global biodiversity hotspot. Much of the land in Arunachal Pradesh, is under tribal ownership, and hence, implementation of conservation laws remains a serious challenge. Even designated protected areas essentially remain 'paper parks'. The implementation of conservation laws remains a challenge. An increasingly large number of 'failed' PAs in India point to the almost complete lack of local support for wildlife conservation and the failure of PA management by a centralised authority that often lacks motivation, and has little accountability. Wildlife conservation only by enforcement often cannot be sustained and can be counter-productive unless conservation initiatives that involve local people are attempted.

Our prior research in Arunachal (from 1995 onwards), suggested that there was a need to address conservation problems (eg. hunting) there. In addition, costs borne by tribal communities due to wildlife conservation need to be addressed and offset by conservation practitioners. Conflicts with local communities living in and around protected areas (PAs) have led to a realization that approaches that involve local people are required to build support for conservation.

Logging, shifting cultivation and encroachment of forests have also precipitated forest-loss. Although ongoing conservation efforts based on state-implemented law-enforcement have worked in some measure, a complementary approach to conservation built around partnerships with indigenous people is urgently needed. This is especially needed in this tribal region where poor infrastructural/industrial development and paucity of employment options often leads to negative impacts on wildlife. There is a need for need for education/awareness/income-generation opportunities for local people tied to wildlife conservation. A proactive strategy is required by co-opting local tribal communities instead of only penalizing them. Effective wildlife conservation requires garnering a conservation commitment and winning support of local people to ensure protection from hunting. There have been no prior examples of such participatory approaches here.

The overall research and conservation program was initiated in April 2003 in two important protected areas in Arunachal Pradesh primarily to address hunting by tribal communities. This initiative was borne out of 8 years of prior ecological research in the area, which included studying hornbill biology, and the impacts of logging and hunting on wildlife.

This is also among a handful of such attempts in North-east India, a region of global importance for conservation. There is considerable debate on merits and demerits of a solely preservationist exclusionary approach as opposed to a participatory approach. However, few working examples are available to demonstrate the effectiveness of the latter approach in managing PAs. In practice, successful conservation requires elements of both protection and community participation.

These approaches are even more necessary in Arunachal Pradesh, a region of global conservation importance that is dominated by tribal communities with most forest land under their ownership. This project is attempting to see if a participatory approach with tribal communities in conservation of specific Protected Areas can actually work.

Overall program goals

The overall goal of the program is to contribute to conservation of endangered wildlife by fostering positive attitudinal and behavioural changes to wildlife among the local tribal communities by addressing their socio-economic needs, and channelling local natural history knowledge in efforts to monitor wildlife, and through conservation education. We are also offsetting conservation costs borne by local communities through addressing socio-economic needs. Applied wildlife research and monitoring to assess abundance and recovery of target faunal groups is also being carried out to evaluate impact of program interventions.

The key threat being addressed is hunting, widely recognized as a serious threat to wildlife here. To address this threat, we are working with the *Lisu* tribe that lives in and around the Namdapha Tiger Reserve. We have gained their trust and co-operation through initiatives that improve their welfare. These include providing health care, primary education, livelihood options, and employing 'reformed' hunters to monitor and protect threatened faunal groups. We employ many *Lisu* in these activities. Our work has already led to some positive attitudinal changes. At another site, the Pakke Tiger Reserve, we employ 'reformed' *Nishi* hunters to monitor hornbill populations and other threatened fauna. We have also initiated conservation education activities to foster a greater awareness and appreciation of wildlife among both rural and urban Indian children.

Significance of the program

This program should result in protection of hornbills and other wildlife at specific sites and reduce or halt existing hunting practices. It would also develop ways in which local communities can benefit from wildlife conservation and garner a commitment to conservation from tribal communities in Arunachal Pradesh by training villagers to act as nature guides , identify income-generation opportunities using traditional skills tied to their unique cultural and wildlife heritage. It would encourage and inculcate an interest and pride in the rich wildlife and forests of the state for a long-term change in the conservation scenario. It would enhance, strengthen and build local infrastructure, institutions and people in the state – to strengthen the capacity of local people to undertake conservation-related work.

Wildlife monitoring program with local communities

As part of the overall program, we are attempting to address wildlife conservation needs in Arunachal by focusing on ways of integrating indigenous people into a range of activities to monitor, value, and conserve wildlife and their habitats. We are using hornbills – birds whose ecology was studied over four years (1997-2000) in a prior research project - as flagship species for this conservation program. Hornbills are an ideal symbol for this purpose because the five species that occur in Arunachal are greatly dependent on threatened primary forests. Hornbills are also conspicuous elements of the local heritage and have much tribal folklore associated with them. Despite this, the market/ritual value of their feathers, beaks, and flesh renders them attractive quarry to local hunters. The precarious status of hornbills necessitates a systematic monitoring of their populations, including their nest and roost sites. However, hunting threatens most other wildlife; primarily ungulates, arboreal mammals, and carnivores. We have enlisted the support of local hunters – who are knowledgeable and skilled, – to assist in monitoring the ecology of hornbills and abundance of other key faunal groups (eg, arboreal mammals, ungulates, carnivores) that are threatened by hunting. These reformed hunters are like 'conservation agents' who are reaching out to their village communities, with whom we are working closely on awareness programs.

Various aspects of the overall program has also been supported and funded over the years by several organizations and funding agencies: the Wildlife Conservation Society (USA), WCS-India Program, National Geographic Society Conservation Trusts Grant, Ford Foundation, Nadathur Conservation Trust, Katha, Disney Wildlife Conservation Fund and private donors.

Target area and people

This project is largely focusing on two important protected areas, the **Namdapha National Park and Tiger Reserve**, Changlang district, eastern Arunachal Pradesh and **Pakke Wildlife Sanctuary and Tiger Reserve,** East Kameng district, western Arunachal Pradesh. We are working with local communities of tribal people primarily the *Nishi* and the *Lisu*.

Specific objectives for Rufford Small Grants (July 2006- June 2007)

1. Establish scientific monitoring of abundance of key faunal groups at two project sites that are primary targets of hunting, including assessment of threats, levels of resource extraction, and changes in threat levels.

2. Assess levels of habitat loss and degradation within one project site (Namdapha Tiger Reserve) and forest cover changes at a larger landscape level.

3. Enhance, strengthen and build local infrastructure, institutions and people in the state.

Project sites

NAMDAPHA NATIONAL PARK

The study was conducted within the 1985 km^2 Namdapha National Park (27°23'30" - 27°39'40"N and 96°15'2" - 96°58'33"E; Fig. 1) in Arunachal Pradesh, north-east India. The site harbours some of the northernmost tropical rainforests in the world (Proctor *et al.*, 1998) and extensive dipterocarp forests. The elevation ranges from 200 to 4571 m. With increasing elevation, there is a transition in habitat to subtropical broad-leaved forests, subtropical pine forests, temperate broad-leaved forests, alpine meadows and perennial snow. Though primary forests cover most of the park, there are extensive bamboo and secondary forests. The park lies within the Indo-Myanmar global biodiversity hotspot (Myers *et al.*, 2000) at the junction of the Palearctic and Malayan biogeographic realms resulting in a highly diverse species assemblage.

With about 425 recorded bird species, Namdapha National Park is a paradise for birdwatchers. Further surveys in the higher altitudes are likely to add to the list. The area has five species of hornbills and several pheasant species. The area is home to several species of rare wren babblers, laughing thrushes, parrotbills, fulvettas, shrike babblers and scimitar babblers. Namdapha is one of just 2 sites known to support the snowy-throated babbler (*Stachyrei oglei*). Other rare, restricted range or globally endangered species include the White-bellied heron, Rufous-necked hornbill, Green cochoa, Purple cochoa, Beautiful nuthatch, Ward's trogon, Ruddy kingfisher, Blue-eared kingfisher, White-tailed fishing eagle, Eurasian hobby, Pied falconet, White-winged wood duck, Himalayan wood owl, Rufous-throated hill partridge, and White-cheeked hill partridge. It is one of the best places to observe and study several species of *Phylloscopus* warblers. Many migratory species range through this area in winter such as the Amur falcon, long-billed thrush, dark-sided thrush and eye-browed thrush.

Ninety mammal species are reported from the park, including nine species of felids, two bear species, 15 viverrid and mustelid species and seven primate species. Four species of mountain ungulates: red goral (*Nemorhaedus baileyi*), serow (*Nemorhaedus sumatraensis*), takin (*Budorcas taxicolor*) and musk deer (*Moschus* sp.) occur at higher elevations, while the hog deer (*Axis porcinus*) is restricted to the grassland habitat in the river valleys. Recent surveys have also resulted in two new records for India, the leaf deer (*Muntiacus putaoensis*) and the black barking deer (*Muntiacus crinifrons*). The main species targeted by hunting are muntjac (*Muntiacus muntjak*), sambar (*Cervus unicolor*), wild pig (*Sus scrofa*) and gaur (*Bos frontalis*). Elephant populations in the Namdapha area have declined considerably with only one or two herds seen occasionally. The area also harbours 5 species of diurnal tree squirrels and at least 5 species of flying squirrel (only site in the world known to support Namdapha flying squirrel (*Biswamoyopterus biswasi*, endemic to India and listed as a critically endangered species). There are many other lesserknown rodents, bats and shrews. Further biological surveys are likely to add to the area's mammal assemblage.

Several indigenous tribes and other communities reside in and around the park; however those that primarily affect the park are the *Chakma*, *Miju Mishmi* and the *Lisu* (Datta, 2007). The *Chakma* and *Miju Mishmi* enter the park for fuelwood, non-timber forest produce collection (Arunachalam *et al.*, 2004), hunting and fishing. While their impact is restricted to the western portion of the park, it is members of the *Lisu* tribe that reside along the eastern fringe of the park who access the interior and remote areas. A population of 3988 (Census of India, 2001) reside beyond the south-eastern park boundary in four villages of the *Lisu* tribe and nine villages of the *Nepali* community. Although some *Lisu* households existed within the park earlier, more *Lisu* families have migrated into the park since 1997, as their populations have grown and owing to a serious decline in cultivable land due to erosion by the River Noa-dihing. Currently, 65 such families resident in the park that practice settled rice cultivation in the river valley.

A 157 km road (from Miao on the west to Vijaynagar on the east) that cuts through the park was built in 1972 (Fig. 1) and is now only motorable for 26 km. Access to facilities in Miao is on foot through the park for *Lisus* and *Nepalis*, while other tribes access the park when carrying food and supplies to Vijaynagar in winter.

Hunting is the biggest threat to wildlife in the park, and is prevalent among all tribal groups. At least 34 species of mammals are hunted as evidenced by skins, skulls seen in villages in the area (Datta, 2002; 2003). The main targets of subsistence hunting are ungulates and primates, and dried wild meat and fish are sold in the villages. There is also commercial hunting for tiger, elephant, musk deer, bears, otters and other cats (Datta, 2002; 2007). Hunting is mainly carried out with guns, cross-bows and a variety of indigenous traps, while metal foot snares are used for tigers.

PAKKE WILDLIFE SANCTUARY

Pakke Wildlife Sanctuary (862 km^2, 92°36' – 93°09'E and 26°54 – 27°16'N; Fig. 2) lies in the foothills of the Eastern Himalaya in the East Kameng District of Arunachal Pradesh. It was declared a sanctuary in 1977, and has been recently declared a Tiger Reserve.

The park is surrounded by contiguous forests on most sides and bounded by rivers in the east, west and north. The terrain is undulating and hilly, with altitude ranging from 150 m to over 2000 m above sea level. The area has a tropical climate, with cooler weather from November to February. The vegetation of the reserve is classified as Assam Valley tropical semi-evergreen forest 2B/C1 (Champion & Seth, 1968). The forests are multi-storeyed and rich in epiphytic flora, woody lianas and climbers with a high representation of Euphorbiaceae and Lauraceae (Datta, 2001). Major emergent species include *Tetrameles nudiflora, Ailanthus grandis* and *Altingia* *excelsa*. The lower elevation forests are dominated by *Polyalthia simiarum, Pterospermum acerifolium, Sterculia alata, Stereospermum chelonioides*, *Ailanthus grandis* and *Duabanga grandiflora* (Datta, 2001). Evergreen species include *Mesua ferrea*, *Dysoxylum binectariferum*, *Beilschmedia* sp. and other middle storey trees in the Lauraceae and Myrtaceae. Subtropical broadleaf forests occur at higher elevations, while bamboo, cane and palms are common near perennial streams. Along larger streams and rivers, there are patches of tall grassland.

Singh (1991, 1994, 1999), Datta *et al.,* (1998) and Pawar & Birand (2001) have recorded 294 bird species from the area. Among these are at least 6 globally threatened species such as the Great hornbill, Rufous-necked hornbill, White-winged duck, Pallas's Fish Eagle and the White-cheeked hill partridge. The area has a great diversity of mammalian fauna with at least 40 species recorded (Datta & Goyal, 1997, Datta, 2001, Pawar & Birand, 2001). The larger herbivore fauna found here include elephant (*Elephas maximus*), gaur (*Bos gaurus*), sambar (*Cervus unicolor*), barking deer (*Muntiacus muntjak*) and wild pig (*Sus scrofa*). Hog deer (*Axis porcinus*) occurs in small numbers in the scattered grasslands near rivers. Goral (*Nemorhaedus goral*) and serow (*Nemorhaedus sumatrensis*) occur in the higher areas of the park. The larger carnivore fauna includes the tiger (*Panthera tigris*), leopard (*P. pardus*), clouded leopard (*Neofelis nebulosa*), black bear (*Ursus thibetanus*) and wild dog (*Cuon alpinus*). Jackals (*Canis aureus*) are also sighted in disturbed secondary forests. Although only the leopard cat (*Prionailurus bengalensis*) was recorded on camera traps, several other cats such as the marbled cat, golden cat and fishing cat occur in the area. Several species of viverrids and mustelids, including the binturong (*Arctictis binturong*), ferret-badger (*Melogale* spp.), Small Indian civet (*Viverricula indica*) and the yellow-throated marten (*Martes flavigula*) also occur here (Datta, 1999). Four primate species *viz.*, rhesus macaque (*Macaca mulatta*), Assamese macaque (*M. assamensis*), capped langur (*Trachypithecus pileatus*), and Slow loris (*Nycticebus coucang*) and four squirrel species, the Malayan giant squirrel (*Ratufa bicolor*), Pallas red-bellied squirrel (*Callosciurus erythraeus*), hoary-bellied squirrel (*C. pygerythrus*) and Himalayan striped squirrel (*Tamiops macclellandi*) are the most commonly encountered mammals (Datta & Goyal, 1997).

Thirteen to fifteen villages and small settlements are located near the south-eastern boundary of the park adjacent to the Pakke River with an adult population of about 4000 people (mostly belonging to the *Nishi* tribal community, 1997-1998 census). Fishing, hunting, collection of cane, bamboo, firewood, honey and dhuna (resin) occurs in the park. There was some level of illegal felling that occurred from within the Sanctuary earlier especially near the south-eastern boundary. A vast portion in the central and northern part of the park is relatively inaccessible due to the dense vegetation, hilly terrain and the lack of trails. Consequently, few people including local tribals venture into the interior of the forest. The Bhareli River acts as a barrier to human disturbance, though occasionally local tribals (*Akas*) do cross over to hunt or cut cane and trees. A village (Mabusa, *ca.* 100 ha) near the southern boundary of the sanctuary was relocated outside the park on the other side of the river in 1994. Two small villages exist in the extreme northern end of the park towards Seppa.

Towards the southern boundary adjoining Pakke River, access is much easier since the river is fordable most of the year. Instances of hunting and trapping of birds are more common in this area. In addition, villagers from Assam regularly enter the NP, adjoining RFs and Nameri NP to collect several species of cane, dhuna *(Canarium strictum*), agar *(*the rare and threatened *Aquillaria malaccensis)* and other minor forest products. Illegal fishing is also a disturbance in the bigger perennial streams towards the southern boundary. But most of Pakke WLS, except the forests near the southern boundary, has undisturbed primary forest.

References

Arunachalam, A., Sarmah, R., Adhikari, D. Majumder, M. & Khan M.L. 2004. Anthropogenic threats and biodiversity conservation in Namdapha nature reserve in the Indian Eastern Himalayas. *Current Science* 87: 447- 454.

Champion, H. G. & Seth, S. K. 1968. *A revised survey of the forest types of India.* Manager of Publications. Government of India. New Delhi. 404 pp.

Datta, A. 1999. Small carnivores in two protected areas of western Arunachal Pradesh, north-east India. *J. Bombay nat. Hist. Soc.* 96: 399-404.

Datta, A. & Goyal, S. P. 1997. *Responses of arboreal mammals to selective logging in western Arunachal Pradesh*. Unpublished report. Wildlife Institute of India, Dehradun. 73 pp.

Datta, A., Singh, P., Athreya, R. M. & Karthikeyan, S. 1998. Birds of Pakhui Wildlife Sanctuary in western Arunachal Pradesh. *Newsletter for Birdwatchers* 38: 91-96.

Datta, A. 2001. *An ecological study of sympatric hornbills and fruiting patterns in a tropical forest in Arunachal Pradesh.* PhD dissertation. Saurashtra University, Rajkot, India.

Datta, A. 2002. *Status of hornbills and hunting among tribal communities in eastern Arunachal Pradesh.* Report submitted to the Wildlife Conservation Society, New York and WCS-India Program, Bangalore. 70 pp.

Datta, A. 2003. *A survey of endangered mammals in Changlang district, Arunachal Pradesh: discovery of two muntjaks from India.* Report submitted to the Wildlife Conservation Society, NY, and India-Program and the Forest Department of Arunachal Pradesh, March 2003. 30 pp.

Datta, A. 2007. Protecting with people in Namdapha: Threatened forests, forgotten people. *Making conservation work: Securing biodiversity in this new century* (ed. by G. Shahabuddin and M. Rangarajan), pp. 165-209. Permanent Black, New Delhi.

F.S.I. 1999. State of the Forest Report, India, 1999. Forest Survey of India, Dehradun.

Myers, N., Mittermeier, R. A., Mittermeier, C. G., da Fonseca, G. A. B., & Kent, J. 2000. Biodiversity hotpots for conservation priorities. *Nature* 403: 853-858.

Olson, D. M. & Dinerstein E. 1998. The global 200: a representation approach to conserving the earth's most biologically valuable ecoregions. *Cons. Biol.* 12: 502-515.

Pawar, S. & Birand, A. 2001. *A survey of amphibians, reptiles and birds in Northeast India.* CERC Technical Report #6, Centre for Ecological Research and Conservation, Mysore.

Proctor, J., Haridasan, K. & Smith, G.W. 1998. How far north does lowland evergreen tropical rain Forest go? *Global Ecology and Biogeography Letters* 7: 141-146.

Singh, P. 1991. Avian and mammalian evidences in Pakhui Wildlife Sanctuary in East Kameng district, Arunachal Pradesh. *Arunachal Forest News* 9: 1-10.

Singh, P. 1994. Recent bird records from Arunachal Pradesh, India. *Forktail* 10: 65-104.

Singh, P. 1999. Bird survey in selected localities of Arunachal Pradesh, India. Unpublished report, Wildlife Institute of India, Dehradun.

Figure 1. Map of Namdapha National Park, Changlang district, eastern Arunachal Pradesh

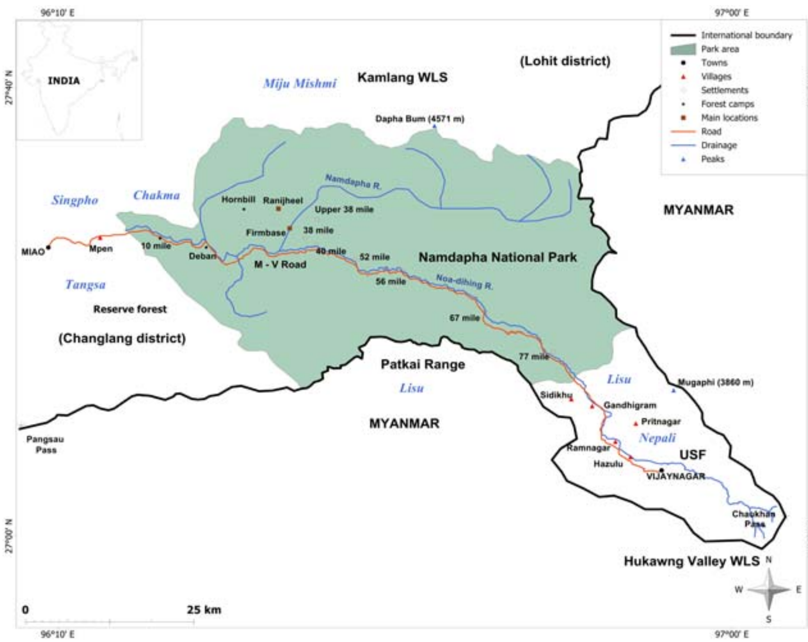
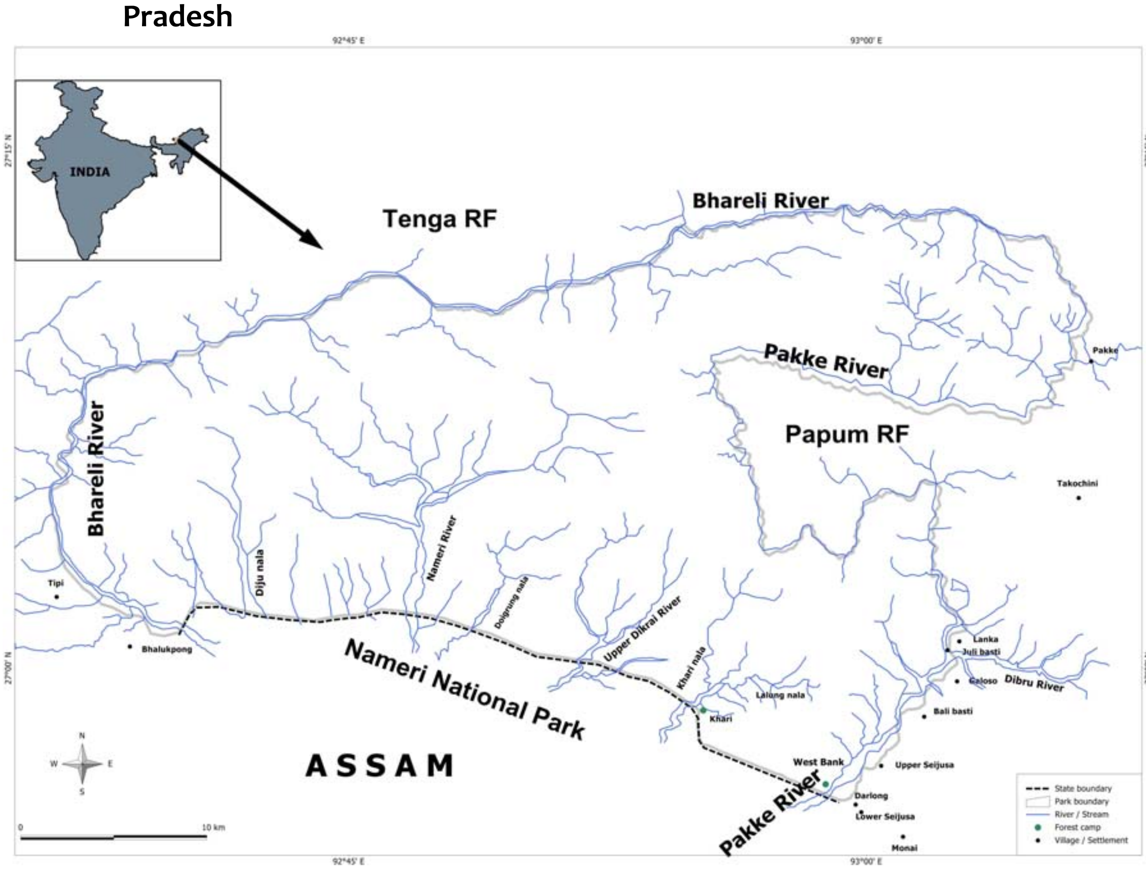


Figure 2. Map of Pakke Wildlife Sanctuary, East Kameng district, western Arunachal Pradesh



Chapter 2

Large Carnivores and Prey Abundance in Namdapha National Park: camera trapping survey

Aparajita Datta, Rohit Naniwadekar, M.O. Anand

Field data collection: Akhi Nathany, Duchaye Yobin, Ngwa-akhi Yobin, Shekhar Subba & others

Volunteer: Meghna Krishnadas

Introduction

Tropical rainforests globally are known to be storehouses of diversity and are home to many threatened mammal species (Terborgh, 1992). However, many of these species are known to naturally occur at low densities because of reasons such as large body size, specialized diets or spatially dispersed social structures (Eisenberg, 1981). To add to that, subsistence hunting in association with high deforestation rates poses immense threats to the wild mammalian populations in most of the tropical forests on the globe (Robinson & Bennett, 2000). Even small-scale hunting in these tropical forests can result in marked declines of animal populations because of the low densities of mammals (Fitzgibbon *et al.*, 1995). For instance hunting of tiger and its prey in association with extensive deforestation has resulted in extinction of two subspecies of tigers (Bali *Panthera tigris balica* & Javan *P. t. sondaica*) (Seidensticker, 1987). Thus one of the important and urgent conservation needs is to understand the ecology of these elusive large mammals and simultaneously monitor their ever declining populations.

Monitoring programs throughout the world focus on estimating one or more state variables like population abundance which can be monitored over time. However, many tropical mammals are extremely elusive and difficult to detect which renders standard surveying methods like distance sampling useless. To add to the woes, laying straight line transects in tropical rainforests is extremely difficult because of the undulating terrain and dense vegetation. To overcome these constraints 'camera trapping', which involves non-invasive remote photo capturing of animals, is thought to be particularly useful for studying rare and elusive animals (Karanth & Nichols, 1998; Karanth *et al.*, 2004b). It involves setting up cameras which are activated by passing animals in remote areas. Cameras are placed on trails which are known to be used by target group of mammals. It is a particularly useful technique because in cases where the individuals (with bold markings on pelage) can be identified, traditional mark-recapture methods can be used for estimating densities (Lancia *et al.*, 1994; Karanth & Nichols, 1998; Williams *et al.*, 2002).

However, mark-recapture methods of estimating densities using remote methods like camera traps will fail if the animals occur at extremely low densities. In a scenario where individuals of a species cannot be identified or where animals (especially carnivores) exist in extremely low densities it results either in very few recaptures of the species or few captures with no recaptures. In such circumstances the relative abundance index is frequently used (Johnson *et al.*, 2006). Relative abundance index is basically defined as the number of days to take a single capture of a species or number of pictures of species taken in 100/1000 days. It is a useful measure of relative abundance when estimation of densities is difficult. For relative abundance index to be useful in estimating densities there has to be monotonic relationship between the index and actual densities (Conroy, 1996). In the past relative abundance indices have been used in regression equations to estimate densities of tigers and its prey species (Carbone *et al.*, 2001; O'brien *et al.*, 2003; Kawanishi & Sunquist, 2004).

In India, a lot of effort has been invested in estimating densities of tiger and its prey using camera traps in the recent past (Karanth & Nichols, 1998; Karanth *et al.*, 2004a). However, the focus has been predominantly in peninsular India. Status and trend of tigers in Northeast India is poorly known. Northeast India has been identified as a high priority landscape for tiger conservation globally (Wikramanayake *et al.*, 1998). Implementation of India's strong conservation laws is a challenge in Northeast India, where local tribes have a strong tradition of hunting. In this region, hunting, on the one hand, is increasingly being driven by high-value markets for derivatives from species such as tigers and elephants *Elephas maximus*. On the other hand, hunting also has ritual significance, recreational value and remains an important means of subsistence, catering to household consumption and providing supplementary cash incomes (Datta, 2002; Mishra *et al.*, 2006).

In the Namdapha National Park and Tiger Reserve in Arunachal Pradesh, one of the four designated tiger reserves in northeast India, hunting remains a serious threat. The main aim of the community-based conservation program which was initiated in 2004 was to progressively eliminate hunting by local communities by addressing their socio-economic needs (Datta, 2007). As part of this program, we are establishing baselines and monitoring the abundance of faunal groups targeted by hunters to enable an evaluation of the effectiveness of conservation interventions in bringing about wildlife recovery.

The results of the first large-scale camera-trapping survey in the Namdapha National Park are presented here. The relative abundance indices would act as a baseline for long-term monitoring of large carnivores and their prey in the area. We have also compared our results with relative abundance indices from other similar areas in Southeast Asia.

Methods

Prior work at Namdapha (only 17 detections of two ungulate species over 740 km walked) suggested that conventional sighting-based transect methods may not be feasible for monitoring terrestrial mammal populations in these forests (A. Datta, *unpubl. data.*). Thus camera trapping was thought to be useful method for large and medium-sized mammals, and pellet and track plot surveys for indirect evidences of large herbivores and ungulates.

Camera trapping

The study focused on an area of 1200 km^2, roughly encompassing the moist evergreen habitat within the Namdapha National Park below 2000 m. A uniform grid (3 x 3 km) was imposed on a map of the area. A grid size of 9 km^2 was selected to match the scale of other camera-trapping surveys in south-east Asia (O'Brien *et al.*, 2003; Kawanishi & Sunquist, 2004; Johnson *et al.*, 2006). Of the 130 grids covering the study area, a random selection of 80 grids was made. With only 16 km of motorable road, all field work was carried out on foot. Given logistic difficulties in the hilly terrain, limitations of time, manpower and equipment, sampling was carried out between October 2006 and January 2007 in 40 of the initially selected 80 grids covering 30% of the study area.

We surveyed large carnivores and prey species using 42 passive infra-red camera trap units (38 DEERCAM-300 camera trap units from Forestry Suppliers Inc., USA and 4 units made by the Centre for Electronic Design and Technology, Indian Institute of Science, Bangalore). In each of 40 sampled grids, two or three camera traps were deployed. Traps were deployed along animal trails, streambeds, wallows and ridgelines, in locations with evidence of animal movement. We recorded the GPS location, altitude and other habitat parameters at each trap site. A group of highly skilled *Lisu* trackers assisted in identifying suitable locations for deploying camera traps. At every location, one passive infra-red camera trap was placed perpendicular to the expected direction of animal movement at a height of 30-40 cm from the ground. We maintained a minimum distance of 400-500 m between trap locations. However, on two occasions we placed traps at a distance of 200 m apart, due to inaccessible terrain and lack of suitable sites. The traps were operational for 24 hours a day, and were removed after a period of 15 days. The number of camera trap days was calculated from the date of deployment till the date of retrieval (if film was not used up) or till the date of the final photo.

Pellet and track plots

In 38 grids, ten 50 X 2 m plots were laid perpendicular to a one kilometre-long trail at 100 m intervals. These plots were intensively searched by two observers for tracks, pellet and dung groups of elephants and large ungulates.

Data analysis

Based on photo-capture rates of large carnivore and prey species, an index of relative abundance was calculated as the number of days required to obtain a photo capture of a species, described as RAI_1 in Carbone *et al.* (2001). Independence of detections was defined following O'Brien *et al.* (2003). Relative abundance values from the current study were also compared to those obtained from studies in geographically and climatically similar forests in six sites in south-east Asia which face lower or comparable hunting pressures (Grassman Jr., 2003; Lynam, 2003; O'brien *et al.*, 2003; Kawanishi & Sunquist, 2004; Rao *et al.*, 2005; Johnson *et al.*, 2006). There is evidence to suggest that RAI_1 is negatively correlated to species abundance (Carbone *et al.*, 2001, 2002; O'Brien *et al.*, 2003) and is a useful tool to compare relative abundances of species, particularly when individuals of these species cannot be distinguished from each other.

Although, we did not detect tigers with a trapping effort of 1537 days, we used the equation derived by Carbone *et al.* (2001) – where tiger density (y) is a function of RAI_1 (x) such that $y = 133.89x^{-0.971}$ – to approximate the maximum possible tiger density in Namdapha, had a tiger photo been obtained on the 1538th trap day.

As tigers select large prey when available (Karanth & Sunquist, 1995), we separated the prey species as large (> 100 kg) and small (< 100 kg) following Johnson *et al.* (2006) to determine the relative abundance of these prey size categories in the area.

Pellet and track plot data was summarized as the mean number of plots per trail in which a species was encountered and used to supplement camera trap data on species presence in the area.

Results

We used 1537 trap-days of data for analysis, after deducting trap-days where cameras malfunctioned and where the film was finished before the end of a 15-day sampling session. There were no detections of tigers, leopards and wild dog, the three major predators of large ungulate prey in Namdapha. The only large carnivore detected was the clouded leopard. Additionally, there were no detections of large herbivore species such as Asian elephant, gaur or serow. Relative abundance values of focus species is presented in Table 1. With the exception of Indian muntjac, encounter rates of the target species were far lower at Namdapha than at most other sites in south-east Asia.

We obtained 156 independent prey photos, of which large prey (sambar *Cervus unicolor* and wild pig *Sus scrofa*) comprised only 3.85%. The remaining photos were of small prey; two primate species: stump-tailed macaque *Macaca arctoides*, capped langur *Trachypithecus pileatus*, Himalayan crestless porcupine *Hystrix brachyura*, brush-tailed porcupine *Atherurus macrourus* and muntjacs *Muntiacus muntjak*. Muntjacs alone made up 45.5% of the independent photos.

We obtained zero captures of tigers in 1537 trap nights. Thus, based on the equation derived by Carbone *et al.* (2001), tiger density in Namdapha would be no more than 0.107/100 km^2 if a tiger were to be detected on the 1538th trap night. This translates to no more than two tigers in the roughly 1200 km^2 lower elevation forests of Namdapha.

Five species of large ungulates were detected in pellet and track plots. The mean number of plots (± SD) per trail with tracks was 6.68 (± 2.14) for muntjac, while it was 2.02 (± 1.65) for sambar, 1.27 (± 1.64) for wild pig, 0.48 (± 1.22) for gaur and 0.18 (± 0.8) for serow. Pellet and dung groups of three species were encountered; with 0.34 plots (± 0.86) per trail with pellet groups of muntjac, 0.11 (± 0.35) for sambar and 0.03 (± 0.16) for gaur. The percentage of tracks and pellet groups for each species is shown in Table 2.

Table 2: Encounter rates of tracks and pellets of ungulates in Namdapha NP (2006-2007)

Species	No. of plots with pellet groups (percent)	No. of plots with tracks (percent)
Indian muntjac. *Muntiacus sp.*	26 (7)	257 (66)
Sambar *Cervus unicolor*	8 (2)	78 (20)
Wild pig *Sus scrofa*	0 (0)	50 (13)
Gaur *Bos gaurus*	2 (0.5)	20 (5)
Serow *Naemorhedus sumatraensis*	0 (0)	7 (2)

Discussion

There were no detections of large carnivores – tiger, leopard and wild dog – and large herbivore species like elephant, serow and gaur in nearly 1600 days of camera-trapping effort. Nevertheless, we conclude that populations of leopard, wild dog, gaur and serow still exist in Namdapha, based on sporadic detections of tracks, scats and dung piles. In addition, wild dog packs (2 -12 individuals) have been sighted on four occasions in grassland habitat in the river valleys in earlier surveys between 2003 and 2005 (A. Datta, *pers. obs.*). However, no primary or secondary evidence was found to suggest the presence of tigers or elephants within the study area. There are unconfirmed reports of tiger sightings by tourists and of cattle kills by tigers in 2005-2006. A single herd of 20 elephants is known to visit occasionally (J. Pansa, *pers. comm.*).

Relative abundance values from Namdapha of most of the target species are among the lowest in the region, comparable to or lower than other highly hunted sites (Rao *et al.*, 2005; Johnson *et al.*, 2006), and far lower than apparently less-hunted sites (Grassman Jr., 2003; O'brien *et al.*, 2003; Kawanishi & Sunquist, 2004). As is often the case in hunted sites, the only species not showing this pattern was the muntjac (Johnson *et al.*, 2006), encounter rates of which were among the highest in Namdapha. A sustained conservation effort may be required for these species to recover to even the low density levels observed in relatively less hunted Protected Areas in south-east Asia (O'Brien *et al.*, 2003; Kawanishi & Sunquist, 2004).

The current status of large mammals is particularly unfortunate, given anecdotal information that as recently as 20 years ago, Namdapha supported healthy populations of tigers and elephants, among other large mammals. Camera trap surveys in the western part of Namdapha in 1996 did not detect tigers in 451 trap nights, although indirect evidence of tiger presence was recorded (Karanth & Nichols, 2000). The large carnivores detected were leopard, wild dog and clouded leopard. On several visits to the park between 1999 and 2005, with more than 1000 km walked, tiger pugmarks were seen on only 4 occasions (A. Datta, *pers. obs.*). A pilot camera trap survey (364 trap nights) in 2005 also failed to detect tigers, although clouded leopard and two bear species were detected (A. Datta, *unpublished data*).

While tiger densities are typically low in 11 other prey-poor rainforest Protected Areas in south-east Asia ranging from 0.53/100 km^2 to 2/100 km^2 as compared to 4/100 km^2 to 16/100 km^2 in seven prey-rich deciduous forest and grassland Protected Area sites in India and Nepal (Carbone *et al.*, 2001; Karanth *et al.*, 2004a), the failure to detect substantial evidence of the tiger in Namdapha in recent years points to a serious decline. Even in highly-hunted sites across the border in Myanmar such as the Htamanthi Wildlife Sanctuary and Hukawng Valley Wildlife Sanctuary and the, estimated tiger densities were 0.49/ 100 km^2 and 1.1/100 km^2 respectively (Lynam, 2003), though in the Hkakaborazi National Park, tigers are believed to be locally extinct (Rabinowitz & Khaing, 1998; Rao *et al.*, 2005).

Although, there is no reliable evidence suggesting the presence of tigers currently in Namdapha, even higher trapping effort and extensive surveys may be necessary to draw conclusions on the fate of the tiger in the park. The inability to estimate animal densities reflect the difficulties surrounding the estimation and monitoring of wildlife populations in tropical forests, where cryptic species occur at inherently low densities (Eisenberg & Seidensticker, 1976; Karanth *et al.*, 2004b), rendering most conventional sighting-based sampling techniques inadequate. It is these properties of populations in tropical forests that make them more vulnerable to declines and extinction (Kenny *et al.*, 1995; Kawanishi & Sunquist, 2004) making the monitoring of their populations all the more crucial. Poor detectability may also result from avoidance of humans in areas with high hunting pressures. We stress the need for development of rigorous techniques for population estimation of terrestrial mammals that occur at low densities in tropical forests and long-term wildlife population monitoring programs in the Protected Areas of north-east India.

Although prey depletion is a major threat to tigers (Karanth & Stith, 1999), poaching is believed to be among the primary factors resulting in the current decline (Banks *et al.*, 2006). This is particularly true in Namdapha, which is located along the international border with Myanmar and close to hotspots of trade in animal body parts (Banks *et al.*, 2006). In Myanmar, there is a documented decline of tigers due to hunting for trade (Lynam, 2003; Rao *et al.*, 2005). Hunting of tigers is a significant threat to the persistence or recovery of tigers and other large carnivores in Namdapha. Based on reliable local informants, we conclude that a considerable number of tigers (10-15) have been killed for the trade between 1994 and 2002 by professional poachers. Currently, all available information suggests that Namdapha may soon be the second Indian Tiger Reserve where the tiger has gone extinct, close on the heels of the Sariska National Park in 2004 (Ttf, 2005). However, if hunting can be stopped, recovery of tiger populations is possible given that Namdapha is contiguous with protected forests on all sides making this amongst the largest contiguous montane forest habitat for tigers in south Asia (Wikramanayake *et al.*, 1998). Till recently, there was no official acknowledgement of the problem with the park authorities reporting 61 tigers in 2002 based on the discredited pugmark census method (Karanth *et al.*, 2003) (http://projecttiger.nic.in/namdapha). Namdapha's problems were highlighted (Datta, 2005; Ttf, 2005; Datta, 2006, 2007), only after attention was focussed on tiger reserves, following the disappearance of tigers in Sariska. The impending extinction of species from a Protected Area is a serious cause for concern and can only be halted only through more proactive measures and political resolve.

References

Banks, D., Desai, N., Gosling, J., Joseph, T., Majumdar, O., Mole, N., Rice, M., Wright, B. & Wu, V. 2006. *Skinning the cat: Crime and politics in big cat skin trade.* Environmental Investigation Agency and Wildlife Protection Society of India.

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

Conroy, M.J. 1996. Abundance indices. *Measuring and monitoring biological diversity: Standard methods for mammals* (ed. by D.E. Wilson, F.R. Cole, J.D. Nichols, R. Rudran and M.S. Foster). Smithsonian Institution Press, Washington DC.

Datta, A. 2002. *Status of hornbills and hunting among tribal communities in eastern Arunachal Pradesh*. Report submitted to the Wildlife Conservation Society, New York and WCS-India Program, Bangalore. 70 pp.

Datta, A. 2005. Fading fauna, forgotten people. *Down to Earth* September 15: 46-49.

Datta, A. 2006. Making headway: Lisus and officials 'talk' in Namdapha, Arunachal Pradesh. *Down to Earth* April 15:44.

Datta, A. 2007.Protecting with people in Namdapha: Threatened forests, forgotten people. *Making conservation work: Securing biodiversity in this new century* (ed. by G. Shahabuddin and M. Rangarajan), pp. 165- 209. Permanent Black, New Delhi.

Eisenberg, J.F. 1981. *Mammalian radiations*. University of Chicago Press, Chicago.

Eisenberg, J.F. & Seidensticker, J. 1976. Ungulates in southern Asia: A consideration of biomass estimates for selected habitats. *Biological Conservation* 10: 298-308.

Fitzgibbon, C.D., Mogaka, H. & Fanshawe, J.H. 1995. Subsistence hunting in Arabuko-Sokoke forest, Kenya, and its effect on mammal populations. *Conservation Biology* 9: 1116-1126.

Grassman Jr., L.I. 2003. *Thailand cat project.* Unpublished final report submitted to Cat Action Treasury, Thailand.

Johnson, A., Vongkhamheng, C., Hedemark, M. & Saithongdam, T. 2006. Effects of human-carnivore conflict on tiger (*Panthera tigris*) and prey populations in Lao PDR. *Animal Conservation* 9: 421-430.

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

Karanth, K.U. & Nichols, J.D. 2000. *Ecological status and conservation of tigers in India.* Final Technical report to the Division of International Conservation, U.S. Fish and Wildlife service, Washington DC and the Wildlife Conservation Society, New York, Centre for Wildlife Studies, Bangalore.

Karanth, K.U., Chundawat, R.S., Nichols, J.D. & Kumar, S.N. 2004a. Estimation of tiger densities in the tropical dry forests of Panna, central India, using photographic capture-recapture sampling. *Animal Conservation* 7: 285-290.

Karanth, K.U., Nichols, J.D. & Kumar, N.S. 2004b. Photographic sampling of elusive mammals in tropical forests. *Sampling rare or elusive species* (ed. by W.L. Thompson). Island Press, Washington DC.

Karanth, K.U., Nichols, J.D., Seidensticker, J., Dinerstein, E., David Smith, J.L., Mcdougal, C., Johnsingh, A.J.T., Chundawat, R.S. & Thapar, V. 2003. Science deficiency in conservation practice: The monitoring of tiger populations in India. *Animal Conservation* 6: 141-146.

Karanth, K.U. & Stith, B.M. 1999. Prey depletion as a critical determinant of tiger population viability. In: *Riding the Tiger: tiger conservation in human-dominated landscape* (eds. J. Seidensticker, S. Christie and P. Jackson). Cambridge University Press, Cambridge.

Karanth, K.U. & Sunquist, M.E. 1995. Prey selection by tiger, leopard and dhole in tropical forests. *Journal of Animal Ecology* 64: 439-450.

Kawanishi, K. & Sunquist, M.E. 2004. Conservation status of tigers in a primary rainforest of peninsular Malaysia. *Biological Conservation* 120: 329-344.

Kenny, J.S., Smith, J.L.D., Starfield, A.M. & McDougal, C. 1995. The long-term effects of tiger poaching on population viability. *Conservation Biology* 9: 1127-1133.

Lancia, R.A., Nichols, J.D. & Pollock, K.H. 1994. Estimating the number of animals in wildlife populations. *Research and management techniques for wildlife and habitats* (ed. by T. Bookhout), pp. 215-253. The Wildlife Society, Bethesda, Maryland.

Lynam, A. (2003) *A national tiger action plan for the Union of Myanmar*. Myanmar Forest Department. Unpublished report. Ministry of Forestry, Myanmar Forest Department and Wildlife Conservation Society, International program. 55 pp.

Mishra, C., Madhusudan, M.D. & Datta, A. 2006. Mammals of the high altitudes of western Arunachal Pradesh, Eastern Himalaya: An assessment of threats and conservation needs. *Oryx* 40: 1-7.

O'Brien, T.G., Kinnaird, M.F. & Wibisono, H.T. 2003. Crouching tigers, hidden prey: Sumatran tiger and prey populations in a tropical forest landscape. *Animal Conservation* 6: 131-139.

Rabinowitz, A. & Khaing, S.T. 1998. Status of selected mammal species in north Myanmar *Oryx* 32: 201-208.

Rao, M., Myint, T., Zaw, T. & Htun, S. 2005. Hunting patterns in tropical forests adjoining Hkakaborazi National Park, north Myanmar. *Oryx* 39: 292-300.

Robinson, J.G. & Bennett, E.L. 2000. *Hunting for sustainability in tropical forests*. Columbia University Press, New York.

Seidensticker, J. 1987. Bearing witness: Observations on the extinctions of *Panthera tigris balica* and *Panthera tigris sondaica*. *Tigers of the world: The biology, biopolitics, management and conservation of an endangered species* (ed. by R.L. Tilson and U.S. Seal). Noyes Publication, Park Ridge, New Jersey.

Terborgh, J. 1992. *Diversity and the tropical rainforest*. Freeman, New York.

TTF 2005. *Joining the dots.* The report of the tiger task force. Report submitted to the Union Ministry of Environment and Forests (Project Tiger), Government of India.

Wikramanayake, E.D., Dinerstein, E., Robinson, J.G., Karanth, K.U., Rabinowitz, A., Olson, D., Mather, T., Hedao, P., Conner, M., Hemley, G. & Bolze, D. 1998. An ecology-based method for defining priorities for large mammal conservation: The tiger as case study. *Conservation Biology* 12: 865-878.

Williams, B.K., Nichols, J.D. & Conroy, M.J. 2002. *Analysis and management of animal populations*. Academic Press, San Diego.

Table 1. Relative Abundance Indices (number of trap days required to get a single photo capture of a species) derived from camera trap surveys for large carnivores and prey species in Namdapha National Park and six other protected areas in south-east Asia.

Location	Namdapha National Park, north-east India	Hukawng Valley Tiger Reserve, north Myanmar	Hkakaborazi National Park, north Myanmar	Taman Negara National Park, Peninsular Malaysia	Nam Et-Phou Louey National Protected Area, Laos	Bukit Barisan Selatan National Park, Indonesia	Phu Kheio Wildlife Sanctuary, Thailand
Reference	Present study, 2006-07	Lynam 2003	Rao *et al.* 2005	Kawanishi & Sunquist 2004	Johnson *et al.* 2006	O' Brien *et al.* unpublished data (1998-2006)	Grassman 2003
Type of camera trap	Passive	Passive	Passive	Active & Passive	Passive	Passive	Active & Passive
Effort (number of trap-days)	1,537	8,836	1,238	14,054	3,588	24,045	1,224
Tiger *Panthera tigris*	-	2945	-	230	417	481	408
Leopard *Panthera pardus*	-	-	-	94	144	-	-
Wild dog *Cuon alpinus*	-	4418	29	878	359	6024	111
Clouded leopard *Neofelis nebulosa*	768	4418	16	878	Present, but data not available	587	612
Indian muntjac *Muntiacus muntjak*	22	184	6	25	36	26	15
Sambar *Cervus unicolor*	512	192	-	44	400	89	34
Wild pig *Sus scrofa*	512	1767	9	28	250	39	31
Gaur *Bos frontalis*	-	2945	-	1562	1250	-	35
Serow *Naemorhedus sumatraensis*	-	-	20	270	326	4007	Not present?
Porcupines (2 species)	40	1104	6	95	55	43	122
Primates	37	1767	8	351	23	20	153
Hog badger *Arctonyx collaris*	-	-	179	-	163	Not present?	408

Chapter 3

Occupancy estimates of four ungulate species targeted by hunting in Namdapha National Park

Rohit Naniwadekar, M.O. Anand, Aparajita Datta

Field data collection: Akhi Nathany, Duchaye Yobin, Ngwa-akhi Yobin, Shekhar Subba & others

Volunteer: Meghna Krishnadas

Introduction

Subsistence hunting like other areas in the humid tropics is regarded as being the most serious threat to wildlife in north-east India where local tribes have a strong tradition of hunting. It is known that even small-scale hunting can result in marked declines in animal populations (FitzGibbon *et al.*, 1995), which in turn impacts other trophic levels and eventually affects tropical forest dynamics (Peres, 2000).While Indian conservations laws are among the toughest, there is a strong disconnect between the law and its enforcement. Implementation of laws is even more challenging in a tribal state like Arunachal Pradesh. Even protected areas essentially remain 'paper parks' and the hunting of wildlife is frequent and widespread, resulting in the 'empty forest' syndrome (Datta, 2002; 2003; 2007). Hunting is largely for subsistence (household consumption and supplementary cash) and recreation, which affects a wide range of species (Mishra *et al.*, 2006; Datta, 2002; 2003; Hilaluddin *et al.*, 2005). However, market-driven hunting for high value species such as tigers *Panthera tigris*, elephants *Elephas maximus* and a few other species is also prevalent. Hunting is a serious threat in the Namdapha National Park, eastern Arunachal Pradesh, and is prevalent among several tribal communities that live in and around the park. The main targets of subsistence level hunting are ungulates and primates and evidence suggests dramatic declines in abundance of several large mammals in the park (Datta *et al.*, 2007, Datta *et al.*, in prep.). Given this background, we initiated a community-based conservation program in 2004 with the *Lisu* tribe, (the main community that affects the park), where the overall goal was to bring about a reduction in hunting by fostering positive attitudinal changes to wildlife. We are attempting to offset conservation costs borne by the *Lisu* by addressing their socio-economic needs (Datta, 2007).

This conservation intervention can be considered successful if only it results in recovery of animal populations which were previously targeted by hunting. 'Targeted monitoring' where studies are designed to track system responses (requiring immediate conservation attention) to specific conservation actions are thought to be an effective means of achieving conservation of affected species (Nichols, 1991; Nichols & Williams, 2006). Thus we are simultaneously monitoring abundance of several faunal groups that are targeted by hunting with the help of reformed *Lisu* hunters, to enable an evaluation of impact of conservation interventions and assess wildlife recovery.

Pilot surveys in Namdapha from 2004-2005 suggested that standard methods for density estimation of ungulate species could not be used because of poor detectability and low abundance of ungulates (Datta *et al.*, 2007). Low densities and poor detectability in these forests frequently render standard density estimation methods inefficient and expensive. Capture-recapture methods require repeated efforts to capture or observe animals and are only possible for species that can be individually identified (Otis *et al.*, 1978; Pollock *et al.*, 1990). Even observation-based methods such as distance sampling (Buckland *et al.*, 2001) and multiple observers (Cook & Jacobson, 1979; Nichols *et al.*, 2000) are viewed as too consumptive of time and effort. In such a scenario, occupancy which is defined as the proportion of an area or proportion of suitable habitat units in an area that is occupied by a given species is a useful state variable is proposed for monitoring rare and elusive species (MacKenzie *et al.*, 2006). Occupancy estimation procedure incorporates detectability which is thought to be a critical aspect of sampling animal populations (MacKenzie *et al.*, 2006). Occupancy surveys involve searches of sample units for evidence of species presence. It is thus possible to use animal signs (tracks or faeces) as an indicator of presence. Detection of animal signs is easier than observation of animals in dense tropical forests.

We therefore chose the occupancy framework for generating baselines of four ungulate species (muntjac, sambar, wild pig and gaur) that are targeted by hunting for long-term monitoring of changes in occupancy of ungulates in response to reduction in hunting pressures. Modeling occupancy as a function of covariates would also help understand the role of ecological and anthropogenic factors on the occupancy of the four species of ungulates.

Methods

The study was carried out from October 2006 to January 2007. Sampling was carried out in areas below 2000 m. With only 10 km of jeepable road in the park, all field work was carried out on foot; therefore sampling above 2000 m would have required much larger logistical support. In addition, hunting pressures on the four species of ungulates are much higher in areas below 2000 m, with fewer hunters accessing the higher areas for occasional hunting primarily for the mountain ungulates, especially musk deer and takin.

The study focused on an area of 1200 km^2, roughly encompassing the moist evergreen habitat within the Namdapha National Park below 2000 m. A uniform grid (3 x 3 km) was imposed on a map of the area. Grids were essentially used to space out our sampling in the study area. Of the 130 grids covering the study area, we randomly selected 38 grids in which intensive sampling were carried out. However, we estimated occupancy using data from 37 grids as we were not able to collect covariate data from one grid. We sampled the forested habitat in the study area that is relatively homogeneous. Grasslands covered a very small portion of the study area in the broad valleys of the Noa-Dihing and Namdapha rivers. Therefore, our occupancy estimates are for the four ungulate species in the forested tracts of the study area.

In each of the grids, we had a one kilometer long trail. At every 100 m along the trail, we laid 50 x 2 m plots perpendicular to the trail. The plots were laid on alternate sides of transect. The plots were used for recording the presence of the different ungulate species (tracks or pellet groups). Two observers searched intensively for relatively fresh tracks (< 2 months) and pellet groups. We define a 'site' as a one kilometer long trail and each of the plots along the trail were our 'surveys'. We had a single 1 km trail in each of the grids, thus we had overall 37 sites and 10 surveys in each site except one site where there were 9 surveys. We used the software PRESENCE Version. 2.0 for estimating occupancy (Hines, 2006).

For each site, we employed the 'point-centred quarter' technique at every 100 m intervals along the trail to estimate tree density and basal area per hectare for the site. We also estimated (ocular) shrub cover on a scale from 0 to 4 at every 100 m interval with 0 for no shrub cover and 4 for impenetrable shrub cover. Elevation and mean distance of the trail from the nearest settlement were extracted using GIS. We also ranked each site based on the levels of disturbance observed at each site. Level of disturbance for the grid was evaluated based on observation of human presence in the form of tree/stem cut signs and trails and information from reformed *Lisu* hunters. Ranking was between 1 and 4 with lowest rank for the least disturbed site. To minimize the influence of observers on detection of tracks and pellets we also incorporated observer as a covariate in the model. The same observer surveyed all the plots at a site therefore observer information was incorporated as a site covariate. The sampling was carried out in a single season (November–January; winter) and therefore we used single-species single season occupancy models for arriving at independent estimates of occupancy for each of the species (Mackenzie *et al.*, 2006). We generated several models with the simplest among them being the one that assumed that the probability of a site being occupied and the probability of detecting the species in a survey are equal across all sites which we refer to as the '1 group constant *p*' model. All our site level covariates remain constant for the season. We modeled the probability of detecting the four ungulate species as a function of different combinations of covariates. For each species we also generated a model that was a function of all the covariates [tree density (td), basal area (ba), shrub cover (sc), distance to the nearest settlement (dist), disturbance index (di), elevation (ele) and observer (obs)]. We refer to this model as the 'general model'.

We also compared our ungulate estimates of occupancy with independent estimates of occupancy of the four species of ungulates from Taman Negara National Park (TMNP) in peninsular Malaysia (for details of sampling sites in TMNP see Kawanishi & Sunquist, 2004). They used a combination of camera trap and 100 m indirect sign transects to arrive at occupancy estimates. They however, had used Nichols-Karanth method (Nichols & Karanth, 2002) to arrive at occupancy estimates. The Nichols-Karanth method advocates that an estimate of the number of occupied sites can be obtained by using closed population mark-recapture methods.

Model selection was done based on the delta AIC values (Burnham & Overton, 1978) where only models with ΔAIC values less than 2 were considered (Burnham & Anderson, 2002).

Results

Twelve models were run and were ranked according to AIC values for muntjac. For muntjac, seven models had virtually identical weight, suggesting that all models provide a similar description of the data (Table 1), despite the different structural forms. One of the seven models was also the 1 group constant *p* model suggesting that occupancy of the muntjac did not vary across sites. Therefore, we cannot make conclusive statements regarding the importance of the covariates for muntjac. In addition, all models gave similar occupancy estimate of 1 (± 0.00) (Table 1) suggesting that muntjac though occurring at low densities was widespread. For sambar, the best model selected was the 1 group constant *p* model from the eleven models. The occupancy estimate of sambar was also high (0.83 ± 0.08). No other model was able to explain the occupancy of sambar better.

The influence of disturbance was evident on occupancy of wild pigs. The summed model weight of the disturbance index was 41% and distance to settlement was 22% suggesting that disturbance was the most important factor for determining whether a site was used by wild pig. The occupancy estimate for wild pig was 0.45 (± 0.10) (Table 1). For gaur, the best model was the one which included ecological and anthropogenic factors (Table 1). The second best model was the general model which included all the covariates. The summed model weights of the two models were 99%. Gaur occupancy was not only affected by disturbance but also by ecological factors. The occupancy estimate for gaur was 0.24 (± 0.05).

Occupancy estimates of muntjac and sambar from NNP were comparable with those in TMNP in peninsular Malaysia (Kawanishi & Sunquist, 2004; Table 2). However, occupancy estimates of wild pig and gaur in NNP were much lower than in TMNP (Table 2). They were also the two species which were affected by disturbance.

Table 1. Summary of models with *ΔAIC* < 2 for four species of ungulates in Namdapha National Park, Arunachal Pradesh, north-east India.

Species		Model type	*ΔAIC*	Weight	*psi (Ψ)*	SE
Indian muntjac	1	1 group constant p	0.00	0.13	1.00	0.00
	2	psi (di), p(.)	0.00	0.13	1.00	0.00
	3	psi (dist), p(.)	0.00	0.13	1.00	0.00
	4	psi (td), p(.)	0.00	0.13	1.00	0.00
	5	psi (ba), p(.)	0.00	0.13	1.00	0.00
	6	psi (sc), p(.)	0.00	0.13	1.00	0.00
	7	psi (ele), p(.)	0.00	0.13	1.00	0.00
	8	psi (dist+di), p(.)	2.00	0.05	1.00	0.00
	9	psi (td+ba), p(.)	2.00	0.05	1.00	0.00
Sambar	1	1 group constant p	0.00	0.86	0.80	0.08
Wild Pig	1	psi (di), p(.)	0.00	0.24	0.45	0.10
	2	psi (di+dist), p(.)	1.32	0.12	0.48	0.09
	3	psi (sc), p(.)	1.49	0.11	0.49	0.09
	4	psi (ba), p(.)	1.64	0.11	0.50	0.08
Gaur	1	psi (dist+di+td+ba+sc+ele), p(.)	0.00	0.61	0.24	0.05
	2	psi (dist+di+ele+td+ba+sc+obs), p(.)	0.97	0.38	0.24	0.04

dist = distance to nearest settlement, di = disturbance index, ele = elevation, td = tree, density, ba = basal area, sc = shrub cover, obs = observer

Table 2. Occupancy estimates of four species of ungulates with variances from Namdapha National Park and from Taman Negara National Park, Malaysia (Kawanishi & Sunquist 2004)

	Namdapha, India (present study)	Taman Negara National Park, Malaysia (Kawanishi & Sunquist 2004)		
Species		Merapoh	Kuala Terengan	Kuala Koh
Indian muntjac *Muntiacus muntjak*	1.00 (± 0.00)	1.00 (± 0.03)	1.00 (± 0.00)	1.00 (± 0.01)
Sambar *Cervus unicolor*	0.80 (± 0.24)	0.64 (± 0.10)	0.46 (± 0.02)	0.81 (± 0.03)
Wild pig *Sus scrofa*	0.45 (± 0.37)	0.88 (± 0.02)	1.00 (± 0.01)	1.00 (± 0.01)
Gaur *Bos gaurus*	0.24 (± 0.09)	0.67 (± 0.04)	1.00 (± 0.31)	0.11

Discussion

This is one of the first studies where occupancy approach is being used to monitor populations of wild ungulates. In addition to generating baselines for future monitoring of these species, the other objective was to determine whether the species were patchily occupying the landscape in response to varied levels of hunting and disturbance in the area. The occupancy estimates of muntjak and sambar were high and suggest that though these two species occur at low densities, they occupy a large proportion of the area of interest. They also do not seem to respond to distance to settlements and disturbance. For long-term monitoring of these two species more robust abundance based measures might be required. However, poor detectability and logistic feasibility in terms of effort to obtain reliable density estimates from standard line-transect sampling is a matter of concern. In the three-month study period, we had only three sightings of muntjacs and none of sambar while walking on foot suggesting that not only is their detection probability low but also that they might be occurring at extremely low densities.

On the other hand, wild pig and gaur seem to be negatively affected by disturbance. They seem to avoid sites which are closer to human settlements and sites with high levels of disturbance. In spite of low levels of occupancy of gaur, the model was able to precisely estimate its occupancy (0.24 ± 0.05). The occupancy framework thus could be successfully used to monitor changes in occupancy of these two species in response to reduced levels of hunting pressures in future. We would expect wild pig and gaur to occupy more sites with reduced hunting pressures. We do not expect these two species to be patchily distributed in the landscape; both species have a wide distributional range and co-occur with muntjac and sambar from the dry forests to evergreen forests in other parts of India.

Occupancy of muntjac and sambar were comparable with similar sites in Malaysia. However, occupancy of wild pig and gaur which are two other important prey species of tiger are much lower in NNP than in the TMNP in Malaysia. Our camera trap survey in the park with an effort of 1537 trap days did not yield a single capture of tiger in the area. We also did not come across any tiger signs (faeces/pugmarks/scrapes) during the three month survey effort. Although direct poaching of tigers has been partly responsible for its decline in the park, the low levels of occupancy and abundance of large prey has also possibly accelerated the decline. We anticipate that over the coming years reduced hunting pressures would result in recovery of wild ungulate populations which would result in increase in tiger densities in the area. Fortunately the area is not isolated and is well connected with other tiger habitats within Indian limits and also beyond Indian borders in Burma.

References

Buckland, S.T., Anderson, D.R., Burnham, K.P. Laake, J.L., Borchers, D.L. & Thomas, L. 2001 *Introduction to Distance Sampling*. Oxford University Press, Oxford.

Burnham, K.P. & Overton, W.S. 1978 Estimation of the size of the closed population when capture probabilities vary among animals. *Biometrika* 65: 625–633.

Burnham, K. P. & Anderson, D. R. 2002 *Model selection and Inference: A Practical Information-theoretic Approach*. Springer-Verlag, New York, USA

Cook, R.D. & Jacobson, J.O. 1979 A design for estimating visibility bias in aerial surveys. *Biometrics* 35: 735–742.

Datta, A. 2002 *Status of hornbills and hunting among tribal communities in eastern Arunachal Pradesh*. Report submitted to the Wildlife Conservation Society, New York and WCS-India Program, Bangalore. 70 pp.

Datta, A. 2003 *A survey of endangered mammals in Changlang district, Arunachal Pradesh: discovery of two muntjaks from India.* Report submitted to the Wildlife Conservation Society, NY, and India-Program and the Forest Department of Arunachal Pradesh, March 2003. 30 pp.

Datta, A., Pansa, J., Madhusudan M.D. & Mishra, C. 2003 Discovery of the leaf deer *Muntiacus putaoensis* in Arunachal Pradesh: an addition to the large mammals of India. *Current Science* 84: 101–102.

Datta, A. 2007 Protecting with people in Namdapha: threatened forests, forgotten people. Chapter in "*Making Conservation Work: securing biodiversity in this new century*". Edited by G. Shahabuddin & M. Rangarajan. Permanent Black, New Delhi.

Datta, A. *et al.* 2007. *Hornbills and tribal communities: wildlife conservation in Arunachal Pradesh 2003-2006*. Interim report submitted to the Arunachal Pradesh Forest Department. 136 pp.

FitzGibbon, C.D., Mogaka, H. & Fanshawe, J.H. 1995 Subsistence hunting in Arabuko-Sokoke Forest, Kenya, and its effect on mammal populations. *Conservation Biology* 9: 1116–1126.

Hilaluddin, K. R. & Ghose, D. 2005 Conservation implications of wild animal biomass extractions in Northeast India. *Animal Biodiversity and Conservation* 28: 169-179.

Hines, J.E. 2006 Program PRESENCE ver. 2.0. USGS. Patuxent Wildlife Research Centre, Laurel, MD, USA.

Kawanishi, K. & Sunquist, M.E. 2004 Conservation status of tigers in a primary rainforest of Peninsular Malaysia. *Biological Conservation* 129: 329–344.

MacKenzie, D.L., Nichols, J.D., Royle, J.A., Pollock, K.H., Bailey & Hines, J.E. 2006 *Occupancy Estimation and Modeling*. Academic Press, London, UK.

Mishra, C., Madhusudan, M.D. & Datta, A. 2006 Mammals of the high altitudes of western Arunachal Pradesh, Eastern Himalaya: an assessment of threats and conservation needs. *Oryx* 40: 1–7

Nichols, J.D. 1991 Extensive monitoring programs viewed as long-term population studies: the case of North American waterfowl. *Ibis* 133 suppl. 1: 89–98.

Nichols, J.D., Hines, J.E., Sauer, J.R., Fallon, F.W., Fallon, J.E. & Heglund, P.J. 2000 A double-observer approach for estimating detection probability and abundance from point counts. *Auk* 117: 393–408.

Nichols, J.D. & Karanth, K.U. 2002 Statistical concepts: assessing spatial distributions. In *Monitoring Tiger and Their Prey: A Manual for Researchers, Managers and Conservationists in Tropical Asia* (eds K.U. Karanth & J.D. Nichols), pp. 29–38. Centre for Wildlife Studies, Bangalore, India.

Nichols, J.D. & Williams, B. K. 2006 Monitoring for conservation. *Trends in Ecology and Evolution* 21: 668–673.

Otis, D.L., Burnham, K.P., White, G.C. & Anderson, D.R. 1978 Statistical inference from capture data on closed animal populations. *Wildlife Monographs* 62: 1–135.

Peres, C.A. 2000 Effects of subsistence hunting on vertebrate community structure in Amazonian forests. *Conservation Biology* 14: 240–253.

Pollock, K.H., Nichols, J.D., Brownie, C. & Hines, J.E. 1990 Statistical inference for capture-recapture experiments. *Wildlife Monographs* 107.

Chapter 4

Relative abundance of small carnivores in two Protected Areas: camera trapping survey

Aparajita Datta, Rohit Naniwadekar, M.O. Anand

Field data collection: Akhi Nathany, Duchaye Yobin, Ngwa-akhi Yobin, Shekhar Subba, others & Meghna Krishnadas(Namdapha)

Rasham Barra, Taya Tayum, Narayan Mogar (Pakke)

Introduction

Small carnivore (herpestids, mustelids, viverrids) diversity is centred in two major regions in the Indian sub-continent, in the Eastern Himalaya and North-east Hills and the Western Ghats (Sterndale, 1884; Pocock, 1939; Nowak, 1999). There are 33 species of small carnivores in India, with more than 50% of these species occur in North-east India, with some species occurring nowhere else in India (Mudappa, *in press*).

The high diversity of small carnivores in North-east India is due to the region being located at the confluence of three important biogeographical realms, with several species being unique to the region within India. These include the spotted linsang, binturong, crab-eating mongoose, hog badger, two species of ferret-badgers, while several of the other civets range into other parts of India, and the yellow-throated marten into the western Himalaya. In the Eastern Himalaya in Arunachal Pradesh, the diversity is greater due to the wide altitudinal range of the state resulting in a high diversity of habitat types from lowland forests to alpine areas

The rainforests have a distinct assemblage of small carnivores with nocturnal and solitary civets being the most species-rich. While many are terrestrial, some especially those in the subfamily Paradoxurinae are arboreal. The rainforests of North-east India harbour a diverse assemblage of mustelids, viverrids and herpestids, many of which are threatened by hunting in this region, yet very little information exists on their status, distribution, abundance and ecology throughout their range in North-east India (Choudhury, 1997a; 1997b; 2003; Datta, 1999) and South-east Asia apart from general status reviews of small carnivores/single species in specific countries based on anecdotal information (Duckworth *et al*., 1994; Duckworth; 1997, van Rompaey; 1995; Evans *et al*., 2000; Azlan, 2003, Holden, 2006; Long & Hoang, 2006). Most information is restricted to sighting records (eg. Nettlebeck, 1997). Anecdotal evidence suggests that hunting of most small carnivores is often retaliatory around villages when poultry is killed by some of these species. There is also accidental or opportunistic killing of these species when they are caught in snares or traps set for other animals. Hunting is mainly carried out with guns, cross-bows and a variety of indigenous traps and snares.

Most species are rare and several are nocturnal precluding observational studies, therefore camera trapping is a useful method to document species richness and estimate relative abundances. However, very few studies have used this method to specifically survey small carnivores (Mudappa, 1998; Long & Hoang, 2006), most often camera traps surveys designed for other species have obtained incidental information on richness and abundance of small carnivores (Grassman, 2003; O'Brien *et al*., 2003; O' Brien *et al*., unpubl. data; Lynam, 2003; Johnson *et al*., 2006). Much work on small carnivores have used night walks along established trails to estimate encounter rates or densities, however in many areas, these may be time-consuming and labour-intensive and preclude wider spatial coverage. Density and abundance estimates vary based on habitat type. In south-east Asian forests, estimates suggest high densities of 31.5/km^2 for 8 civet species in undisturbed primary forest (Heydon & Bulloh, 1996), although encounter rates for most species drop in logged forests. A few studies have used radio-telemetry to study ranging patterns of small carnivores (Rabinowitz, 1991; Joshi *et al*., 1995; Grassman, 1998; Grassman *et al*., 2005; Mudappa, 2001), while effects of habitat fragmentation has been studied on small carnivores in the Western Ghats (Mudappa *et al*., 2007).

Namdapha and Pakke are believed to harbour 14 species of terrestrial/arboreal forest-dwelling small carnivores, apart from 2-3 species of the aquatic otters. In addition, Namdapha also harbours the red panda (*Ailurus fulgens*) and possibly high-altitude weasels in the temperate and alpine areas (Ghosh, 1987).

In this chapter, we only report on the relative abundance and diversity of species that occur in the evergreen and semi-evergreen forests up to 1200m based on camera-trapping surveys carried out from 2005-2007 and on opportunistic sightings. Relative abundances of small carnivores were estimated and compared to those obtained in several other tropical forests.

Methods

Camera trapping

The study focused on an area of 1200 km^2, roughly encompassing the moist evergreen habitat within the Namdapha National Park below 2000 m. A uniform grid (3 x 3 km) was imposed on a map of the area. A grid size of 9 km^2 was selected to match the scale of other camera-trapping surveys in south-east Asia (Grassman, 2003; O'Brien *et al*., 2003; Kawanishi & Sunquist, 2004; Johnson *et al*., 2006). Of the 130 grids covering the study area, a random selection of 80 grids was made. With only 16 km of motorable road, all field work was carried out on foot. Given logistic difficulties in the hilly terrain, limitations of time, manpower and equipment, sampling was carried out between October 2006 and January 2007 in 40 of the initially selected 80 grids covering 30% of the study area.

We surveyed small carnivore species using 42 passive infra-red camera trap units (38 DEERCAM-300 camera trap units from Forestry Suppliers Inc., USA and 4 units made by the Centre for Electronic Design and Technology, Indian Institute of Science, Bangalore). In each of 40 sampled grids, two or three camera traps were deployed. Traps were deployed along animal trails, streambeds, and ridgelines, in locations with evidence of animal movement. We recorded the GPS location, altitude and other habitat parameters at each trap site. A group of highly skilled *Lisu* trackers assisted in identifying suitable locations for deploying camera traps. At every location, one passive infra-red camera trap was placed perpendicular to the expected direction of animal movement at a height of 30-40 cm from the ground. We maintained a minimum distance of 400-500 m between trap locations. However, on two occasions we placed traps at a distance of 200 m apart, due to inaccessible terrain and lack of suitable sites. The traps were operational for 24 hours a day, and were removed after a period of 15 days. The number of camera trap days was calculated from the date of deployment till the date of retrieval (if film was not used up) or till the date of the final photo. A potential bias of our survey was that all camera traps were located on the ground; therefore certain species that are more reported to be more arboreal may not be captured as frequently.

Data analysis

Based on photo-capture rates of small carnivore species, an index of relative abundance was calculated as the number of days required to obtain a photo capture of a species, described as RAI in Carbone *et al.* (2001). Independence of detections was defined following O'Brien *et al.* (2003). Relative abundance values from the current study were also compared to those obtained from studies in geographically and climatically similar forests in six sites in south-east Asia which face lower or comparable hunting pressures (Grassman, 2003; Lynam, 2003; O'Brien *et al.*, 2003; O'Brien *et al.*, unpubl. data; Kawanishi & Sunquist, 2004; Johnson *et al.*, 2006).

Results & Discussion

Table 1 lists the evidence used to determine presence, qualitative assessments of status and hunting pressure and the reasons for hunting each of the small carnivore species. Pakke and Namdapha were similar in species richness, however there was limited trapping effort in Pakke, therefore fewer were recorded on cameras (Table 2). We recorded six species in 1537 trap nights in Namdapha during the survey from November 2006 to January 2007, while at Pakke with a limited effort of 231 trap nights, we recorded four species. Additional trapping effort in October-November 2007 of 119 trap nights in Namdapha yielded 1 more species, the hog badger. Direct sightings and indirect evidence confirmed the occurrence of some other species.

Species richness in Pakke

Of 15 species of small carnivores (viverrids, mustelids and herpestids), four species were recorded with a limited trapping effort of 231 trap nights spread over six months (Table 3).

Six species of civets are believed to occur in Pakke TR, an additional species (the Small-toothed palm civet) is believed to occur, although this remains unconfirmed. Only two civet species, the Large Indian civet and Small Indian civet were captured. It is possible that some of these species such as the binturong and spotted linsang were not captured as they are more arboreal. In Pakke, the crab-eating mongoose, a little-known and relatively rare mongoose was captured twice during the sampling period. The diurnal yellow-throated marten was not recorded in photo captures, although it was seen once during a transect walk. However, this species has been sighted several times during prior research (1995-2000) in the area and is relatively common. The binturong is reported to be nocturnal, crepuscular and more arboreal (Nowak, 1991; Nettlebeck, 1997;, Grassman *et al.* 2005). There were three sightings of binturong in Pakke during earlier work (1995-2000). All sightings were in the daytime on trees and they were recorded feeding on figs.

Species richness in Namdapha

Of the total 15 species of small carnivores (viverrids, mustelids and herpestids), only seven were recorded on camera traps (Table 4). Three civet species, the Himalayan or Masked Palm civet, the Common palm civet and the Large Indian civet were photo-captured. The Crab-eating mongoose and the Chinese ferret badger were photo-captured in the wild for the first time during this survey. Although the two species of ferret-badgers that are known to occur here are mainly differentiated based on dentition and facial markings, another feature is the difference in the extent of the dorsal streak, which in the Burmese or Large-toothed ferret badger *Melogale personata* runs all the way to its tail and in the Chinese or Small-toothed ferret badger *Melogale moschata* runs only up to the shoulders. Based on this, we tentatively conclude that we recorded the Chinese ferret badger. The hog badger was not recorded in the initial 3 month trapping survey, but was recorded once later during October 2007. The yellow-throated marten is the only small carnivores that is sighted relatively often in the daytime, was also recorded on camera traps.

However, only 8 of the 15 are true rainforest-dwelling species. These include the spotted linsang, binturong, Burmese and Chinese ferret-badger, hog badger, stripe-backed weasel, Himalayan palm civet, large Indian civet.

We recorded three of six species of civets are believed to occur in Namdapha National Park, an additional species (the Small-toothed palm civet *Arctogalidia trivirgata*) is believed to occur (Choudhury, 2003), although this remains unconfirmed. The common palm civet and the Small Indian civet are also reported in deciduous forest habitats, while the latter is known to occur even in degraded forests close to human habitation. The Small Indian civet was possibly not recorded as our sampling was restricted to interior primary forests. The Small Indian mongoose was also not recorded as it generally occurs in open degraded forests close to habitation. Otters were not recorded possibly because they are aquatic and only a few of our trapping locations were close to streams. The more arboreal binturong and spotted linsang were also not captured. We also did not record the stripe-backed weasel.

Relative abundance

Relative abundances of all six species were high relative to that in tropical forest sites in south-east Asia (Table 5); however rare species such as the binturong *Arctictis binturong*, spotted linsang *Prionodon pardicolor*, and stripe-backed weasel *Mustela strigidorsa* were not recorded by camera trapping at either of the two sites. In addition, the more open habitat species such as the Small Asian mongoose and Small Indian civet were not recorded in Namdapha. Capture rates of the Large Indian civet *Viverra zibetha* was relatively high in Namdapha compared to other species and along with the yellow-throated marten, they appear to be more common. Evidence of incidental or retaliatory hunting was recorded for most species; otters are highly threatened in Namdapha due to considerable hunting for its skin which has high market value.

Other evidence for species not recorded on camera traps

The stripe-backed weasel has been recorded very rarely, either capture of a live animal (Grassman *et al*., 2002) or in two camera trap surveys (Johnson *et al*., 2006, Small Carnivore Conservation Program of Cuc Phuong National Park). Abramov (*et al.*, 2007), however conclude that they are possibly "*inconspicuous denizens of chronically under-surveyed regions*". The status of the species is uncertain, but it may not be particularly rare, as many of these species are believed to be resilient and show habitat plasticity. During field work in Namdapha, there were two potential sightings of the species (2005), but these cannot be confirmed. One skin was recorded from a *Lisu* village inside Namdapha in December 2006. The animal had been killed in retaliation for killing poultry. An old skin was also seen in the museum maintained by park authorities. The binturong is another species that was not recorded on camera traps and was not sighted in Namdapha. The spotted linsang is another rare viverrid. It is solitary, nocturnal, and reported to be equally at home on trees and the ground (see van Rompaey, 1995). One skin was recorded from a *Lisu* village outside Namdapha in December 2005. The animal had been killed in retaliation for killing poultry.

Hunters report occasional killing of all the small carnivore species usually in retaliation or when they are accidentally killed in traps and snares. None of the species appeared to be targeted for any particular use, although if killed, the meat is eaten. Skins/skulls of most species were seen, although no direct or indirect evidence of hunting for binturong or ferret-badgers were seen in Namdapha. The only small carnivores that are under severe threat from high hunting pressures are the otter species for their skins which fetch Rs. 10,000-12,000. Table 6 lists the local names used by three tribes for some small carnivores that occur in the survey areas.

Table 1. Presence, status, hunting pressures on small carnivores in Pakke Wildlife Sanctuary and Namdapha National Park

Species	Namdapha	Pakke	Status	Hunting pressure	Reason for hunting
Red panda	Local reports	Not present	Rare	Moderate	Skin, accidental
Otters (2-3 species)	2 sightings	Sightings, indirect signs, skin	Threatened in Namdapha	High	Skin for trade
Large Indian civet	Camera trap	Camera trap	Common	Moderate	Retaliatory, accidental, decorative value
Small Indian civet	2 sightings	Camera trap, sightings	Common	Moderate	Retaliatory, accidental
Common palm civet	Camera trap	Camera trap, sightings	Common	Moderate	Retaliatory, accidental
Masked palm civet	Camera trap, 2 sightings	Local reports	Common	Moderate	Retaliatory, accidental
Binturong	Local reports, droppings?	Sightings	Uncommon	Occasional, low	Accidental?
Spotted linsang	Skin	None	Rare	Moderate	Retaliatory, accidental, decorative
Yellow-throated marten	Camera trap, several sightings, skins	Several sightings	Most common	Occasional, low	Retaliatory, accidental (meat not usually eaten)
Crab-eating mongoose	Camera trap, 2 sightings	Camera trap	Common	Occasional, low	Accidental?
Small Indian mongoose	None, but known to occur	Sighting, captive animal	Common	Occasional, low	Accidental
Stripe-backed weasel	Skin, 2 possible sightings	Partial skin? (in 1996)	Rare	Occasional, low	Retaliatory, accidental
Hog badger	Camera trap, droppings, local reports	None	Uncommon	Moderate	Accidental, sport (meat not usually eaten)
Large-toothed ferret-badger *Melogale personata*	None	None	Unknown	Unknown	Accidental?
Small-toothed ferret-badger *M. moschata*	Camera trap, [a] reports of 2 specimens	Skin (in 1997)	Uncommon	Occasional, low	Accidental?

Table 2. Small carnivore species richness in Pakke WLS and Namdapha NP (2003-2007).

AREA	No. of reported species	Species recorded on camera traps	Species recorded by other methods	*Other evidence	No confirmed recent evidence
Namdapha	15	7	2	4	2 (1 otter species, 1 ferret-badger species)
Pakke	15	4	4	1	6

* includes skin, skulls, confirmed droppings, signs, reliable sighting records by others

Table 3. Relative abundance indices for species recorded in Pakke WLS on camera traps (231 trap nights) from December 2005 - May 2006 and September – October 2006.

Species	Total photos	Independent photos	RAI_1	RAI_2
Small Indian civet *Viverricula indica*	1	1	231	0.43
Large Indian civet *Viverra zibetha*	5	4	58	1.73
Common palm civet *Paradoxurus hermaphroditus*	1	1	231	0.43
Crab-eating mongoose *Herpestes urva*	3	3	77	1.30
Total	10	9	26	3.90

RAI1: Number of days required to get single photo capture, RAI2: Number of photos per 100 trap-days

Table 4. Relative Abundance indices for species recorded on camera traps in Namdapha NP from Oct 2006-December 2007 (1537 trap nights).

Species	Total photos	Independent photos	RAI_1	RAI_2
Chinese Ferret badger *Melogale moschata*	5	4	384	0.26
Yellow-throated marten *Martes flavigula*	10	5	307	0.32
Large Indian civet *Viverra zibetha*	12	11	140	0.72
Common palm civet *Paradoxurus hermaphroditus*	11	4	384	0.26
Masked palm civet *Paguma larvata*	5	5	307	0.32
Crab-eating mongoose *Herpestes urva*	4	2	768	0.13
***TOTAL**	47	31	50	2.02

RAI1: Number of days required to get single photo capture, RAI2: Number of photos per 100 trap-days.

*Additional trapping effort of 119 days in October-November 2007 yielded 1 photo of hog badger and 1 of Masked palm civet.

Table 5. Relative Abundance Indices (number of trap days required to get a single photo capture of a species) derived from camera trap surveys for carnivores and prey species in Namdapha National Park and four other protected areas in south-east Asia.

Reference	Present Study	Kawanishi & Sunquist 2004	Tim O'Brien unpubl. data (1998-2006)	Grassman 2003	Lynam 2003
Location	Namdapha NP, India	Taman Negara NP, Malaysia	Bukit Barisan Selatan NP, Indonesia	Phu Khieo Wildlife Sanctuary, Thailand	Hukawng Valley Tiger Reserve, Myanmar
Trap Nights	1537	14,054	24,045	1224	8836
Yellow- throated Marten	**384**	**2008**	**1717**	**1224**	**-**
Common Palm Civet	**384**	**3513**	**1718**	**306**	**-**
Masked Palm Civet	**307**	**2342**	**650**	**-**	**8836**
Large Indian Civet	**140**	**2008**	**NA**	**68**	**736**
Small Indian civet	**-**	**-**	**-**	**-**	**2945**
Binturong	**-**	**4685**	**3005**	**408**	**2945**
Small-toothed palm civet	**-**	**-**	**12022**	**-**	**-**
[a]Linsang	**-**	**14054**	**829**	**-**	**-**
Hog badger	**-**	**NA**	**NA?**	**408**	**-**
Chinese ferret-badger	**384**	**NA**	**NA**	**NA**	**-**
Burmese ferret-badger	**-**	**NA**	**NA**	**-**	**-**
Crab-eating mongoose	**768**	**NA**	**NA**	**-**	**631**
Stripe-backed weasel	**-**	**NA**	**NA**	**-**	**-**
[d]Total species recorded	**6**	**8***	**9#**	**5**	**5**

[a]Includes both the banded and spotted linsang, only the spotted linsang is known to occur in NE India, the banded linsang only occurs further east in south-east Asia.
*Includes 2 other species of civets and banded linsang *Prionodon linsang* and I otter species
#Includes 2 other species of civets, Malay badger, banded linsang and 1 otter species

Table 6. Local names of small carnivores among three tribes of Arunachal Pradesh

S.No	Common name	*Lisu*	*Wancho*	*Nishi*
1.	Red panda	Wubi	Does not occur	Does not occur
2.	Otters	Ngwala	Jagam	Seram
3.	Large Indian civet	Shiodu	Kookung	Seeng
4.	Small Indian civet	?		Seeng
5.	Common palm civet	Payi-maca	Tham	Seeng
6.	Masked palm civet	Payi-anna	Tham	Seeng
7.	Binturong	Payi-gulo		Seeng
8.	Spotted linsang	Jula		
9.	Yellow-throated marten	Jela	Langku	Sorchi
10.	Crab-eating mongoose	?	Ju-chayi	
11.	Small Asian mongoose	Namsolo?		
12.	Stripe-backed weasel	Namsolo		
13.	Hog badger	Mwe-ayi-wu	Gang-bak	
14.	Burmese ferret-badger	Hainwe		
15.	Chinese ferret-badger	Hainwe?		

References

Abramov, A.V., Duckworth, J.W., Wang, Y.-X. and Roberton, S. 2007. The stripe-backed weasel *Mustela strigidorsa*: taxonomy, ecology, distribution and status. *Small Carnivore Conservation.*

Azlan J., Mohd. 2003. The diversity and conservation of mustelids, viverrids, and herpestids in a disturbed forest in Peninsular Malaysia. *Small Carnivore Conservation* 29: 8–9.

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

Choudhury, A.U. (1997a) The distribution and status of small carnivores (mustelids, viverrids, and herpestids) in Assam, India. *Small Carnivore Conservation*. 16: 25-26.

Choudhury, A.U. (1997b) Small carnivores (mustelids, viverrids, herpestids, and one ailurid) in Arunachal Pradesh, India. *Small Carnivore Conservation*. 17: 7-9.

Choudhury, A. 2003. *The Mammals of Arunachal Pradesh.* Regency Publications, New Delhi.

Datta, A. 1999. Small carnivores in two protected areas of Arunachal Pradesh. *Journal of Bombay Natural History Society*. 96: 399-404.

Duckworth, J. W., R. J. Timmins, R. M. Thewlis, T. D. Evans & G. Q. A. Anderson. 1994. Field observations of mammals in Laos, 1992–1993. *Natural History Bulletin of the Siam Society* 42: 177–205.

Duckworth, J.W. 1997. Small carnivores in Laos: a status review with notes on ecology, behaviour and conservation. *Small Carnivore Conservation* 16: 1-21.

Evans, T. D., Duckworth, J. W. & R. J. Timmins. 2000. Field observations of larger mammals in Laos, 1994–1995. *Mammalia* 64: 55–100.

Ghosh, A. K. 1987. *Qualitative analysis of faunal resources of proposed Namdapha biosphere reserve*, Arunachal Pradesh. Zoological Survey of India, Calcutta.

Grassman, L. I. Jr. 1998. Movements and fruit selection of two Paradoxurinae species in a dry evergreen forest in southern Thailand. *Small Carnivore Conservation* 19: 25-29.

Grassman Jr., L.I. 2003. *Thailand cat project.* Unpublished final report submitted to Cat Action Treasury, Thailand.

Grassman, L.I. Jr., Kreetiyutanont, K., & Tewes, M. E. 2002. The Back-striped Weasel *Mustela strigidorsa* Gray, 1853 in northeastern Thailand. *Small Carnivore Conservation* 26: 2.

Grassman, Jr, L.I., Tewes, M.E., and Silvy, N.J. 2005. Ranging, habitat use and activity patterns of binturong *Arctictis binturong* and yellow-throated marten *Martes flavigula* in north-central Thailand. *Wildl. Biol.* 11: 49-57.

Heydon, M. J. & Bulloh, P. 1996. The impact of selective logging on sympatric civet species in Borneo. *Oryx* 30**:** 31-36.

Holden, J. 2006. Small carnivores in Central Sumatra. *Small Carnivore Conservation* 34&35: 35–38.

Johnson, A., Vongkhamheng, C., Hedemark, M. & Saythongdum, T. 2006. Effects of human–carnivore conflict on Tiger (*Panthera tigris*) and prey populations in Lao PDR. *Animal Conservation*. 9: 421–430.

Joshi, A. R., Smith, J. L. D. & Cuthbert, F. J. 1995. Influence of food distribution and predation pressure on spacing behaviour of palm civets. *J. Mamm.* 76: 1205-1212.

Kawanishi, K. & Sunquist, M.E. 2004 Conservation status of tigers in a primary rainforest of peninsular Malaysia. *Biological Conservation*. 120: 329-344.

Long, B. & Minh Hoang. 2006. Recent records of and notes on the conservation of small carnivores in Quang Nam province, central Vietnam. *Small Carnivore Conservation* 34 & 35: 39–46.

Lynam, A. 2003. A national tiger action plan for the Union of Myanmar. Myanmar Forest Department. Unpublished report. Ministry of Forestry, Myanmar Forest Department and Wildlife Conservation Society. pp. 55.

Mudappa, D. 1998*.* Use of camera-traps to survey small carnivores in the tropical rainforest of Kalakad-Mundanthurai Tiger Reserve, India. *Small Carnivore Conservation* 18**:** 9-11.

Mudappa, D. 2001. *Ecology of the brown palm civet Paradoxurus jerdoni in the tropical rainforests of the Western Ghats, India.* Bharathiar University, Coimbatore, India.

Mudappa, D., Noon, B.R., Kumar, A. and Chellam, R. 2007. Responses of small carnivores to rainforest fragmentation in the southern Western Ghats, India. *Small Carnivore Conservation* 36: 18-26.

Mudappa, D. in press. *Herpestids, viverrids and mustelids of South Asia. In*: A.J.T. Johnsingh & N. Manjrekar (Eds.), Mammals of South Asia: ecology, behaviour and conservation. Universities Press, Hyderabad, India.

Nettlebeck, A.R. 1997. Sightings of Binturong in the Khao Yai National Park. *Small Carnivore Conservation* 16: 22-24. (April).

Nowak, R. M. 1999. *Walker' Mammals of the World*. Vol. I: Pp.704-786. The John Hopkins University Press, Baltimore and London.

O'Brien, T.G., Kinnaird, M.F. & Wibisono, H.T. (2003) Crouching tigers, hidden prey: Sumatran tiger and prey populations in a tropical forest landscape. *Animal Conservation* 6: 131-139.

Pocock, R. I. 1939. *The Fauna of British India, Including Ceylon and Burma. Mammalia*, 2nd edition*. Vol. 1.* Taylor & Francis, Ltd., London.

Rabinowitz, A. R. 1991. Behaviour and movements of sympatric civet species in Huai Kha Khaeng Wildlife Sanctuary, Thailand. *Journal of Zoology, London* 223: 281–298.

Sterndale, R. A. 1884. *Natural History of the Mammalia of India and Ceylon*. Thacker, Spink & Co., Calcutta, India.

van Rompaey, H. 1995. The Spotted linsang, *Prionodon pardicolor*. *Small Carnivore Conservation* 13**:** 10-13.

Chapter 5

Long-term monitoring of nest and roost sites of three hornbill species

Aparajita Datta

Field data collection: Narayan Mogar, Rasham Barra, late Taya Tayum

Introduction

Hornbills are large and conspicuous birds of the tropical forests of Asia and Africa. They are brightly coloured, have loud calls, and characteristically large bills and casques. Due to their predominantly frugivorous diet, hornbills have always been considered important agents of seed dispersal in the tropical forest. The tropical forests in north-east India have a diverse assemblage of hornbills, ranging from the cooperatively breeding Brown hornbill (*Anorrhinus austeni*) to the monogamous territorial Great hornbill (*Buceros bicornis*).

Most hornbill species have specialized requirements and are threatened and vulnerable in varying degrees, because of traditional hunting and the recent accelerated habitat loss and modification due to logging, shifting cultivation and clearing of land for settlements and agriculture.

The status of hornbills in most of the north-east region is precarious due to hunting by several tribal communities. The NE region has 64% forest cover which is considerably higher than other areas of India. However, fifty-six% of these forests are community forests with a predominantly tribal population and an area of 173,000 km^2 under *jhum* cultivation. From 1991 to 1999, estimates show a decrease of 1800 km^2 in forest cover in North-east India.

Within north-east India, the status of hornbills is probably better in Arunachal Pradesh than in other states, where hunting and forest loss to *jhum* (shifting cultivation), tea plantations and logging has been greater. However, even in many parts of Arunachal, hornbills are extremely rare or have become locally extinct due to both hunting and habitat loss. Though 12% of the geographical area has been brought under the PA network, the on-ground implementation of wildlife laws against hunting has not been successful. However, despite the imperfections of law enforcement and the prevalence of hunting even in PAs, they still afford a greater level of protection to wildlife than Unclassed state forest (USF) and Reserved Forests (RF) (70% of the forests are community-owned). Although population density is the lowest in India, the growth rate is high at almost 3% per year, increasing from 10 per km^2 in 1991 to 13 per km^2 in 2001. However, due to low population densities, in many areas, the *jhum* cycles are still relatively long compared to other states in the North-east. According to some estimates, shifting cultivation occupies 2300 km^2. Today, however, *jhum* is on the decline among many communities. Recent estimates suggest that dense forests cover only 16% of the area. The main sources of revenue for the state were forest-based industries till 1996, after which the Supreme Court banned logging. Combined with shifting cultivation, poorly regulated logging has resulted in loss of forest cover especially in the foothill forests of some districts. About 421 km^2 of dense forest has been lost over the last decade. Scientific studies have documented the detrimental impacts of logging on wildlife and forests. Moreover, hunting has led to the local extinction and rarity of several species of wildlife. Although, most hunting is for domestic consumption and sale, the extent of such hunting has resulted in population declines. With no proper land demarcation and cadastral surveys, there is encroachment of forest land for agriculture expansion.

While hornbills play an important role in the culture of many tribal communities in Arunachal, hunting of hornbills is a major conservation issue due to the traditional value of these birds for their feathers, beaks, casques, flesh and supposed medicinal value of their fat.

We are using hornbills as flagship species for this conservation program. Hornbills are an ideal symbol because the five species that occur here are greatly dependent on primary forests.

Pakke Wildlife Sanctuary and the adjoining Doimara and Papum reserve forests is one of the few large remaining areas of reasonably intact foothill forest and remains the best areas for hornbills in Arunachal Pradesh. In addition, the *Nishis* in the area have traditionally had a ban on hunting these birds in the breeding season. However, in recent years there has been habitat loss due to illegal forest clearing and encroachment for settlements and agriculture in adjoining forests in Assam on the Assam-Arunachal border. Hunting remains a threat, because of the traditional value and increasing rarity of these birds in other areas of Arunachal. They are very rare and even locally extinct in many other areas of Arunachal Pradesh. Namdapha National Park which harbours five species of hornbills (including the threatened Brown hornbill *Anorrhinus austeni*) is another relatively good area for hornbills. Hornbill abundance in other protected areas (Mehao WLS, Kamlang WLS, Tale Valley WLS, Itanagar WLS, Mouling National Park) and reserve forests in Arunachal Pradesh is much lower. Apart from higher hunting pressures, many of these areas are in higher elevations where the Great hornbill and the Oriental Pied hornbill are not seen much (being largely restricted to foothill forests below 1000 m), and the Wreathed hornbills only come in seasonally in the non-breeding season. The Rufous-necked hornbill is sighted in the high elevation areas above 900 m but is heavily hunted in these areas.

Surveys across 3 PAs and 4 Reserve forests and community forests (USF areas) in Arunachal were carried out between 1999 and 2002 covering 6 districts. Twenty-nine villages were visited in eastern Arunachal, while 10 villages were surveyed in western

Arunachal. A total of 181 households were visited and 140 hunter and key informant interviews were carried out. 34% of households (n = 80) had hornbill heads on display.

The survey found that hornbill abundance was generally higher in PAs with all species present, while there was very low abundance in most reserve and community forests. Some species were not recorded in some community forests especially in Tirap district where both high hunting pressures and habitat loss and degradation (due to logging and *jhum*) have contributed to the decline. The status of hornbills was good in reserve forests in East and West Kameng where hunting pressures appear to be lower, while some reserve forests in Jairampur Forest Division also hold good populations of hornbills as it has extensive patches of primary forests, although abundance was lower than in reserve forests of East and West Kameng.

Prior research on hornbills

A prior 4 year study on three sympatric hornbill species, the Great hornbill (*Buceros bicornis*), Wreathed hornbill (*Aceros undulatus*), and the Oriental Pied hornbill (*Anthracoceros albirostris*) in the lowland tropical semi-evergreen forests of Pakhui Wildlife Sanctuary (WLS) and adjoining reserve forests in western Arunachal Pradesh has gained an understanding into various aspects of hornbill biology including their breeding biology, diet, nest and roost site requirements.

The current program builds on that knowledge to ensure continued long-term protection of this important area for hornbills. We initiated a long-term monitoring program in 2003 to ensure protection of hornbills and crucial nesting and roosting habitat, continue scientific monitoring of hornbill populations, and assess nest site availability. Hornbills are secondary cavity-nesters with a prolonged breeding season, when they remain vulnerable to disturbances. Hornbills roost in large numbers in particular sites year after year, many of the known roost sites are close to habitation. Continuous monitoring of these roosts provides important demographic data on population structure and ensures protection of these vulnerable sites, some of which are close to human habitation.

Through our 4 year monitoring with reformed hunters we have ensured that there are no disturbances at nests during this crucial period and obtained estimates of nesting success (number of chicks fledged). Our assessments of hornbill abundance have also led to an understanding of factors that cause variation in local abundance and are also important in identifying potential population declines.

Methods

Standard methods are being followed in monitoring known hornbill nest sites during the breeding season for various parameters including date of nest entry, periodic visits to determine whether the nest is active, date of exit of female and chicks, nesting success and number of chicks fledged. Prior to the breeding season, searches to locate new nests are carried out every year during February-March. All known nest sites and new ones located every year are marked with a GPS and nest tree species and other parameters of the nest tree and nesting habitat noted. Similarly, crucial roosting sites are being monitored throughout the year. These counts from roost sites provide important demographic data on the population structure as it is possible to age and sex birds arriving at the roost. It also gives an idea of numbers in the area and is important in detecting any changes due to disturbance to roosting habitat. Most of this information is being collected by trained field staff under supervision, and is primarily a way to ensure continued monitoring and protection.

Results and discussion

Three species of hornbills (Great Hornbill, Wreathed Hornbill, Oriental Pied Hornbill) occur in the foothill forests of Pakke WLS, while the globally endangered Rufous-necked Hornbill is restricted to higher areas. At Namdapha, unlike Pakke, there has been no prior ecological study of hornbills; the initial effort was to locate hornbill nest and roost sites. This area has five species of hornbills; apart from the four species mentioned earlier, there is the rare Brown hornbill that is only found in lowland evergreen forests in eastern Assam and Arunachal within India. These two species have not been studied at all and there is almost no information available on them, even on nesting times. In the first year, we were able to locate 5 nests, 2 of the Rufous-necked hornbill, 2 of the Brown hornbill and 1 of the Great hornbill. We also located some roosting sites. In Namdapha, the nesting of these two species starts late (from end-April to August) coinciding with the heavy monsoon preventing access into the forests. Due to numerous logistic difficulties, the nests could not be monitored in the last 2 breeding seasons. Most of the hornbill nest and roost monitoring has taken place in Pakke WLS. In Pakke, nesting commences in mid-March and is over by July.

Nest and roost sites of three hornbill species (Great hornbill, Wreathed hornbill, Oriental Pied hornbill) were monitored during a prior research study from 1997-2000 in the Pakke Tiger Reserve. During the current project, nest and roost sites are being monitored from 2003. Research findings indicate that availability of suitable nesting cavities is a crucial limiting factor for hornbill populations in the area.

Prior research between 1997 and 2000 had estimated nesting densities of all three species to be 1 nest/km^2. Hornbills in the area are primarily dependent on a single tree species (*Tetrameles nudiflora*) for nesting, with 85% (n = 55) of nests on this species, and the remaining on *Ailanthus grandis*; both these are emergent softwood species and largely occur in foothill forest which is the main nesting habitat for hornbills.

The earlier study had documented high degree of overlap in both nest species and nesting habitat used by the three hornbill species. However, structural characteristic were important in determining nest site selection by the three species and the main parameters that differentiated nest characteristics of the three species were cavity size and size of nest tree, with the Great hornbill using the largest cavities, while the Oriental Pied hornbill used the smallest cavities. Nest tree size was also a secondary factor, wherein the Oriental Pied hornbill appeared to nest at greater heights as most often its cavities were on tertiary and quarternary branches, while the Great hornbill used cavities located on the main trunk. Cavity shape was also an important criterion in differential selection by species, with most nests of Great hornbill being elongated, while that of the Wreathed hornbill was mostly oval and Oriental Pied hornbill nests were round. No instances of direct competition for nests or nest takeovers were noted during 1997-2000.

However, between 1995 and 2000, there was large-scale deforestation in adjoining areas of Assam (232 km^2) that resulted in loss of crucial nesting habitat for hornbills. From 2003, when the monitoring program was initiated, we observed inspection and use of 'sub-optimal' nest cavities by hornbills that were never used earlier. Instances of interference competition for nest sites between hornbill species are being observed from 2003 due to loss of nesting habitat and nest trees from 2000 in adjacent foothill forest in Assam. In 2004, a nest takeover of a Wreathed hornbill nest that had been in continuous use for at least 8 years by a Great hornbill pair was observed. However, the pair did not use the nest in 2004 or 2005, although they displaced the Wreathed hornbill pair from the nest. In 2006, 3 nest takeovers of Wreathed hornbill nests by Great hornbills were observed and 1 attempt at a takeover of an Oriental Pied hornbill nest by a Wreathed hornbill pair was observed. These observations indicate a shortage of nesting sites in the area due to the considerable loss of foothill forests over the last 10 years.

In addition, there is a considerable turnover of nest sites. 63% of the nests known from the earlier study are no longer in use, while 20% have been lost due to felling. All nest trees (11) that were cut down were in the adjoining reserve forests in Assam, while one nest tree in the PA fell due to a storm. Sometimes, a nest maybe inactive for a few years, but maybe re-used after a gap of 1-3 years. A nest tree can become inactive due to occupation by monitor lizards, cavity shrinkage of hole, human disturbance during nesting and other unknown factors.

The total known nest trees are 55 (22 of GH, 21 of WH, and 12 of OPH), of which 44 are currently standing. Twenty-four new nests have been found between 2004 and 2006. A total of 46 nests were monitored in 2006, of which 2 were cut down in Papum Reserve Forest. The number of active nests was 32 (14 GH, 11 WH and 7 OPH) in 2006.

In 2003, 9 nests were monitored, while nesting was initiated in 6 nests with successful chick fledging in all 6 nests.

In 2004, 29 nests were monitored, while nesting was initiated in 22. Nesting success could not be determined because of heavy rains and a flood in July that prevented access into the forests to monitor the nest trees at the end of the breeding season.

In 2005, 36 nests were monitored while nesting was initiated in 21 nests, successful chick fledging was directly observed in 13 nests, while others could not be accessed at the end of the breeding season due to heavy rains.

In 2006, 46 nests were monitored, of which 32 were active and chicks fledged successfully in 28 nests. Eleven new nests were discovered (6 of Great hornbill, 4 of Wreathed hornbill and 1 Oriental Pied hornbill) in the 2006 breeding season. Most (87%) of the active nests in the 2006 breeding season were successful in raising chicks.

The percentage of nests that were active (that is, nesting was initiated) was high in most years (65-84%), except for 1999 and 2005 when nesting was initiated in only 50-58% of nest trees. There was poor fruit availability in the breeding season of 1999, especially of non-fig fruits that may have resulted in lower nesting. Phenological data is not available currently as fruiting is not being monitored; therefore the reasons for lower nesting in 2005 cannot be elucidated. However, nesting success was generally high in all years except in 2005.

Table 1. Long-term monitoring (1998-2006) of hornbill nests in Pakke: total nest trees, number monitored, active nests and successful nests and nest tree loss/takeovers. Data for 1997 is not shown as only two nests were monitored in that year.

	1998	1999	2000	2003	2004	2005	2006
Known trees	19	21	22	23	34	40	46
Monitored	19	16	17	9	29	36	46
Active	16	8	11	6	22	21	32
% Active	84	50	65	67	76	58	70
Success	13	8	11	6	NM	13	28
% Success	81	100	100	100	NM	62	87.5
Trees cut/fallen	3	2	0	0	1	0	2
Nest takeover	0	0	0	0	1	0	3

Initial assessments of nesting site availability were started in April 2006, but could not be completed this year because all field staff contracted malaria and were seriously ill for two months.

Roost sites

Hornbills in the area roost communally, although the phenomenon is more pronounced in the non-breeding season. The Great hornbills (60+) roost communally only in the non-breeding season. The Wreathed hornbills are seen in the largest numbers (100+) and roost communally throughout the year. Both single species roosts and mixed-species communal roosts are seen. Mixed species roosts have only been seen in the non-breeding season.

Most of the known roost sites are close to habitation in open grassland habitats near large rivers, perennial streams or on cliff faces along streams. They mainly use scattered trees of *Albizzia* spp. and *Bombax ceiba* as roost trees.

Counts have been made at dusk at 5-6 roost sites over the last 7 years. A particular roost site may be used only for a few days at a time or up to 3 months.

Figure 1. Wreathed hornbill numbers (minimum-maximum range) at particular roost sites in the non-breeding season (August to February) from 2003-2006.

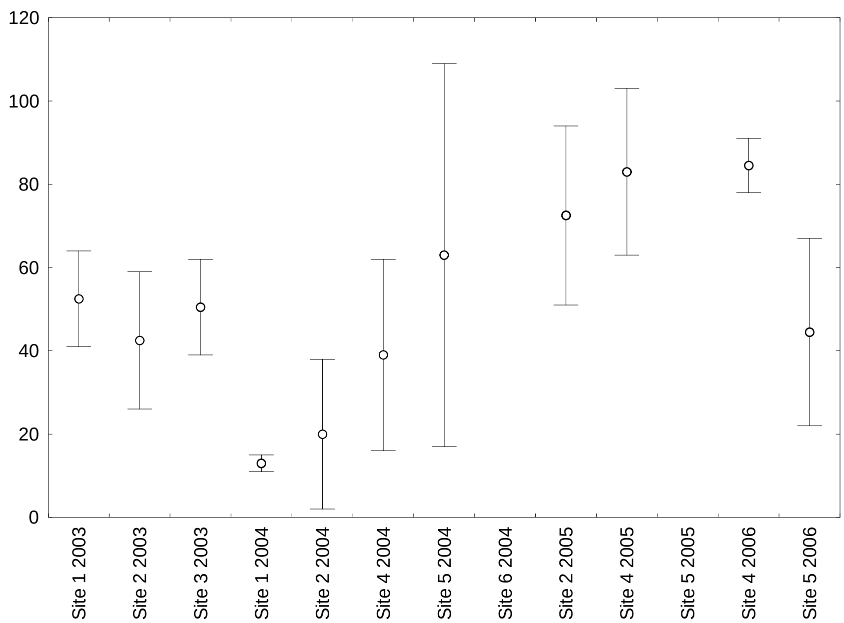
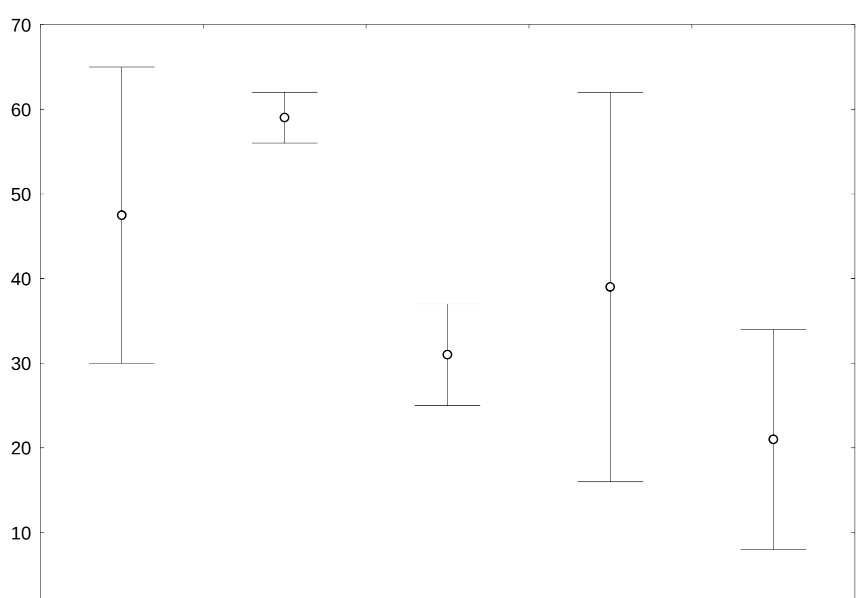
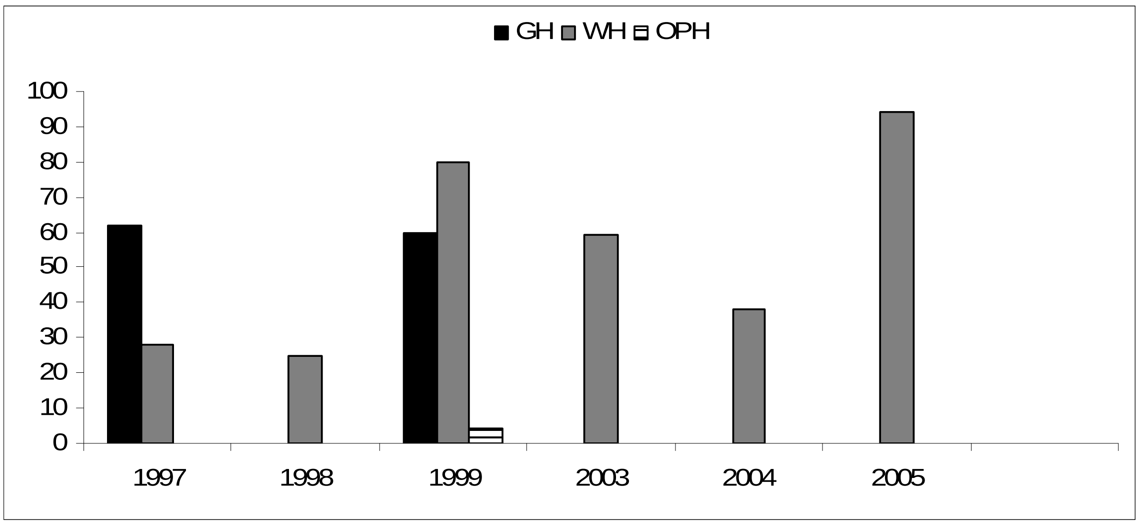


Figure 2. Wreathed hornbill numbers (minimum-maximum range) at particular roost sites in the breeding season (March to July) from 2003-2006.



One of the roosting sites (mainly of the Wreathed hornbill) is on the Assam side of the inter-state boundary. They use this roost site every year in August-November and sporadically in much smaller numbers at other times. In 2004, floods and erosion caused loss of crucial roost trees and there is increased human disturbance. However, the site is still being used by Wreathed hornbills despite the disturbance. In 2005, we made recommendations to the Assam Forest Department on measures to protect this crucial roosting site. The known hornbill roosts continued to be in use despite increased human disturbance at some roost sites, although the Great hornbill has not been observed using one roost site anymore since 1999 (Fig. 3).

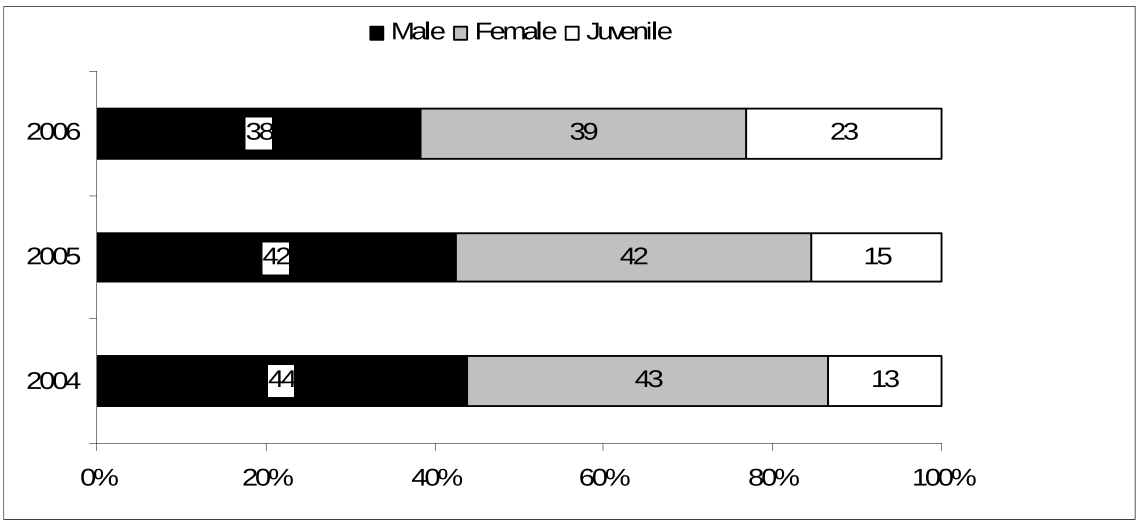
Figure 3. Hornbill numbers (maximum counted) at a roost site over 6 years.



Roosting flock composition

Hornbills (mainly the Wreathed hornbill) arriving at the roost can be classified according to age and sex. Immediately after the end of the breeding season in August-September the non-breeding season, this enables an estimation of population recruitment as juveniles accompany the parent birds to roost sites. Based on roost counts over 3 years, it appears that at least 13-23% of the population is of juvenile/subadult birds. On a single day roost count, at least 32-37 juvenile birds were seen every year immediately after the breeding season.

Figure 4. Age and sex composition of Wreathed hornbills at roost sites in the non-breeding season.



There is now 8 years of data on hornbill populations, nest and roost sites, and breeding success because of continued monitoring since 1997. Much of this information is now being collected by trained tribal assistants who were hunters earlier. At Pakke, three assistants are monitoring and protecting already known nests of three hornbill species (the Great hornbill, Wreathed hornbill and Oriental Pied hornbill), searching for new nests and keeping track of hornbill numbers at roost sites. Twenty-four of the nests being monitored currently have been located in the last 2 years by tribal field assistants. Continuous monitoring of hornbill nest sites by assistants who were earlier hunters, has ensured that there is no disturbance at the nest sites (hunting of hornbills during the breeding season is anyway taboo among the *Nishi* tribe). No known hunting instances at nest and roost sites occurred in Pakke WLS due to the continued monitoring and protection and increased awareness among the tribal *Nishi* villagers.

Chapter 6

Monitoring abundance of arboreal mammals, hornbills, pheasants and large herbivores in Namdapha & Pakke

Aparajita Datta

Research Affiliate: Rohit Naniwadekar

Field data collection:
Local assistants: Narayan Mogar, Rasham Barra, Kumar Tayum, Taya Tayum, Shekhar Subba (Pakke)
Local assistants: Akhi Nathany, Duchaye Yobin and Ngwa-akhi Yobin (Namdapha)

Introduction

The monitoring of wildlife populations is one of the most difficult, yet important components of a wildlife conservation program. In order to make reasonably accurate estimates of the state of wildlife populations, it is necessary to collect data in a systematic, scientifically sound manner. Long-term wildlife monitoring can be used to assess change in ecological systems. It is also important to establish baselines to enable temporal comparisons. At both project sites, hunting by humans is a serious threat: therefore our efforts focused on establishing the impacts of hunting on wildlife populations. The species known to be most affected by hunting – terrestrial mammals, arboreal mammals (squirrels and primates) and large birds (pheasants and hornbills) – were thus the target groups for monitoring. At Namdapha NP, we have also initiated interventions to address socio-economic needs of the community. Over the long-term, we aim to use this research as an indicator of the progress of our community-based conservation initiatives: we expect that a reduction in hunting within Namdapha National Park will be reflected by an increase in currently low animal populations. The current estimates will serve as a baseline for future comparisons. We also monitor similar faunal groups in Pakke Wildlife Sanctuary, where hunting levels are lower due mainly to better park management and protection in order to make spatial comparisons between two of the most important PAs (that are also tiger reserves).

NAMDAPHA NATIONAL PARK AND TIGER RESERVE

Direct sightings of mammals in Namdapha are extremely rare. This is due to a combination of factors: their low population densities and the dense vegetation, which makes the spotting and identification of wildlife extremely difficult. We relied primarily on indirect sampling techniques to detect the presence and relative abundances of terrestrial mammals (Chapter 2 & 3), while we attempted to obtain encounter rates by walking trails for arboreal mammals, pheasants and hornbills. Trail walks, and systematic line or strip transects are used in many places to estimate animal densities. In Namdapha National Park, however, over 23 trails totaling an effort of roughly 41.96 km between 2005 and 2007, there was just one sighting of a terrestrial mammal: barking deer was seen once and its calls were detected on four occasions. The species encountered during transects were arboreal mammals – four species of squirrels and five species of primates (hoolock gibbon, capped langur, Assamese macaque, stump-tailed macaque and rhesus macaque) – hornbills, pheasants and partridges. Due to very low numbers of sightings of species, we summarize and report the encounter rates (no. per km) of species groups (such as primates, or ungulates). The results are presented below.

Table 1. Encounter rates of large birds, arboreal mammals, ungulates in Namdapha

Species group	No. detections (Encounter rates (no/km)	No. sightings (Encounter rates (no/km)
Primates	28 (0.67)	19 (0.45)
Ungulates	4 (0.09)	1 (0.02)
Squirrels	14 (0.33)	15 (0.36)
Hornbills	13 (0.31)	7 (0.17)
Pheasants and partridges	7 (0.17)	5 (0.12)

PAKKE WILDLIFE SANCTUARY AND TIGER RESERVE

Methods

Trail monitoring had begun in 2005-2006 with an effort of 182.46 km along 11 trails between December 2004 and May 2006, however there was variable effort and sighting distances were not recorded during this period. Trail lengths varied from 1.2 to 3.5 km. A total of 18 species were observed in all, including four species of ungulates, three primate species, four squirrel species, three pheasant and three species of hornbills with a total 402 sightings.

In 2006-07, we established nine trails that were marked every 100 m. We attempted to walk eight trails of 2 km and 1 of 2.45 km twice every month from September 2006 to June 2007. However, in some months all trails could not be walked twice due to various factors. The trails were mainly walked by 3-5 trained tribal assistants. The total distance walked was 265.2 km over the ten months. Two to three observers walked each trail. Transect walks commenced between 5:45 am and 7:00 am and ended between 8:00 am and 9:45 am. The start and end time, date, weather, location and name of transect were noted. On detecting an animal, the following were noted: 1) species, 2) number, 3) time, 4) perpendicular distance, 5) if on tree, the tree species, if known, 6) activity, 7) if feeding, food species and 8) GPS location. The number of observers that detected the animal and the observer who detected it first were also noted. Calls were also recorded and identified.

Results

We obtained a total of 823 detections and 752 sightings of 24 species on these transects. Encounter rates were only calculated for 19 species (four squirrel species, three primate, three hornbill, three pheasant, four ungulate species and the elephant). There were also sightings of clouded leopard, yellow-throated marten, two species of porcupine etc on transects. Table 2 depicts the number of detections, sightings, and total numbers counted for each of the target species that are being monitored.

Among the four ungulate species, barking deer was the most abundant (87 sightings), while gaur was sighted only 3 times. Elephants were recorded often and the average group size was about 5. Among primates, the capped langur was the most abundant with 18 sightings of troops, while Assamese macaque was only recorded twice. Among the squirrels, the Red-bellied squirrel was very abundant (207 sightings), while the largest species, the Malayan giant squirrel was relatively less abundant. Red jungle fowl was the most common pheasant species. Among hornbills, the Oriental Pied hornbill was the most abundant.

Further analysis is underway to estimate densities for some species as well understand the monthly, seasonal and annual patterns of abundance for some species. With a long-term data set, we plan to track any changes in abundance and relate it to environmental and anthropogenic factors. In future, we also plan to compare the abundance of these faunal groups with those in Namdapha to understand the influence of differential hunting pressures in the two areas.

Species	*Detections	Sightings	Total numbers	Group size	Encounter rate (detections)	Encounter rate (nos)
Barking deer	89	84	87	1.03	0.33	0.33
Sambar	14	14	15	1.07	0.05	0.06
Wild pig	20	20	45	2.25	0.07	0.17
Gaur	3	3	3	1	0.01	0.01
Elephant	24	19	88	4.63	0.09	0.33
Assamese macaque	2	2	31	15.50	0.01	0.12
Rhesus macaque	7	7	61	8.71	0.03	0.23
Capped langur	19	18	103	5.72	0.07	0.39
Malayan giant squirrel	9	9	11	1.22	0.03	0.04
Red-bellied squirrel	207	190	229	1.20	0.78	0.86
Hoary-bellied squirrel	40	38	60	1.58	0.15	0.23
Himalayan striped squirrel	20	20	20	1	0.07	0.07
Red jungle fowl	76	65	87	1.34	0.29	0.33
Peacock-pheasant	38	32	40	1.25	0.14	0.15
Kaleej pheasant	20	19	24	1.26	0.07	0.09
Great hornbill	71	63	106	1.68	0.27	0.40

Wreathed hornbill	63	60	143	2.38	0.24	0.54
Oriental Pied hornbill	89	77	212	2.75	0.33	0.80

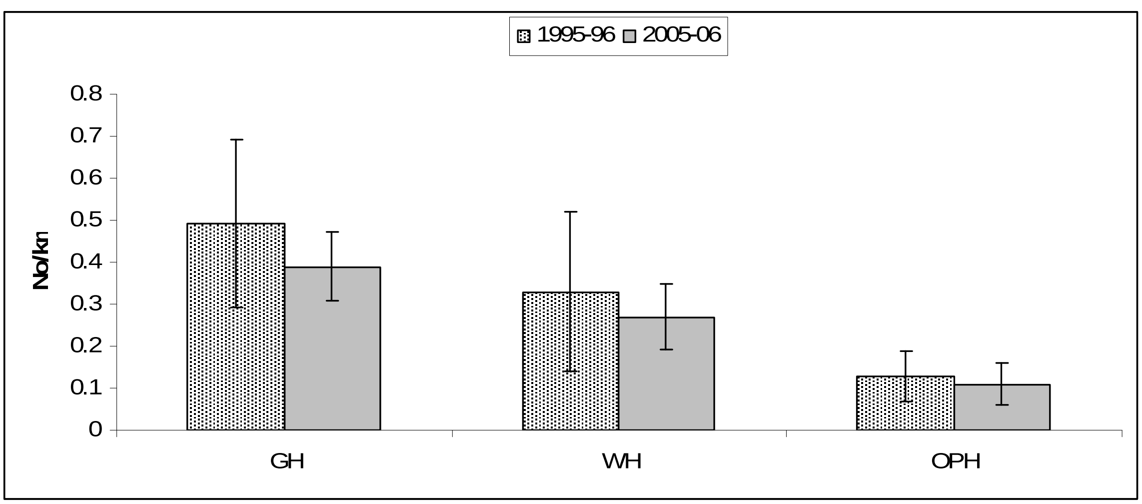
*Detections include both calls and sightings

For all three primates that are group-living, the exact number of individuals in a troop was not possible to count on most occasions; therefore, the encounter rate for detections is for troops and is more reliable.

HORNBILLS: comparison of encounter rates over time

We compared the encounter rates for hornbills obtained during the current monitoring with data from a study in 1995-96 that used several of the same trails in the sanctuary or were carried out in similar/adjacent locations to the trails currently being used. The total distance walked during the 1995-96 study was 99.34 km along 7 trails in Tipi (unlogged primary forest), Khari (semi-disturbed forest) and Seijusa (old logged forest). This study was carried out from December 1995 to April 1996. In 2005-06, the total distance walked was 139.83 km along 11 trails in Dichu (unlogged primary forest), Khari (semi-disturbed forest) and Seijusa (old logged forest) from October 2005 to May 2006. There appears to be a marginal decline in encounter rates for all the three hornbill species in 2005-06 (Fig. 1). In 2006-07, the encounter rates of Great and Wreathed hornbill remained similar, however the encounter rate of Oriental Pied hornbill increased significantly from 0.11/km to 0.82/km.

Figure 1. Relative abundance (no/km) of three hornbill species between 1995-96 and 2005-06 in Pakke WLS



Chapter 7

Fading forests: assessing forest cover change in Namdapha National Park

Aparajita Datta, Harini Nagendra, Somajita Paul

Remote sensing analysis: Somajita Paul, Harini Nagendra
Assistance: Bhawna Sharma & R. Raghnunath

Introduction

Recent studies have highlighted increasing deforestation in Asia (Laurance 1999, Sodhi *et al*. 2004, Pandit *et al.* 2007) and in the entire North-eastern region landscape generally, and in Arunachal-Assam in recent years (Menon *et al*. 2001, Srivastava *et al*. 2002, Kushwaha & Hazarika 2004). The major causes have been due to logging, shifting cultivation, expanding agriculture and settlements, expansion of tea estates, other development activities accompanied by population increase. The Eastern Himalaya is a global biodiversity hotspot (Myers *et al*. 2000) and has been receiving much attention in recent years with various studies assessing vegetation structure, composition, and patterns in biological richness (Behera *et al*. 2002, Behera *et al*. 2005, Roy & Behera 2005, Behera & Kushwaha 2007), with several also using GIS and remote sensing techniques (Behera *et al*. 2001, Roy & Joshi 2002, Singh *et al.* 2002). However, apart from broad assessments by FSI, there are few reliable assessments of forest cover status/change using remote sensing techniques inside specific PAs in the North-east region. A broad-based analysis by FSI in 2004 of forest cover change in tiger reserves of India, surprisingly reported a 3 km^2 increase in forest cover in Namdapha from 1997-2002 and of 9 km^2 in areas surrounding the park (http://www.fsi.nic.in/fsi_projects/). However, this study was carried out without any ground-truthing or verification. An assessment of the forest cover of the entire state by Menon *et al.* (2001) estimated that though 70% of the state was forested in 1988, 50% of forests would be lost by 2021 based on projected population growth and resultant resource extraction pressures. This analysis predicted that the Namdapha Tiger Reserve and its surrounding landscape would be almost completely deforested by 2021.

As highlighted earlier in Chapter 1, the Namdapha National Park and Tiger Reserve in eastern Arunachal Pradesh is a biologically rich area with diverse habitat types across a wide altitudinal range. Its floral diversity has not been properly documented but estimates suggest > 1000 plant species (Chauhan *et al*. 1996). A few recent studies have assessed tree diversity and structure in these forests across a disturbance gradient (Bhuyan *et al.* 2003, Nath *et al.* 2005). Till recently, it has remained relatively pristine compared to many other PAs with low resource extraction/development pressures compared to other PAs in India. This is largely due to low human population density and almost no impact of livestock grazing pressures. The main threat the park faces has been due to illegal hunting. However, since the late 1990s, anthropogenic pressures on the park have increased due to the diverse local communities that live around the park that are dependent on fuelwood, timber and various NTFP resources (Arunachalam *et al.* 2004). The pressures are increasing especially towards the western edge of the park from the *Chakma* and other resident communities. A prior study documented the change in forest cover from 1973 to 2002 towards the western part of the park and in adjoining reserve forests on the western boundary for an area of 685 km^2 (Yadava *et al.* 2003).

There has also been an influx of the *Lisu* community from the east (from the main *Lisu* village of Gandhigram outside the park) into various scattered locations inside the park. The exodus largely started in 1997, although there were a few households in some localities earlier. The families that have moved in have cleared new areas for settlement, one of which is relatively closer to the western part of the park near the designated tourism zone. Increasing land shortage for valley wet rice cultivation outside the park is the primary reason for *Lisu* settlement in the park (Datta 2005, 2007a). These encroachments have received much media attention and there have been official calls for removal of these encroachments. However, the relocation plans have been now pending for about 10 years (Datta 2005, 2006, 2007a) with little action on the ground. The inability of an under-staffed, ill-equipped, poorly motivated Forest Department to access most of the park on a regular basis has also resulted in an almost non-existent park management with little control over activities inside the park. The remoteness of the area also results in weak administrative control of other government agencies. The issue of the park boundary and land rights for the *Lisu* is a major source of conflict between *Lisus* and forest authorities. The creation of the park in 1983 and demarcation of the boundary is still contested by the *Lisu* (Datta 2007a). Given that land is the most valued resource for tribal communities, and the *Lisu* see the entire area as theirs, the conflict can only escalate unless amicable solutions are found. Despite meetings and much paper work, there has been little action on the ground and no resolution of the problem (Datta 2007b).

The magnitude of the problem and pressures on the park due to the presence of these settlements and cultivation needs to be known prior to decision-making. It is also important to establish ecological baselines to understand the status of the forest and habitats within the park. There is also an urgent need to assess how much change has occurred due to human settlements in the park and make projections into the future. This is also necessary for reconciling conflict and suggesting solutions for park management. Our ongoing community-based conservation program with the *Lisu* (Datta 2007, Datta *et al*. 2007) has also provided an understanding of the socio-economic needs and attitudes of the *Lisu* and the factors causing the influx into the park.

For this study, we had several objectives:

a) asses the scale of degradation by settlements in the park between 1997 and 2005
b) assess changes in the surrounding landscape outside the park
c) broadly classify vegetation/habitat types in the area
d) assess changes at a landscape level for Namdapha and surrounding areas over 30 years

However, analysis has been partially completed only for the first three objectives as of now.

Background and area description

As has already been described in Chapter 1 of this report, the Namdapha NP comprises an area of 1985 km^2 with altitude ranging from 150 m to 4571 m asl. The terrain is steep and rugged. There are two main drainages of the Noa-dihing and the Namdapha river along with numerous perennial streams. Namdapha is reported to have the world's northernmost rainforests (at 27° N) and has contiguous forest on almost all sides with huge tracts of forest in adjoining Myanmar to the south, east and north-east. The area can be broadly classified into tropical, sub-tropical, temperate, sub-alpine and alpine regions. The lower foothills have extensive evergreen dipterocarp forests, along with tropical semi-evergreen forests. There are also subtropical pine and broadleaved forests, followed by temperate broadleaved forests, alpine and perennial snow areas. Small areas of rock-strewn grasslands occur in the broad river valleys. Champion & Seth (1968) categorized the forests here into eight main types. The park has significant and unparalleled floral and faunal diversity and a comprehensive botanical survey of the entire area needs to be carried out.

A description of the communities and their populations in the park is given in Chapter 1.

Methods

Onground assessments of human impact and vegetation structure

Forest cover change assessment based on remote sensing

We acquired two satellite imageries for two dates in 1999 and 2005 from the National Remote Sensing Agency, Hyderabad, India. These were IRS 1C Liss 3 for 1 December 1999 and IRS P6 Liss 3 for 9 December 2005. The area has little seasonal variation in images, however, cloud-free images are difficult to obtain and winter (Nov-Jan) is the best period for cloud-free images. The pixel size of the images was 23.5 m.

The 1999 image was geo-referenced to nine Survey of India toposheets of the area using nearest neighbour algorithm, while the 2005 image was registered using 1999 image as the base. Care2 was used to reduce RMS (root mean square) error to < 0.5 pixels to ensure both images overlapped correctly. While we had over 500 GPS locations for ground-truthing from field visits from 2004-2007, many of these were mainly from dense tropical forest and were not useful for classification or distinguishing other habitat types. We finally used about 190 training sites and expert knowledge (ours and local tribal people) to delineate certain areas.

We used a supervised classification approach. There were misclassifications due to rugged terrain that cast a shadow over the landscape and because of lack of ground-truthed data from areas above 1800 m. The overall accuracy for the classification was 90.9%, however it ranged from 60% for open forest to 100% for certain categories that were more clearly differentiated (error matrix analysis, Kappa statistics).

We delineated 10 land cover classes and used an elevation cut-off for areas >1800 to 3000 m and > 3000 m. Our main interest was to assess change due to recent anthropogenic pressures in the park and there are no settlements and cultivation or human presence/activity (apart from occasional hunting) in the park above 1800 m. We delineated areas above 3000 m as subalpine and alpine, while areas between 1800 and 3000 m were categorized as temperate forest.
The ten land cover classes were:

1) Dense tropical forest (< 1800 m): canopy > 60%
2) Bamboo forest (up to 3000 m)
3) Open forest – natural (due to past landslides)
4) Grasslands
5) Exposed landslides
6) River and water bodies
7) Temperate forest (>1800 to 3000 m)
8) Alpine and sub-alpine, snow (> 3000 m)
9) Degraded forest
10) Human settlement and cultivation

We compared the change in these classes over the two time periods to determine the magnitude and percent of change. However, both the original images did not cover the entire 1985 km^2 of the park, and the comparable area that was classified in both images was 1637.5 km^2, therefore about 348 km^2 of the park area on the western edge remained unclassified. Similarly, for the area outside the park only 352.4 km^2 of the USF area to the east of the park in Vijaynagar circle was classified of the total 637 km^2. We could not compare areas outside the park to the west as our image did not encompass this region.

Results & Discussion

On-ground assessments: *Lisu* population growth

The *Lisu* population in the 1961 census was 78, increasing to 926 in the 1971 census. In 1981, some records only show five *Lisu*(Dutta Choudhury 1980); although Maitra (1993) reports 971, while his own household census was 1016. In 1991, the *Lisu* population totaled 1530 (Dutta Choudhury 1980, Choudhury 1996), while the 2001 census records 2106 in 376 households. My estimate from a household census of *Lisu* villages (including those in the park) in 2004 enumerates 2310 (Table 1a & 1b). There was considerable migration from Myanmar between 1961 and 1971 (1.08 per year). Following this, the growth rate declined to an average of 0.03 per year calculated between 1971 and 1991 possibly due to the curtailment of immigration and high infant mortality rates. The growth rate has increased in the last ten years at 0.07 per year. *Lisus* marry very young (often at 16, or lower) and the average number of children per family is 6. Arunachal's growth rate is about 0.03 per year, while for India, it is 0.02 per year. Given lack of family planning and high reproductive rates, the average growth rate of 0.04 (1971-2005) among *Lisus* is not surprising. There is a widespread belief and rumors that *Lisus* are still migrating in from Myanmar. These reports by the FD and some conservation NGOs have been circulated in the media without proper on-ground verification. I analyzed available census data and used my socio-economic data collected in 2004 to examine this contention.

In 1971, the *Yobin* (*Lisu*) formed 0.25% of the Scheduled Tribe population (1971 census), now they form less than 0.002% of the total ST population. Yet there are continuing fears and rumours of *Lisu* population growth, influx and migration from Myanmar. A detailed demographic analysis of population structure, birth and death rates would provide a clearer understanding of the contention that *Lisu* numbers are increasing due to recent migration from Myanmar. Details of village-wise Lisu population in 2004-05 is given in Table 2.

Based on time spent in these villages, the socio-economic survey and cross-checking electoral rolls and other records, it appears that these rumours are baseless. They have been probably fuelled by the fact that *Lisu* hunters from Myanmar (and others too) do come into the area occasionally mainly to hunt and given the lack of communication it is easy for such rumours to spread. There is government administration, SIB, SB, Assam Rifles and the Air Force guarding these border areas. If migration was happening, the Government has to curtail it; the burden of proof should not be on existing Indian *Lisus* who are often suspected as encouraging this. *Lisus* say they already face land shortage, and would not support new *Lisus* coming into the area. In addition, this can be remedied by issuing ID cards to all Indian *Lisus* to check new infiltrations. Occasional migration from Myanmar is also prevalent in Changlang district by *Tangsas* and *Singphos* who also originally came from Myanmar.

The other community that resides in the USF area of Vijaynagar circle are Nepali ex-servicemen who were settled here by the Assam Rifles in 1961. Their population is almost equal to that of the *Lisu* and they live in 9 villages (Table 3). This community was allotted land *pattas* for settlement and cultivation (see Datta 2007 for more details).

Table 1a. *Lisu* population in Vijaynagar circle, Changlang district

Census year	Population	Reference
1961	**78**	**Government census**
1971	**926**	**Government census**
1981	**1016**	**Government census**
1986	**1305**	**Maitra 1993**
1991	**1530**	**Government census**
2001	**2106**	**Government census**
2005	**2310**	**Datta 2007**

The Census of India was conducted in Arunachal for the first time only in 1961.

Table 1b. The *Lisu* population as enumerated in a household census conducted in December 2004. (census included three settlements of Ngwazakha, Musathi and Nibudi in the park and Gandhigram and Hazulu in Vijaynagar circle)

Age group	Male	Female	Total numbers	% of total population
Infants	73	84	157	8.9
3-5 years	113	121	234	13.2
6-10 years	132	130	262	14.8
11-17 years	115	125	240	13.6
Adults (> 18 years)	442	433	875	49.5
TOTAL	**875**	**893**	**1768**	

Household census was not carried out in Dawodi (34 households), 77 mile (11 households) and in there was data for only 17 households.

Table 2. All *Lisu* villages and settlements in Vijaynagar circle

Village	Total HH	Population	Location
Ngwazakha (38 mile)	18	83	Inside Namdapha NP
Musathi (Upper 38 mile)	6	36	Inside Namdapha NP
Nibudi (52 mile)	28	135	Inside Namdapha NP
*Sichudi (77 mile)	11	55	Inside Namdapha NP
Hazulu	33	174	Outside park in USF

Gandhigram	226	1340	Outside park in USF
*Dawodi	34	170	Outside park in USF
[a]Sidikhu	34	192	Outside park in USF
[b]Other scattered households	7	45	Outside park in USF
TOTAL	397	2230	

Table 3. 2001 census data for Vijaynagar circle

S.No.	Village	Community	HH	Total	Family size	Male	Female	BPL census
1	**Daragaon**	**Nepali**	39	198	5.07	91	107	35
2	**Phaparbari**	**Nepali**	48	257	5.35	128	129	43
3	**Gehrigaon**	**Nepali**	11	59	5.36	30	29	10
4	**Ramnagar**	**Nepali**	25	139	5.56	69	70	28
5	**Chidudi**	**Nepali**	31	174	5.61	80	94	38
6	**Mazgaon**	**Nepali**	45	244	5.42	115	129	51
7	**Two hut**	**Nepali**	44	259	5.89	124	135	47
8	**Topi Hill**	**Nepali**	32	186	5.81	96	90	37
9	**Buddhamandir**	**Nepali**	25	142	5.68	66	76	27
10	**Gandhigram**	***Lisu***	270	1569	5.81	799	770	315
11	**Sidikhu**	***Lisu***	33	176	5.33	91	85	--
12	**Hazulu**	***Lisu***	33	161	4.88	74	87	37
13	***Vijaynagar**	**Mixed**	95	424	4.46	254	170	61
	TOTAL		**731**	**3988**	**5.40**	**2017**	**1971**	**729**

*Vijaynagar includes the *Lisu* village of Dawodi (34-40 households) and some Nepali households and a mixed population of non-tribals and tribals from other parts that work in various Government departments and Assam Rifles staff

Agricultural land holdings and shortage of land:

While the total land area to the east of the park (USF forests in Vijaynagar circle) is 637 km^2, relatively flat land is approximately 24 km^2. Not all of this is agriculturally suitable and what is suitable, is already occupied by the existing Nepali and *Lisu* villages. In 2005, we measured the entire area available for rice cultivation in Gandhigram village. The total area currently available is 311 ha in the valley which amounts to about 1.35 ha per family in Gandhigram. Individual landholdings were measured separately for 16 households (average landholding of 1.51 ha, ranging from 0.36 ha to 4.5 ha). In Sidikhu, the average landholding size was 0.9 ha, while in Hazulu it was 0.59 ha.

Our estimates on ground shows that about 375 ha of agricultural land existed outside the park in the 4 *Lisu* villages in the community forests (unclassed state forest) in Vijaynagar circle In contrast, the agricultural landholdings of Nepalis in 9 villages amounts to 764 ha with an average landholding of 3.96 ha. Nepali families reportedly have excess rice production often up to 800 tins per household.

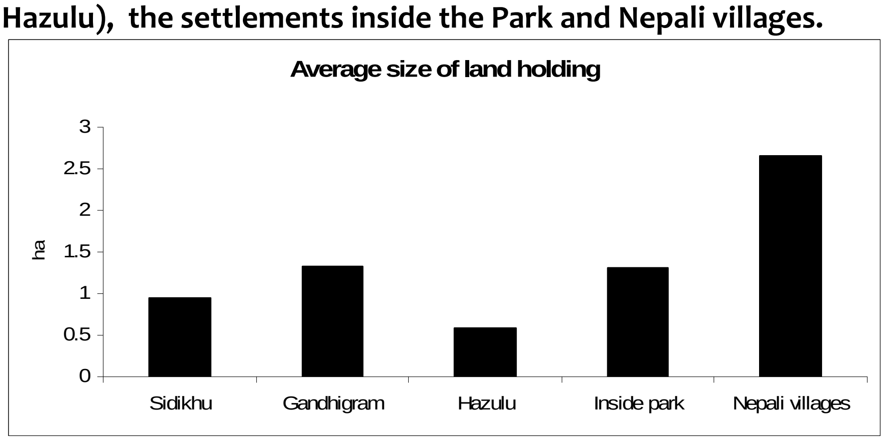
Therefore, the *Lisu* landholding per family (1.35 ha) is almost three times smaller than that of Nepalis (3.96 ha). The average size of landholdings for *Lisu* families in the villages outside and inside the park and that of Nepalis is given in Figure 1.

The limited availability of flat land has become a serious concern for the *Lisu* that have a growing population and it is also compounded by the erosion of existing agricultural land by the Noa-dihing river in this hilly, landslide-prone heavy rainfall area, over the last 10-15 years. The importance of flat valley agricultural land for settled rice cultivation has increased tremendously over the last 20 years, with the decline of *jhum*, as currently only 27% of families practice *jhum* cultivation.

The influx of *Lisu* households into the park started in 1997, however most came in around 2000. The number of households in the park in 2005 was 65 with 317 people in 3 main settlements along with 1-3 households that resided in the park for a few months to run small shops selling essential items to people passing through on their to and from Miao. Of the 65 households, 20 reported moving in due to less land or low production not enough to meet household rice requirements in their original village of Gandhigram; nine had no agricultural land left. For 14 households there appeared to be no damage to agricultural land in Gandhigram, yet they had moved in to the park probably fearing future land shortage or because they moved with their relatives and kin to a new area. The reasons for movement of 5 more families remain unclear. The 65 *Lisu* families in the park are now cultivating an estimated area of 86 ha with an average landholding of 1.32 ha. In addition, eyeball estimates suggested that 10-15 km^2 of the park area adjoining these settlements are partially affected by fuelwood extraction, felling of poles and timber clearing. New clearings have been made since 2005 with the number of households in the park increasing now to about 67-70. There are also sporadic reports and evidence of militant camps inside the park since the last 2 years.

What needs to be emphasized is that land shortage is not restricted to the families that have moved into the National Park. In a household survey in Gandhigram, 70% of households reported real or perceived land shortage (n = 254), either because of low production, less land to meet annual household needs, or direct loss to erosion, floods, sand deposition and landslides. Only 30% household reported no problem or damage. Unless solutions are found soon by the government, there will be further movement of people into the park.

Fig. 1. Average size of landholding (ha) in 3 *Lisu* villages (Sidikhu, Gandhigram & Hazulu), the settlements inside the Park and Nepali villages.



Vegetation structure and tree density

Prior studies have shown a declining trend in tree density and basal area with increasing disturbance based on a study in the western part of the park (Nath *et al.* 2005).

In 2007, we sampled vegetation in an area of 1200 km^2, roughly encompassing the moist evergreen habitat within the Namdapha National Park below 2000 m. A uniform grid (3 x 3 km) was imposed on a map of the area. Of the 130 grids covering the study area, we randomly selected 37 grids for vegetation sampling (28.5% covered). We sampled the forested habitat in the study area that is relatively homogeneous.

For each site, we employed the 'point-centred quarter' technique at every 100 m intervals along the trail to estimate tree density and basal area per hectare for the site. We also estimated (ocular) shrub cover on a scale from 0 to 4 at every 100 m interval with 0 for no shrub cover and 4 for impenetrable shrub cover. Elevation and mean distance of the trail from the nearest settlement were extracted for each grid using GIS. We also ranked each site based on the levels of disturbance observed at each site. Level of disturbance for the grid was evaluated based on observation of human presence in the form of tree/stem cut signs and presence of trails and local information from the *Lisu*. Ranking was between 1 and 4 with lowest rank for the least disturbed site.

The elevation of 37 grids sampled for tree density and basal area ranged from 460 m to 1115 m with a mean of 850 m, while distance to settlement ranged from 830 m to 11 km with a mean of 4.3 km. The average tree density for 37 grids was 556 trees per ha (± SD 125) while basal area per ha was 68 (± SD 31). Distance from settlement did not appear to affect tree density or basal area. There was a weak positive correlation of increasing basal area per ha with increasing distance from settlement, however this was not significant ($r = 0.24$), and none with tree density ($r = -0.01$). Mean tree density however was highest in those grids that had the least disturbance (rank 1), while mean basal area per has was the highest in those grids that had slightly greater levels of disturbance (disturbance rank 2). The lowest mean tree density and basal area was in those grids in disturbance rank 3, while grids ranked as having the highest level of disturbance (4) had tree density and basal area similar to that with the least disturbance. Therefore, there was no clear trend of decline in tree density and basal area with disturbance levels.

Preliminary assessment of forest cover change using remote sensing analysis

There appears to be a tremendous decline in area under dense tropical forest inside the park with a decline of 83 km^2 (percent change 5.09%) from 1999 to 2005 (Table 4a, Fig. 1). Other land cover categories such as degraded forest, grassland and settlements and cultivation that have been modified due to human presence and activity showed an increase. Although the area under settlement and cultivation showed only a very minimal increase in the last 6 years, the area of degraded forest increased by almost 16 km^2 (Table 4a).

Two other categories that showed a significant increase are natural open forest - created due to past landslides) and bamboo forests. However, the reasons for such an increase in these two categories remain unclear. The park is recorded to have 8-9 species of bamboo (Chauhan *et al.* 1996) , most of which are patchily distributed as extensive stands usually of single species and many specifically grow in specific conditions and altitudes only. While, in many other areas in the North-east, an increase in bamboo is attributed to degradation by human activity, particularly because of *jhum*, which usually comes up in areas following repeated *jhum* cycles, the regeneration patterns of forests following *jhum* in Arunachal is somewhat different. Regeneration following *jhum* here is mostly of woody tree species (ref). Possible changes in climatic patterns may also have resulted in increased bamboo cover. Another possibility is that errors remain in the classification of bamboo forests and natural open forests as they are very difficult to distinguish from some of the other categories given the green canopy even in human-modified and less dense forests. The pixel size of 23.5 is probably too coarse a resolution to detect accurately changes in forest cover. A higher resolution of 1m or 5 m may be necessary to accurately assess these changes. Further refinement and ground-truthing is required to assess these changes.

The main decrease (61.4 km^2) in tropical dense forests appears to be due to the increase in bamboo and natural open forest, while change due to human impacts (about 16 km^2) is largely restricted to a patchily in the main valley of the Noa-dihing river. There is also an increase in grassland by about 6 km^2 and of river and waterbodies by 1.2 km^2. The entire area has very heavy rainfall (8-10 months in the year) and is prone to frequent landslides and is a mosaic of dynamic successsional habitats especially on the slopes which may have resulted in some of the differences over the years.

Of the 352 km^2 area classified under community forests to the east of the park outside, the percent change and decline of dense tropical forest is higher (9.08%), while there is a similar increase again in bamboo forest and natural open forest. The percent change in degraded forest and area under settlement and cultivation is higher (Table 4b, Fig. 1).

Further verification and refinement of the classification is needed to assess the significance of the changes in forest cover based on this preliminary analysis.

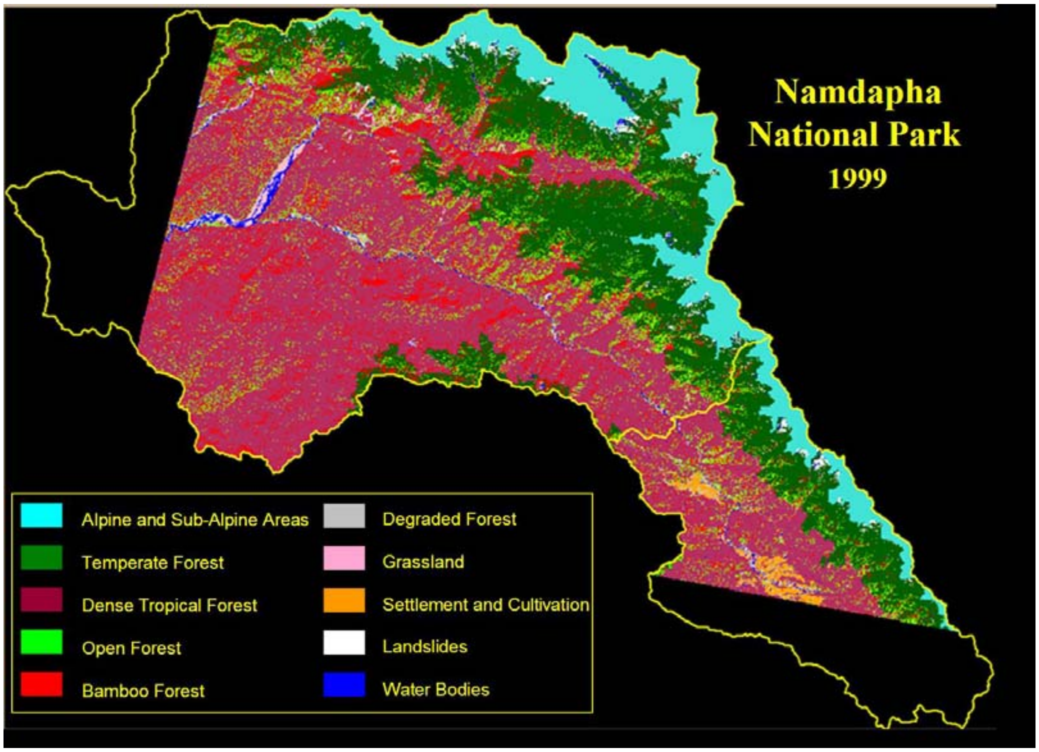
Table 4a. Change in land cover types from 1999 to 2005 inside the park

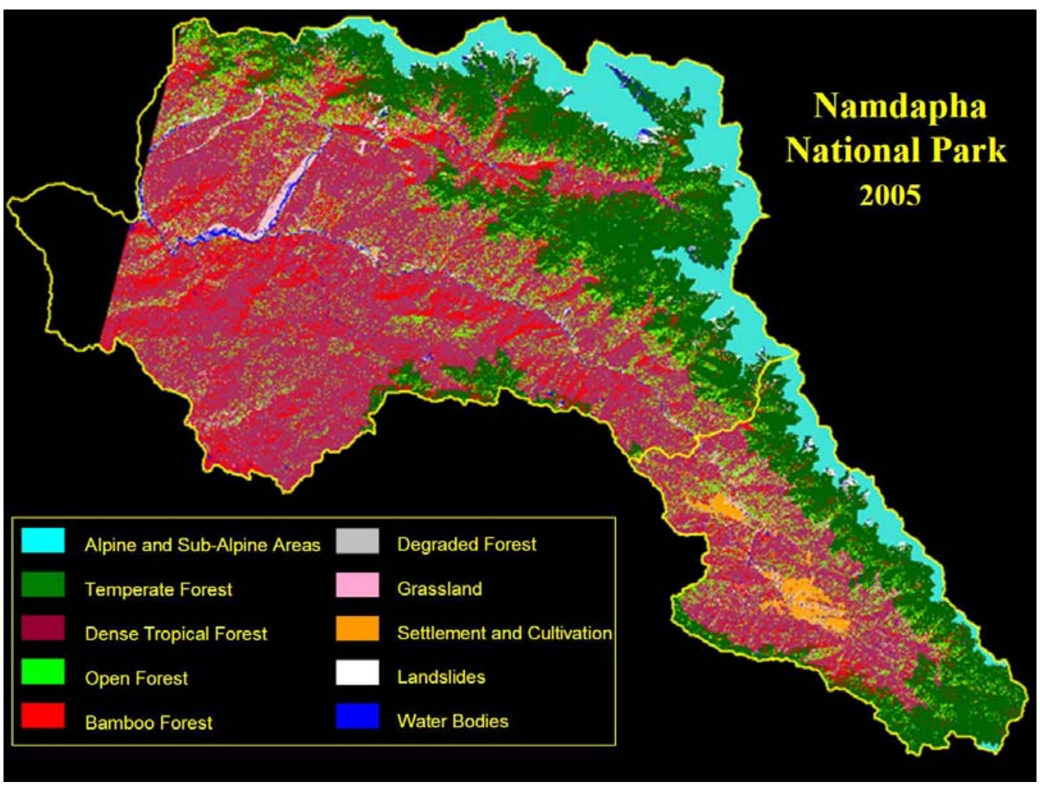
Land cover categories	*1999 (km^2)*	*2005 (km^2)*	*Change (km^2)*	*Percent change*
Dense tropical forest	725.7	642.4	-83.4	-5.09
Bamboo forest	179.7	221.0	41.3	2.52
Grassland	17.2	23.1	5.9	0.36
Open forest	141.1	161.2	20.1	1.23
Degraded forest	3.8	19.5	15.7	0.96
Settlement & cultivation	0.2	0.8	0.5	0.03
River & waterbodies	17.2	18.4	1.2	0.07
Exposed land slides	18.7	17.3	-1.4	-0.08
Temperate forest	371.9	371.9	0.0	0
Alpine & subalpine areas	162.0	162.0	0.0	0
Total area classified	1637.5	1637.5		

Table 4b. Change in land cover types from 1999 to 2005 inside the park

Land cover categories	*1999 (km^2)*	*2005 (km^2)*	*Change (km^2)*	*Percent change*
Dense tropical forest	139.7	107.6	-32.0	9.08
Bamboo forest	17.0	24.4	7.4	2.10
Grassland	2.3	4.7	2.3	0.66
Open forest	29.8	39.2	9.4	2.67
Degraded forest	5.3	11.4	6.1	1.73
Settlement & cultivation	15.5	23.1	7.6	2.15
River & waterbodies	3.2	2.7	-0.5	-0.13
Exposed land slides	4.1	3.8	-0.3	-0.09
Temperate forest	92.9	93	0.1	0.03
Alpine & subalpine areas	42.5	42.4	-0.2	-0.05
Total area classified	352.4	352.3		

Fig. 1. Classification of land cover types in Namdapha National Park (1999 and 2005)





Appendix 1. Mammal and terrestrial bird species recorded on cameras in Namdapha NP and Pakke WLS (2005-2007)

Species	Pakke WLS	Namdapha NP
Stump-tailed macaque *Macaca arctoides*	Not present	Yes
Capped langur *Trachypithecus pileatus*	No	Yes
Asian Elephant *Elephas maximus*	Yes	No
Sambar *Cervus unicolor*	Yes	Yes
Indian muntjac *Muntiacus muntjak*	Yes	Yes
Wild pig *Sus scrofa*	Yes	Yes
Gaur *Bos gaurus*	Yes	No
Red goral *Nemorhaedus baileyi*	Not present	Yes
Himalayan black bear *Ursus thibetanus*	No	Yes
Malayan Sun bear *Helarctos malayanus*	Not present	Yes
Wild dog *Cuon alpinus*	Yes	No
Clouded leopard *Neofelis nebulosa*	No	Yes
Marbled cat *Pardofelis marmoratra*	No	Yes
Golden cat *Catopuma temmincki*	No	Yes
Leopard cat *Prionailurus bengalensis*	Yes	Yes
Chinese Ferret badger *Melogale moschata*	No	Yes
Yellow-throated marten *Martes flavigula*	No	Yes
Small Indian civet *Viverricula indica*	Yes	No
Large Indian civet *Viverra zibetha*	Yes	Yes
Common palm civet *Paradoxurus hermaphroditus*	Yes	Yes
Himalayan palm civet *Paguma larvata*	Yes	Yes
Crab-eating mongoose *Herpestes urva*	Yes	Yes
Hog badger *Arctonyx collaris*	No	Yes
White-tailed mole *Parascaptor leucura*	No	Yes
Asiatic brush-tailed porcupine *Atherurus macrourus*	Yes	Yes
Himalayan crestless porcupine *Hystrix brachyura*	Yes	Yes
Indian porcupine *Hystrix indica*	Yes	No
Squirrels (*Dremomys* sp. & *Calloscirus* sp.)	No	Yes
Malay tree shrew *Tupaia belangeri*	No	Yes
Bat	Yes	No
Rats	Yes	Yes
Red jungle fowl *Gallus gallus*	Yes	
Kaleej pheasant *Lophura leucomelanos*	Yes	Yes
Grey peacock pheasant *Polyplectron bicalcartum*	No	Yes

Other birds recorded on camera traps

Emerald dove
Rufous-throated partridge
White-cheeked partridge
Blue whistling thrush
Jungle crow
Little green heron
Green-billed malkoha
Laughing thrush
Scimitar babbler
Blue-naped pitta
Birds of prey (3 spp.)

WILDLIFE MONITORING PROGRAM

Hornbill monitoring program (Photo credits: Aparajita Datta)

Pellet and track survey in Namdapha and tiger pugmark in Pakke

(Photo credits: Aparajita Datta)

Field monitoring team and setting up camera traps in Namdapha, December 2006

(Photo credits: Rohit Naniwadekar, Charudutt Mishra)

Camera trap survey pictures from Namdapha 2006-07

(Photo credit: Namdapha Wildlife Monitoring program, Nature Conservation Foundation)

Namdapha forests, clearings in the park and agricultural lands outside the park

(Photo credits: Aparajita Datta, Rohit Naniwadekar)