Synthesis

Socio-economic drivers of landscape change in Upper Brahmaputra Valley

Habitat Fragmentation

Effect on primate species distribution in fragments

Spatio-temporal trends, patterns and processes

Mechanisms of co-existence: Insights from a unique fragment

Strategies for primate conservation in Upper Brahmaputra Valley
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7.1 The thesis in context

Human actions have altered tropical forests worldwide resulting in their loss and fragmentation. As discussed in Chapter 1, such habitat modifications have negatively impacted several plant and animal taxa. The survival of species in habitat fragments depends not only on the various ecological and anthropogenic characteristics of fragments and their surrounding landscape, but also on the traits of individual species themselves. Most importantly, the continued survival of species in fragments also depends on our active efforts to protect and manage them (Laurance & Bierregaard Jr., 1997). The challenges to conserving habitat fragments face become manifold, especially when they are located within human-dominated production landscapes.

There remain a greater challenge and limit to the conservation of fragments. First, as resources allocated for the biodiversity conservation are scarce (McCarthy et al., 2012), the larger protected area receive conservation priorities. Second, small fragments are often embedded in a landscape dedicated to production and, therefore, they face continued pressure from various socio-economic factors. Third, the prospect of long-term survival of species in fragments has been questioned as species are more vulnerable to extinction in small fragments than in larger areas (Turner, 1996). However, conservation biologist increasingly began to appreciate the role of small forest fragments in conservation of biodiversity as they retain reasonable number of threatened and endangered species and as a result, complement biodiversity conservation (Turner & Corlett, 1996; Fischer & Lindenmayer, 2002; Tscharntke et al., 2002; Anand et al., 2010). Moreover, there are new opportunities to conserve such fragmented habitats even in the face of growing economic pressure (Mudappa & Raman, 2007). However, the conservation value of fragments must be reconciled with the negative consequences that habitat fragmentation imposes on species distribution, persistence and extinction.

Habitat fragmentation affects a wide variety of taxa but primates, in particular, are severely affected. In the present context where nearly 48% of primates are threatened by extinction due to habitat loss and fragmentation
(IUCN, 2010), it is necessary to understand the effect of habitat fragmentation more comprehensively. It is in this larger context that the results of this thesis should be examined.

7.2 Habitat fragmentation and primate conservation: revisiting the results

Deforestation worldwide has altered tropical forests resulting in their loss and fragmentation. Today, forest remnants are the most ubiquitous feature of the tropical landscape (Ribeiro et al., 2009). Given their significant conservation value, the first step towards their conservation is to understand how they were created. Tracing the history of fragmentation not only provides insight into how a landscape becomes fragmented but such analysis is vital if we are to ask where we go from here and how we get there. Chapter 1 of the thesis has showed that socioeconomic factors, primarily the political economy and demography under three historical regimes, have impacted the forest cover and progressively led to a greater fragmentation of the forests of the Upper Brahmaputra Valley. The contemporary landscape of the Valley is characterised by many small fragments, which are located in a vast human-dominated production landscape. One may ask, therefore, if these fragments are worth conserving given their relatively small size and high isolation. If yes, how do we meet the various challenges encountered in the conservation of various primate species in these fragments?

Chapter 3, 4 and 5 of the thesis addresses these questions and examine the effect of habitat fragmentation on primate distribution, persistence and extinction in many of the lowland fragments of the Valley. I found that these fragments have significant conservation value as they have not only retained almost 50% of the species of their original species pool (Chapter 3) but these occur as varying subsets of species (Chapter 4). Multi-year data on the population of several species also showed that a large fragment, the Hollongapar-Gibbon Wildlife Sanctuary (HGWS), has not only retained almost 86% of the original species complement, but that its primate populations have increased significantly in the last decade (Chapter 5).

Significant challenges, however, still remain for the conservation of primates in these fragments. For a start, on average, a fragment in the Valley has lost one-third of its original habitat. Correspondingly, they have also already lost almost half of their original species pool from the time of isolation
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until 30 years ago (Chapter 4), and further lost one species, on average, from each fragment over the last thirty years (Chapter 3). Moreover, recent population trends from three smaller fragments of the Valley show that several species of primates are not only declining but have also become locally extinct; even the large fragment (HGWS) had lost its Assamese macaque population (Chapter 5). But our research also helps identify some of the key reasons underlying these losses. For example, illicit tree felling and habitat loss appear to be key drivers of the occurrence of a species such as the Assamese macaque and capped langur in these fragments (Chapter 3).

The large fragment (HGWS) is an anomaly in that despite losing one species, it retains all other species in fairly high abundance (Chapter 5). This fragment, therefore, presents an opportunity to examine the ecological question on how species manage to co-exist in this fragment and what insights one may gain from it to further the prospects of co-existence between sympatric primates in other fragments in the Valley. Our results (Chapter 6) show that primate species in HGWS, particularly the congeneric macaque species, have been able to co-exist by partitioning their niches along two axes—space and food. All the three species studied, the rhesus macaque *Macaca mulatta*, northern pig-tailed macaque *M. leonina* and the stump-tailed macaque *M. arctoides* showed differential habitat and food resource use in this fragment.

The disappearance of the Assamese macaque *Macaca assamensis* from the sanctuary may not only have been driven by anthropogenic causes, but may also have involved ecological mechanisms such as competitive exclusion, though establishing this conclusively is exceedingly difficult. Although not a typical representative of an average fragment in the Valley, the insights into primate coexistence from HGWS, nevertheless, do point us to factors that might enable such coexistence in other fragments of the Valley. For example, fragments that offer a habitat matrix with roosting and foraging opportunities are also able to promote greater co-existence of these species.

Our results, therefore, on the one hand, show the precarious state of primates in several fragments of the Valley but, on the other, point to the opportunities to conserve and manage them, given that, on average, half the original complement of species still survives in these fragments. However, significant threats still exist to these fragments from various socio-economic factors.
Moreover, our analysis suggests that the drivers or factors that have threatened the existence of these fragments have remained virtually unchanged since colonial times. Although the actors have changed, these forests, even today, are being exploited either to facilitate the expansion of tea plantations or to extract natural resources. The people around these fragments are still relying heavily on forest resources. The problem, therefore, remains the same but we perhaps need to adopt different approaches to solve them.

7.3 Where do we go from here?

Our results have thus not only generated baseline ecological information on the effect of habitat fragmentation on primate communities of the Upper Brahmaputra Valley but have also identified major threats to the primates and their habitats. Where does this information lead us? How does this information help us address challenges and further the prospect of species survival in these fragments? I suggest that there is a need to take two parallel paths. First, detailed knowledge is required on a few questions that remained unanswered and/or emerged as significant during our study. Second, to mitigate some of the major threats that I identified during the study, immediate conservation actions are needed as well.

7.3.1 Knowledge-based approach

7.3.1.1 Importance of matrix and edge effect

The matrix surrounding a fragment is important for the survival of species and can offset the negative effects of reduced fragment area and its isolation. Moreover, the ability of species to use the matrix habitat will determine their vulnerability to habitat fragmentation (Gascon et al., 1999). Although our study held the effects of matrix constant (as it was predominantly composed of open agriculture, Chapter 3), a detailed study on the primate communities in Hollongapar-Gibbon Wildlife Sanctuary (Chapter 6) revealed the importance of the matrix habitat for several primate species. Rhesus macaques were observed to extensively use the matrix habitat not only as supplementary feeding sources but also as roosting sites. During the dry season, they fed almost exclusively on the fruits of Acacia auriculiformis and Lantana camara, which were abundant in the surrounding matrix of HGWS. Capped langurs were also seen to quite frequently use trees of Albizzia lutea adjacent to HGWS and spend considerable time foraging and resting outside the fragment. Even hoolock
gibbons were observed to feed on a few scattered trees of *Artocarpus lakoocha* located in a neighbouring tea plantation (pers. obs.). Pig-tailed macaques and Assamese macaques have also been seen or reported to use matrix habitats in the smaller Borajan fragment (pers. obs.). As the distance between two fragments is large and establishment of corridors is not often logistically feasible, the management of the matrix habitat becomes critical for the persistence of primate populations in these fragments. In addition to that on matrix habitats, future research should focus on the effect of edges on the persistence of primates in fragments as edge effects could drastically alter the habitat structure of a fragment, which, in turn, might affect the survival of these primates.

7.3.1.2 Co-existence mechanisms

The fragments of the Upper Brahmaputra Valley offer excellent 'natural laboratories' to examine how different species subsets co-exist in the absence of other species. As different species have been lost from different fragments, this offers us a natural perturbation experimental setup, which can yield more robust inferences on the opportunities and limits to primate coexistence in the fragments. There is a need to extend the co-existence study to other fragments of different sizes and anthropogenic gradients that will enable us to understand the co-existence mechanisms better.

7.3.1.3 Human resource use

A preliminary study on the human-dimensions of primate conservation in one of the fragment demonstrates the importance of such a study for a better understanding of primate conservation in the Valley. Given that these fragments are shared by nonhuman primates and humans alike, priority should be given to examine, in great detail, resource use by the local human communities and their influence on the remaining primate populations.

7.3.2 Action-based approach

7.3.2.1 Long-term monitoring of primate populations

A primary thrust area for the conservation of primates in the Upper Brahmaputra Valley should include a regular monitoring programme for the remaining primate populations in the fragments. Our study clearly demonstrates that long-term monitoring of populations provides important
temporal trends of survival and growth, which are vital to recommend 
conservation measures for the concerned species, as demonstrated in Chapter 
5. Regular monitoring of primate populations can, however, be a costly exercise 
and needs great manpower. In the context of the Upper Brahmaputra Valley, 
this can be best achieved through active collaborations between researchers, the 
forest department, local environmental NGOs and students from neighbouring 
concerned institutions.

7.3.2.2 Protection of fragments and regulation of resource extraction

Although a certain degree of legal protection has been accorded to these 
fragments, which are administratively under the reserve forest category, 
enforcement is extremely poor. As the proportion of habitat loss has negatively 
impacted primate species richness, prevention of loss of habitat should be one 
of the priorities to conserve the unique assemblage of primates in these 
fragments. However, species such as rhesus macaque *Macaca mulatta*, may not 
need protection as we found that they thrived well in human-dominated 
landscapes (Chapter 3). Poor protection has also resulted in unregulated 
extraction of forest resources, including illicit tree felling activities. Monitoring 
of forest resource use in one of the fragments, the Hollongapar-Gibbon Wildlife 
Sanctuary, revealed that over 25% of the forest produce extracted were food 
plants of the primate species of the fragment (Sharma, 2010). It is 
understandable that the marginalised local people that live around these 
fragments rely heavily on them for their resource needs. Strict protection is, 
therefore, required to minimise such extraction as well as the uncontrollable 
exploitation of forest timbers, for example, for charcoal production, which is 
common around many of these fragments. Most of the extracted resources are 
used for fuelwood; minimising the dependency of the local people on the forest 
for fuelwood can possibly be achieved through measures such as regular 
distribution of liquefied petroleum gas (LPG) in the fringe areas at subsidised 
rates. There are encouraging results from elsewhere (Bandipur National Park of 
 southern India, for example), where LPG distribution appears to have reduced 
the dependence of the local communities on forest resources.

7.2.3.3 Restoration of degraded fragments and reintroduction of species

The continuous exploitation of forest resources has resulted in the degradation 
of most the fragments in the Valley, many of which remain mere shadows of 
their past. However resilient these fragments may be, it is simply not possible
for these fragments to recover fully from the past disturbances unless an active restoration programme is implemented in them. I, however, recommend that this should be carried out only when the original factors that have caused their degradation are actively reversed. Increasing the availability of food and roosting trees, particularly of keystone resources such as figs and other fast-growing primate food plants, for example, can provide crucial help to the long-term survival of isolated primate populations. The funding and other resources to support such activities is, however, limited; I, therefore, suggest that developmental schemes such as the Indian government’s Mahatma Gandhi National Rural Employment Guarantee Act should be linked to critical habitat restoration activities. This Act aims at enhancing the livelihood security of rural people by guaranteeing employment and we are optimistic that by linking it to habitat restoration, we could achieve the dual goal of habitat conservation and generation of livelihood opportunities. Finally, I recommend the carefully planned and monitored reintroduction of primates into select fragments, but only after restoring their degraded habitats and addressing the factors that had caused the local extinction of the primates from these fragments in the first place.

7.4 People, fragments and primates: is long-term co-existence possible?

The thesis conclusively demonstrates that the primates in the fragments of Upper Brahmaputra Valley are worth conserving as they support several tenuously surviving populations, many of them forming unique communities. Moreover, there is an urgent need to conserve and protect them as many of these populations are declining and more than one-third of their suitable habitats may have already been lost. Any further loss of such vital habitats would surely accelerate their irreversible decline in the future. Our results, thus, corroborate the growing support for retaining forest fragment for the preservation of regional biodiversity (Turner & Corlett, 1996; Tscharntke et al., 2002; Anand et al., 2010). However, at the same time, we must acknowledge that the primates of the Upper Brahmaputra Valley have to share space with people and their economic aspirations. This is particularly true for a landscape with diverse communities and their varied political ideologies, such as in Upper Assam, where protected forested land has always been a contentious
issue and a source of much conflict. Moreover, being a production landscape, the state- and central governments have economic aspirations for the region, as large reservoirs of oil and coal lie underneath these forests, and the land is suitable for tea plantations as well. Also, being located in a flood-prone area, the region is highly unstable with annual episodes of flood rendering many people homeless and landless. These fragments are among the few options available to governments to settle people in an already-crowded landscape. Hence, is any kind of reconciliation between people and primates possible in the Upper Brahmaputra Valley?

There are, in fact, important opportunities for primate conservation in the Valley that need to be seized. First, the region has low hunting pressure (except in areas adjoining Nagaland and Arunachal Pradesh, and often from tea garden labourers) – one of the reasons why primates still persist in these fragments. People are not only more tolerant of primates in this region but also greatly respectful of the trees that are important for their survival. For example, many isolated populations of hoolock gibbons continue to survive in villages of upper Assam (Choudhury, 2009). The Moran community of upper Assam, for example, has declared the hollong tree *Dipterocarpus retusus* (one of the major roosting trees of primates) as a traditionally important tree and have barred its further felling from the forests of upper Assam (Duarah, 2009). Such cultural tolerance has, in the past, and will, hopefully, in the future, promote the long-term co-existence of people and wildlife, and boost species conservation.

Second, instead of viewing industries as potential threats, it is advisable that one treats them as our potential allies in conservation. Such an outlook is more pragmatic in the present context and can potentially aid in species conservation. There are enough opportunities in the Upper Brahmaputra Valley of devising wiser land-use strategies with the help of industries that can not only conserve species in the fragments but, in turn, provide benefits to the industries themselves. In southern India, for instance, scientists have been working closely with tea companies to restore degraded rainforest fragments (Mudappa & Raman, 2007). As tea plantations constitute a major matrix type, the management of such matrices to make them more tolerant to indigenous species can also help in species survival in the adjoining fragments. Industries such as coffee plantations are increasingly adopting pragmatic land-use practices that could better promote the conservation of local biodiversity (Aerts
et al., 2010). In return, they face more promising prospects for the distribution and sale of their products through ecologically aware and sensitive certification processes (as, for example, the Sustainable Agriculture Network; http://sanstandards.org/sitio/). Such a win-win situation can be extended to important industries of the region, such as coal and oil; they should also be induced to adopt more environmentally responsible activities.

Third, the greatest challenge for the continued survival of primates and their fragmented habitats in the Valley is to find ways to minimise the reliance of the large, neighbouring human populations on the forest fragments as the insidious extraction of forest resources from these fragments continues to be a major cause of their chronic degradation. An alternate to fuelwood, for which most of the people rely on these fragments, can be a viable option. In fact arrangements can be made with oil industries of the region to distribute LPG at subsidised rates to the fringe populations around the fragments. Habitat restoration of the degraded fragments could be linked to the Mahatma Gandhi National Rural Employment Guarantee Act (MNAREGA), whereby the marginalised local populace can be more meaningfully employed and in ways that would not only buffer the impact of people on the fragmented forests but also enhance the possibilities of the survival and further growth of the fragments.

7.5 Final words...

This thesis addresses several questions pertaining to the effect of habitat fragmentation on the primate communities of the Upper Brahmaputra Valley. Although ecological knowledge has focused on understanding how different species are affected by habitat fragmentation and loss, it does not yet provide us the necessary understanding of the human dimensions of primate conservation in the Valley. Without studies that shed light on the interactions between people and primates, our understanding of a core issue of primate conservation will remain incomplete. The next step, therefore, should be to begin an extensive study of human dimensions of the effective conservation of primates and their habitats in the Upper Brahmaputra Valley so that our conservation strategies are based not only on sound ecological understanding but on a robust foundation of human welfare as well.
7.6 Literature cited


Duarah, R. (2009) Moran students move to save Hollong tree


