CHAPTER – 5

UNGULATE – HABITAT RELATIONS:
A SYNTHESIS
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5.1 The conservation issue

Ungulates are amongst the most vulnerable group of mammals (Ceballos et al. 2005; Schipper et al. 2008), which are under unrelenting pressures from humans (Brashares et al. 2001; DeFries et al. 2010). Hunting (Corlett 2007), habitat loss (Macdonald 2001), habitat change (Groom 2006) and intense market-driven forest resource-use (Geist and Lambin 2002), have all contributed to the dramatic contraction of their range (Baillie et al. 2004; Karanth et al. 2010), as well as unprecedented reduction in their abundance levels particularly in increasingly human-dominated, fragmented landscapes of India (Karanth et al. 2009; Karanth and DeFries 2010). This is particularly true of ungulates in tropical forests of Asia (Baillie et al. 2004). Despite this overall decline, ungulate populations are doing reasonably well in habitats where ecological conditions are favorable and they receive effective protection from hunting and other human impacts (Karanth and Sunquist 1992; Khan et al. 1996; Kumar 2000; Karanth et al. 2004; Karanth et al. 2008; Steinmetz et al. 2010). This indicates that ungulates can flourish if appropriate management strategies are implemented.

In the foregoing chapters, I have described need for a reliable assessment of ungulate-habitat relations (chapter 1) and the, ecological and methodological challenges involved in studies to meet this need (chapters 1
and 2). Currently, most of the studies in the tropics that investigate factors influencing the distribution and abundance of ungulates are from Africa (Skidmore and Ferwerda 2008). A few available studies from India (Karanth and Sunquist 1992; Khan et al. 1996; Bagchi et al. 2003, 2004) suggest it is difficult to predict ungulate abundance patterns based on generalizations from African studies. Furthermore, all published studies from Africa and India are limited by the lack of a methodology that explicitly and simultaneously accounts biases due to ecological, observation and spatial processes that commonly affect survey data (Royle and Dorazio 2008; Joseph et al. 2009). Given the need for science-based management of remaining ungulate habitats, application of reliable methods to study ungulate-habitat relationship is urgently required. This thesis is presented in this wider context.

5.2 Central questions

Several bio-physical factors (e. g. forest vegetation type) and inherent biological traits (e. g. body size, diet) are well known to determine ungulate abundance levels (Eisenberg 1980). The current decline in distribution and abundance of ungulates in India is linked to anthropogenic pressures (Karanth et al. 2004; Karanth et al. 2010). However, there are empirical examples of management interventions that have positively influenced ungulate densities (Khan et al. 1996; Karanth et al. 1999; Walston et al. 2010). Given the broad array of factors (chapter 1) that potentially
determine ungulate abundance patterns, can we reliably identify key habitat factors that determine abundances ungulate species differing in body size and diet (chapters 1 and 2)? How important are different potential predictors of abundance for different species (chapter 3)? How do ungulate abundance patterns change across landscapes in the case of different species (chapter 3)? Can we objectively measure and assess the spatial distributions of proximate conservation threats to ungulates (chapter 4)? What management actions are required to mitigate such threats and recover ungulate populations (chapter 4)?

These are some of the questions I have tried to address in this thesis. The field study was carried out in the 1400 km$^2$ area of Nagarahole-Bandipur reserves, which, for historical reasons provide natural experimental settings (chapter 1) to test my a priori predictions on ungulate-habitat relations (chapter 3) on five ungulate species that differed markedly in terms of their morphology, behavior and ecology (chapter 1).

5.3 Hierarchical models: A methodological advance

I propose that recent developments in Hierarchical modeling (Royle et al. 2004; Royle and Dorazio 2005, 2008) of animal populations offer major advantages in pursuing the questions I have posed above to pursue these answers effectively. First, such a modeling approach enables unambiguous specification of two major components essential to deal with survey data
from field studies: (a) an ecological model that describes the ecological process of interest. In this case the relationship between ungulate abundance patterns and a set of habitat factors that potentially induce changes in them, (b) an observation model that describes the actual sampling process involved in the conduct of field surveys. The critical issue, often ignored in field studies is that the “observation process” often obscures the “ecological process” of interest to the investigator. Hierarchical modeling framework allows biologist to explicitly focus on real parameters of interest, without getting overwhelmed by the nuisance parameters which are inevitably a part of the observation process. Second, hierarchical modeling approach enables biologist to construct explicit probability models to describe ecological relationships or systems, unlike the traditional approach where regression models are viewed as a default “procedure for inference” without due consideration of probability distributions that may underlie the species abundance patterns we observe (Bolker 2008; Royle and Dorazio 2008; Link and Barker 2010).

Other advantages of hierarchical modeling include an ability to account for different (both structured and unstructured) sources of variance in the data, ability to simultaneous handle data at different spatial scales (e.g. local and landscape level), possibility of integrating different kinds of data (e.g. continuous or categorical data), ability to deal with mis-alignment of spatial sampling units (e.g. transect lines spanning over several lattice
data units) and multiple levels of parameters (e.g. individual covariates such as cluster size, sigma parameter in the distance function, regression coefficients, lambda parameter, spatial regressor, indicator variables) (see chapter 2 for details). Development of speedy, efficient computing algorithms (such as Markov chain Monte Carlo (MCMC) sampling methods) and freely available, user-friendly application software programs (R statistical package, WinBUGS) have made complex hierarchical models readily accessible to field biologists. In this study, I used this efficient approach to develop and build realistic models of ungulate-habitat relations for five ungulate species of great conservation priority in tropical Asia (chapter 2).

5.4 A Review of results

I examined the role of ecological and management factors in influencing the abundance patterns of five ungulate species that greatly differed in their biological traits such as body size, diet and sociality. The results (chapter 3) showed that there is no single habitat or management covariate, which can explain abundance patterns of these species. Although, forest vegetation type (habitat deciduousness) mattered most for several species, other biophysical factors (e.g. terrain complexity, water availability) were also important. Among management factors, strict protection against human intrusions and impacts (habitat protection) was more important than habitat manipulations carried out to enhance ungulate densities (chapter 4).
As predicted based on biological traits (Hudson 1984), abundance of a large sized ungulate (sambar) was near-uniform across the study area. However, this was not the case with the mega-herbivore species, gaur. Gaur abundance was clumped around well-protected areas with least human disturbance, particularly in steep terrain. Muntjac were conspicuously absent from areas intensely used by humans. Abundances of chital and wild pig were highest in well-watered, moist deciduous forest patches that offered most edge and eco-tone effects, a result consistent with earlier studies (Karanth and Sunquist 1992; Gangadharan 2005). Given the ability of large ungulates to switch between grazing and browsing during periods of resource crunch (Schaller 1967; Geist 1982; Hofmann 1989) and given the plentiful and uniform distribution of water resources in the landscape, bio-physical factors (such as terrain feature) and management factors (such as habitat protection) played a relatively important role in determining ungulate abundance levels.

5.5 Conservation implications
These results have important management implications (chapter 4). The remaining forest vegetation of some type or the other covers nearly 20% of India’s 1.1 million km² land area. About 65% of this forest cover is of mixed-deciduous type (Sanderson et al. 2006), which is a prime habitat for several ungulate species. India’s deciduous forests are also heavily impacted by a variety of anthropogenic pressures (Chundawat et al. 1999;
Sanderson et al. 2006; Karanth and DeFries 2010), despite the fact that about 40,000 km² area is within nature reserves (protected areas) (Walston et al. 2010). Given their inherent productivity, my results show that still there are many opportunities to manage these remaining deciduous forests to maintain high ungulate densities, which in turn can support substantial populations of endangered carnivores such as the tiger, leopard and dhole.

The study also provides a methodological framework to systematically monitor threats to ungulate habitats and identify their vulnerability zones in order to focus protection and management efforts (chapter 4). The predictive capabilities of the modeling approach also enable evaluation and prioritization of potential interventions in an adaptive management framework (Williams et al. 2002; Nichols and Williams 2006), and, to allocate conservation resources wisely (Salzer and Salafsky 2006). Furthermore, long term monitoring of ungulate populations and their habitats (Lindenmayer and Likens 2010) using such rigorous approaches will help understand their basic spatio-temporal dynamics and provide reliable metrics to evaluate success or failure of management efforts (Williams et al. 2002; Nichols and Williams 2006). I view results from this study as conservation tools applicable not just to the Nagarahole-Bandipur study site or just to the five ungulates that I studied, but as being applicable to a much wider array of threatened ungulate and carnivore species inhabiting deciduous forests of Asia and other regions of the world.