CHAPTER – 1

INTRODUCTION
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1.1. GLOBAL CONTEXT OF BIODIVERSITY LOSS

1.1.1. General Background and literature review

Global biodiversity is disappearing at an alarming rate (Meffe and Carroll 1994, Dirzo and Raven 2003). Growing human pressures have altered most natural habitats across the globe (Sanderson et al. 2002). Although deforestation rates vary in different parts of the world, tropical forests are the worst affected biomes. During 2001-2005 period around 274, 615 km² or 1.4 % forests were lost (Asner et al. 2009). Deforestation has also fragmented large forest blocks and created extensive forest edges (Broadbent et al. 2008). Human populations are responsible for depletion of biodiversity through several impacts, such as excessive exploitation of forest products, hunting, harvesting, pollution and introduction of invasive species (Robinson and Bennett 2000). Such unsustainable exploitation is driving major declines of biodiversity (Ehrlich and Holdren 1971, Terborgh and van Schaik 2002).

Vertebrate taxa in general and mammals in particular, are worst affected (Schipper et al. 2008). During last 500 years it is estimated that 1159 vertebrate species have been lost and 16,928 other species have become highly threatened (Vie et al. 2009). If these trends continue it is expected that over the 50 years at least 565 mammalian species are predicted to go extinct (Dirzo and Raven 2003). About 5487 mammalian species (25% of all
terrestrial mammals (n=1137) are threatened with extinction. Amongst mammals, carnivore species are highly vulnerable to extinction because of their unique biological traits such as position higher up in the food chain, conflict-prone behavior and low densities (Ceballos et al 2005; Schipper et al. 2008).

Birds are also severely affected by deforestation and hunting (BirdLife International 2000, Sodhi et al. 2004b). Many tropical birds are habitat specific, occur at low densities, or have poor dispersal abilities. These characteristics increase their vulnerability to extinction (Terborgh 1990, Laurence et al. 1997). More than 830 threatened bird species are found in tropical forests (BirdLife International 2000). Countries such as Singapore have recoded loss of 67% of their original birdlife during last 100 years period (Costelletta et al. 2000). Habitat destruction is considered to be the prime cause for bird species local extinctions (Pimm and Raven 2000, Gaston et al 2003). However, these problems increase manifolds in human dominated landscapes of south Asia.

1.1.2. Challenges Posed by Human Impacts in Asia

Human impact on biodiversity, especially on larger vertebrates, in human-dominated landscapes of south Asia are poorly documented and there exist only a few studies focused on specific impacts such as the studies on impact of local hunting on large ungulate densities (Madhusudan and Karanth 2000), impact of minor forest produce collection on the (a) regeneration of
the indigenous plant species (Murali et al. 1996), (b) structure and composition of vegetation (Kumar and Shahabuddin 2005), (c) structure and composition of birds (Kumar and Shahabuddin 2006), and (d) broader impacts of resource use on habitat quality (Karanth et al. 2006). The evaluation of impacts of human pressures on different forms of biodiversity within ecologically similar habitats but differing in management regimes will provide useful insights for the choice of a particular model of conservation to aid biodiversity management.

1.1.3. Specific Drivers of Biodiversity Loss

Various forms of human activities for forest-resource use are considered to be major drivers of biodiversity loss. Human population, human per capita consumption and efficiency of resource use are the root causes of extinction (Terborgh and Peres 2002, Ehrlich and Holdren 1971). Proximate causes of biodiversity loss are habitat destruction, degradation (Brooks et al. 2002, fragmentation (Fahrig 2003), hunting (Robinson and Bennett 2000, Madhusudan and Karanth 2002), unsustainable forest produce collection etc (Murali et al. 1996). Human impacts are mostly of local origin such as grazing (Rahmani 2003, Middleton 2003), fires, and biomass removal (Somnathan and Borges 2000). Some of the impacts are due to larger regional policies and initiatives such as logging, NTFP collection, and development projects such as roads, dams and power lines. The impacts are enormous across the continent, for example 90% loss of vegetation cover in Indo-Burma regions, 77% in
Western Ghats-Sri Lanka region and 75% in Himalyan region and equal portion in dry tropical forests of central India are lost due to human pressure (Singh and Kushwaha 2008). Such high pressures of human population and resource consumption patterns alter the ecosystems rapidly through deforestation, degradation, and habitat fragmentation, leading to isolation of biodiversity, insularisation and species extinction.

The growing human populations and changing aspirations in India pose a challenge to conserving biological diversity. Over the last 60 years, human population has grown from 390 million people in 1951 to more than a 1 billion (Directorate of Census Operation 2004). During this time the per capita forest got reduced to 0.064 hectares per capita against world average of 0.64 ha per person (Singh and Kushwaha 2008). Furthermore, the cattle population of 350 million grew to 520 million during this period adding enormous pressure on remaining forests. In India during last 100 years 25 large mammal species have gone locally extinct from 14% to 96% of their historic range (Karanth et al. 2010).

1.1.3.1. Habitat loss

Habitat loss is most obvious effect of human disturbance (Heywood 1995). Habitat loss results in species loss (Fahrig 1997, 2001). Habitat loss is also occurring in biodiversity hotspots and if present trends continue, significant portion of biodiversity will be lost (Myers et al. 2000). Endemic species are particularly vulnerable (Brooks et al. 2002). Since they are often habitat
specific, intolerant to any modifications in the habitat are the worst affected and become locally extinct (Didham 1997). Habitat loss is closely associated with loss of ecosystem services (Dobson et al. 2006, Reyer et al. 2009). Loss of species at higher trophic levels will lead to loss of ecosystem services (for examples see Jones et al. 1998, Chapin III et al. 2000). These losses may be negligible in the beginning, but there will be virtual collapse of ecosystem services (Dobson et al. 2006, Reyer et al. 2009).

1.1.3.2. Habitat fragmentation

Habitat fragmentation results from deforestation, leading to smaller and isolated vegetation patches, loss of habitat and this in turn leads to loss of diversity (Andren 1994, Bender et al. 1998, Noss and Csuti 1997, Fahrig 2003). The insulated island populations without chances of any gene pool exchange eventually result in reduction in population leading to local extinctions (Brown and Hutchings 1997). Fragmentation leads to decline in populations ranging from no change to up to 80% of original population depending on the biology of the species (Wiegand et al. 2005, Noss et al. 2006). Fragmentation and habitat loss is directly associated with loss of overall species richness, populations and individuals (Terborgh and Winter 1983, Debinski and Holt 2000).

Forest roads and timber trails are the prime reasons for fragmentation, creating more forest edges (Ritters et al. 2000) and creating islands of populations. The timber roads affect regeneration of forest species
seriously; the problem persists even after many year of cessation of timber extraction activities (Malcolm and Ray 2000). Often expanding roads provide easy access to habitat making the animals vulnerable to hunting (Wilkies et al. 2000). Fragmentation is also caused by power lines, fences, canals, vegetation removal by livestock, colonization by invasive species and other related human activities (Noss et al. 2006).

Effects of fragmentation are varied and far reaching. Habitat fragmentation is reported to have contributed to nearly 15% of species loss (Weigand et al. 2005), besides affecting resource availability that in turn influences animal distributions ((Norton and Griffiths 1995). Fragmentation has also influenced lesser known changes like regeneration (Turner et al. 1996), mortality (Torborgh and Winter 1980) and other processes determining population dynamics. Studies have also documented the effects of fragmentation on the social organization and behavior (e.g. Lawes et al. 2000), dispersal, insularization (e.g. Dinerstein et al. 2006, Rangarajan et al. 2010) and ripple effects along the food chain (e.g. Donaldson et al. 2002).

1.1.3.3. Habitat degradation

Human disturbances alter the regeneration drastically, change forest structure and composition (Horn and Hickey 1991, Hong et al. 1995). Timber harvesting particularly clear felling alters the ecosystem drastically through elimination of key tree species. Along with removal of old trees,
species living or depending on those trees get eliminated, and this affects their local populations (Thiollay 1997). In contrast selective timber harvesting considered innocuous to ecosystems has range of associated impacts. Selective harvesting of timber reduces ground cover and affects species such as terrestrial and insectivorous birds and mammals (Thiollay 1997). Logging does not accommodate the specific feeding requirements of these highly evolved and specialized feeders, in terms of dietary specialization, restricted feeding strata, rendering bird and mammalian species vulnerable to logging interventions. Selective logging also has been found to affect the bird populations, for example leading to declines of bird population of 94.6% compared to original bird population in North America (Terborgh 1989). Many hunted birds and mammals are responsible for seed dispersal, and influence the structure of the tropical forests. Along with this collection of forest products by people activities are leading to local extinction of species and disruption of ecological functions.

1.1.3.4. Hunting

Local and commercial hunting is a major driver of biodiversity loss among terrestrial vertebrates world-wide (Robison and Bennett 2000). Even forests unaffected by logging are often empty forests (Redford 1992). Although ‘subsistence hunting’ appears ‘harmless’ superficially, in terms of quantity and impact it often surpasses commercial hunting. Overall both types of hunting practices are detrimental to all major faunal groups (e.g. non-
primates, Redford 1992; primates and birds, Parry et al. 2009; ungulates, Milner-Gulland et al. 2003) and are found to be unsustainable in the long run (Robinson and Bennett 2000).

In the forest areas of Western Ghats in India, despite strict law-enforcement against illegal hunting, constant low intensity hunting has greatly affected large bodied mammals (Karanth and Madhusudan 2002). Similarly subsistence hunting is prevalent in North-Eastern states of India, and this has resulted in “empty forest syndrome”, with almost no animals left in otherwise well stocked tropical forests (Misra et al. 1998, Datta 2002). Hunting seriously affects the natural prey availability (Robinson and Bennett 2000, Kumara and Singh 2004), and pushes predators to depend on the livestock for food (Karanth and Madhusudan 2002). Prey densities ultimately determine predator densities (Karanth et al. 2004). Low prey densities are responsible for increasing human-animal conflicts and associated revenge killing by the villagers. Top predators are the often worst affected by local hunting.

1.1.3.5. Impacts of other extractive human activities

While the impacts of habitat loss, fragmentation, degradation and hunting on different components of biodiversity are stark, impacts of other extractive uses of forests are subtle, difficult to detect and therefore, least understood. Recent studies in India have shown how vegetation structure, diversity and composition have been altered by fuel wood collection and
grazing (Kumar and Shahabuddin 2005), and how extractive uses of forests have affected forest regeneration (Daniels et al. 1995, Murthy et al. 2002) and suppressed native species (Sagar and Singh 2004). Such extractions over a prolonged period are found to affect the ecosystem adversely (Murali et al. 1996, Kumar and Shahabuddin 2005). Low intensive local uses, often promoted as “conservation tools that provide livelihood options” for the local people, are also shown to have deleterious effects on biodiversity.

1.2. BIODIVERSITY CONSERVATION APPROACHES

1.2.1. Global Scenario

The protected area approach has been chosen as a major strategy to preserve biodiversity by majority of the countries of the world (Burner et al. 2001). IUCN has recognized six different categories of protected areas depending on the purpose and extent of human exploitation (IUCN 1994, Dudley 2008). These include strict nature reserves with no exploitation of any kind to sustainable use nature reserves with open access to forest resources (Dudley 2008). Globally the natural biodiversity is almost confined to 12% of geographical area in various categories of protected areas (IUCN 2003).

1.2.2 Indian Scenario

India is one of the 17 mega-biodiversity countries, with 4.79% of land under protected areas, with 12% of world’s flora and 7.28% of global faunal species (GOI 2009). Three distinct management approaches are adapted for
biodiversity conservation in India. These are (1) predominantly protected areas which include national parks and sanctuaries under administrative control of state; (2) community conservation areas mostly outside the protected areas and traditionally owned by village communities, which are small and spread across nation; and, (3) biosphere reserves which are biodiversity rich large landscapes that encompasses protected areas, adjoining forest areas, rivers and private lands including agricultural lands (GOI 2009). During last 50 years, protected area evolved in to an umbrella for conservation of biodiversity (Rodgers and Panwar 1988, Kothari et al. 1989).

1. 2. 1. Protected areas in India: National parks and Sanctuaries.

The protected areas are designated legally under the provisions of Wildlife Protection Act 1972 as National Parks or Sanctuaries. National parks and sanctuaries are managed as per Wildlife Protection Act (WPA) 1972 and with latest amendments in 1991. The protected areas mostly state initiated (Gadgil & Guha 1995). No commercial exploitation of any kind allowed in the national parks and sanctuaries. Prior to 1991 amendments in WPA 1972, there was some kind of exploitation allowed in sanctuaries. There are many villages landlocked with in sanctuaries, legally there are no provisions for the villagers to use sanctuary resources.

In India, there are 99 national parks and more than 513 sanctuaries, covering 4.79% of geographical area to protect biodiversity (GOI 2009).
National parks are declared and managed as per provisions under section 35, while Sanctuaries are declared under section 18 and managed as per provisions under sections 27-34 of WPA. No human activities are permitted in National parks without the approval of National Board for Wildlife. Certain kinds of human activities are allowed within sanctuaries to meet the bona fide needs of people living within and around protected areas. Activities like grazing are totally banned in National Parks. The IUCN system of classification is not strictly followed in India. Very few protected areas in India fall under Category II and majority of them fall under category IV. All National Parks and Sanctuaries in India are owned by state, and, there are no privately owned National parks and Sanctuaries. However, there are private land holdings within these protected areas (Kothari et al. 1989). Management efforts in these protected areas include protection to reduce human activities which are detrimental to biota; habitat manipulation to meet exigencies like fire, water crisis; mitigation of human wildlife conflicts; habitat restoration activities like weed removal. The principle rationale behind management is wilderness can be recovered and restored if given an opportunity and freed from human pressures. This involves exclusion of human interferences through strict enforcement of law, and all consumptive human uses are restricted in these designated protected areas to minimize human impacts. The majority of parks in India are small and most of them have human habitations within them that fragment remaining forested habitats (Kothari et al. 1989, Singh and Kushwaha 2008).
Community Conserved Areas (CCAs) are not legally declared protected areas; however, there are provisions under WPA (1972 amended in 1991) to convert these community owned CCAs to legally defined protected areas. Any government area adjoining National Parks and Sanctuaries, which is of conservation significance (e.g. a corridor connecting two protected areas) can be declared as Conservation Reserve under section 36A of WPA 1972. Areas of conservation value protected by private individuals or communities are notified as Community Reserves under section 36C of the WPA 1972. Consent of the communities is a prerequisite for declaration of such CCAs (WPA 1972). Many traditional societies preserved biodiversity rich areas because of unique belief and value systems and revered them as sacred groves, homes of Gods, spaces for ancestors, spirits or places for spiritual reflection and cultural values (Pathak 2004).

Community Conserved Areas are often very small, and have therefore inherent limitations in protecting large bodied, landscape level species, endangered species and ecologically sensitive species. The CCAs are supplementary to larger conservation sites in a landscape mosaic with other types of protected areas (Ostrom and Nagendra 2007, Shahabuddin and Rao 2010). These CCAs (sacred groves) in Western Ghats of India are found to protect biodiversity to a limited extent of less than 50% of the species compared to the strictly protected areas (e.g. National Park or
Sanctuary) of nearby area (Bhagawat 2005) and often do not cover endemic species. CCAs are also considered as instruments to achieve social justice to the local communities (Schwartzman and Zimmerman 2005). Participation of entire community in conservation of CCA is quite uncommon, and, some dominant communities have greater role in conservation of biodiversity and ecosystem services (Pathak 2004, Kothari 2006, Nagendra 2007). The CCAs are complex in nature in terms of management, require well-defined, socially cohesive group and with strong authority to manage and in absence of such arrangement they fail to protect biodiversity (Shahabuddin and Rao 2010).

1. 2. 2. 3. Biosphere Reserves

Biosphere Reserves (BR) are large areas both terrestrial and marine, defined under the Man and Biosphere (MAB) programme of UNESCO and they do not have any legal recognition. The scheme was initiated in 1986 to conserve key ecosystems. Sustainable development, protection, research, monitoring, education, training and information exchange are major components of the scheme. So far 14 biosphere reserves in India have been created covering an area of 55,762 km².

Biosphere Reserves are conceived as places where both people and nature coexist; these are representative areas of biomes. They encompass protected areas and adjacent areas inhabited by people, who are considered an integral part of the ecosystem. Biosphere Reserves manage both
wilderness areas and landscapes manipulated by humans. Biodiversity conservation is as important as human welfare, co-existence is the underlying approach. BR have three zones of management: core area which is largely un-manipulated natural forest area, free of human interference; buffer zones which adjoining core areas, mainly meant to protect core areas, with limited activities (include tourism, restoration zone, demonstration zones and education zones); transition zones which include croplands, manipulative zones, and intensive recreational zones. BR are managed based on provisions of National Conservation strategy and Policy, National Action Plan on Biodiversity (1197), National Forest Policy (1988), Environmental Protection Act (1986) and Wildlife Protection Act (1972), with amendments in 1991. BR consider more inclusive approaches of conservation, with greater scope for people’s participation in conservation (GOI 2007).

1.2.3. Ownership and management issues of Protected Areas

Different forms of forest management and conservation strategies have been proposed for arresting biodiversity loss. State or Governmental ownership (mostly in Asia), community-ownership of land or large private or corporate holdings (mostly in Africa, Latin America) are typical management models (Brandon et al. 1998, Terborgh et al. 2002). In India there are two broad types of forest/conservation area ownership models: first where forest lands are owned by the government with
different degrees of legal access for local users and the second in which
land ownership is under communities or families as in some parts of
north-eastern Indian Hill states.

In India biodiversity conservation is focused on a species and
protected area-centered approach is practiced under the legal framework of
the Indian Forest Act, and the Wildlife Protection Act. Several species or
habitat centered schemes and plans such as the Central sponsored schemes,
National Wildlife Action Plan 1984, National Biodiversity Action Plan,
Project Tiger, and Project Elephant etc. are implemented under this
approach. The policy and substantial proportion of the funding needs are
provided by the Union Government, while a part of the funding and actual
management and implementation are the responsibility of the State
Governments (GOI 2009).

1.2.4. Management of Protected areas in the Indian Context

After enactment of Wildlife Protection Act in 1972, many areas classified as
forests were elevated to the state of Sanctuary or National Park. Growth of
protected areas was unparalleled during 1970 – 1990: at the beginning of
1970 there were 4 National Parks, 61 Sanctuaries, which grew to 51
National Parks and 164 Sanctuaries by 1980 and by 1990 the National Parks
had increased to 71 and Sanctuaries to 417 (WII 2007).
The basic model of conservation implemented in these reserves is "preservationist" in nature (Karanth et al. 1999, Madhusudan and Karanth 2000) that involves enforcing anti-hunting laws and preventing the adverse impacts of fires, livestock grazing, forest product removal, logging and reducing habitat fragmentation through removal of human encroachments. Although tigers, their prey and their habitats have recovered as a result of various management measures (Karanth 2002, Madhusudan and Mishra 2003), these impacts and recovery processes have not been quantitatively well documented.

1.2.5. Integrating Surveys, Monitoring and Management Objectives

Successful biodiversity conservation can only be based on reliable mechanisms to assess biodiversity and human impacts at various scales. Many models, approaches and principles have been suggested to measure biodiversity and human impacts at regional, biome level and national level at different spatial scales (Noss 1990, 1999, Yoccozi et al. 2001, Green et al. 2005, Nichols and Williams 2006). A systematically planned, unified monitoring system can provide basis for future adaptive management (Balmford et al. 2005, Buckland et al. 2005, Nichols and Williams 2006).

The monitoring protocols being followed by protected area managers in India, however, are census-based approaches, which are based on the premise that all the animals in the survey area are detectable and are effectively counted. These are largely faulty both from statistical and
biological perspectives as exemplified in the case of the tiger (Karanth et al. 2003) and elephant (Rangarajan et al. 2010). Recent advances in the statistics and quantitative ecology have addressed the problem of imperfect detections thus leading to much better methods for measuring biodiversity (Yoccoz et al. 2001).

Fundamental to the modern approaches of sampling is the following canonical estimator that lays out the central idea:

\[ N = \frac{C}{PA} \]

Where \( N \) is the parameter of interest to the investigator; this could be number of individual animals in the surveyed area or number of species in the surveyed area or number of patches of habitat that possess a certain attribute (e.g. presence of an animal/plant species of interest) in the surveyed area.

And,

\( A = \) sampling fraction: *the proportion* of the overall area that was actually sampled and surveyed (e.g. 10% of all area)

\( P = \) the detection probability; *the probability* that an individual animal, or, a species or a patch of habitat possessing the desired attribute was actually observed/detected and counted during the survey.

\( C = \) the count statistic resulting from the field survey; *the detected/observed numbers* of individual animals, or, species or patches of habitat possessing the desired attribute, which were counted during the survey.
Of course, the canonical estimator only provides an overall representative schematic of key parameters and count statistics involved in wildlife sampling. It can rarely be directly applied to specific sampling situations on ground in the above form.

Reliable and practical statistical models rooted in the concept of this simple Canonical estimator (Williams et al. 2002), which is designed to accommodate the biological attributes of the surveyed objects as well as logistical and analytical considerations of surveys, are required to be applied to answer specific questions. However, as pointed out elsewhere (see Karanth et al. 2003) survey methods traditionally employed in India at great cost and effort to count wildlife, including flagship species of tigers and elephants (Jhala et al. 2008, Rangarajan et al. 2010, respectively), do not fully address these fundamental issues framed by the simple canonical estimator.

Conservation of biodiversity is one of the fundamental goals of management in India. Plants are the primary producers in the system and species diversity and richness of plants is often correlated with biodiversity of the ecosystem (Williams et al. 1998). Abundance, distribution and species richness and diversity of birds and mammals are also good indicators of changes in habitat (Caterbury et al. 2000). In this study, I have assessed the status of three biodiversity components: Plants, Birds and large Mammals by employing statistically reliable cost effective monitoring tools.
that fully address problems of imperfect detections and spatial sampling (Buckland et al. 2005). My study also aims to examine impacts of human activities on different forms of biodiversity under different levels of physical access, strictness of protection and resource extraction regimes.

Although my study addressed the above issues in the specific context of Nagarahole, Karnataka, I believe the results presented here are relevant to the conservation and management of a wide range of habitats and species in protected areas in India.