Status of Research and Monitoring in Protected Areas of the Indian *Terai* - An Overview

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Abstract

The east-west stretch of the vast northern alluvial flood plains of the rivers Ganges and Brahmaputra in the States of Uttar Pradesh, Bihar, West Bengal, and Assam is recognised as the Indian *Terai*. The characteristics of this tract include a high water table, annual flooding, and the synergistic influence of annual grassland fires. Once the *Terai* represented a lush belt of green vegetation comprising mainly moist deciduous forests dominated by sal (*Shorea robusta*) interspersed with tall, wet grasslands and numerous swamps. The tall grasslands were dominated by *Saccharum, Narenga, Sclerostachya, Imperata,* and *Typha* species. The complex woodland—grassland—wetland ecosystem harboured a variety of floral and faunal life, including several charismatic and obligate species. However, the highly diverse and productive *Terai* ecosystem witnessed a massive change during the country's post-independence era as a result of abrupt changes in land use policy, settlement of refugees, uncontrolled expansion of agriculture and the associated large-scale reclamation/conversion of grassland and swamp habitats, heavy deforestation, ever-increasing resource dependence and factors like fire, livestock grazing, and flash floods. These factors greatly reduced the once extensive *Terai* into smaller fragments. Some of these fragments were declared Protected Areas (PAs) in order to ensure conservation of representative biodiversity. As a result, what exists today are a few scattered PAs that experience high biotic pressure amidst a sea of extensive crop fields and human settlements.

In spite of the known significance of research and monitoring for sound and effective PA management, these PAs lack planned research and monitoring programmes. The existing research contributions are mainly in the form of check lists, inventories, ecological surveys (e.g., grassland habitats, turtles and tortoises, Bengal florican, cranes, swamp deer, Asian wild buffalo) and mainly species-oriented research on selected endangered mammals (*Rhinoceros unicornis, Bubalus bubalis, Cervus duvauceli duvauceli*) and birds (Bengal florican—*Houbaropsis bengalensis,* blacknecked stork—*Ephippiorhynchus asiaticus*). Sporadic studies also exist for selected PAs on resources mapping and land use changes. Up to now no baseline information has been collected on the structure, composition, and dynamics of forests, grasslands, and swamps in the rapidly changing landscapes. Likewise, well-planned and detailed experimental studies are needed on grassland diversity, succession, and the effect of burning, harvesting, and grazing. This paper highlights some of the constraints that have led to the present state of research and monitoring in these PAs, and recommends planned and co-ordinated multidisciplinary research including socioeconomic research; assessments at multiple hierarchical levels; application of modern technologies, *viz.* remote sensing and GIS; and management-oriented experimental research. The paper also recommends the adoption of a well-developed comprehensive approach for a long-term monitoring programme for each PA based on 'vital signs' and selected taxa.

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The Threatened *Terai* Ecosystem

India is fortunate in having a rich diversity of natural ecosystems ranging from the snow-capped peaks of the Himalayas in the north, to a vast hot sandy desert in the west, dense evergreen forests in the east, and biologically unique islands and coastal areas in the south. These result from the country's strategic location at the confluence of different biogeographic realms. Rodgers and Panwar (1988) in their biogeographic classification divided the country into 10 biogeographic zones and 26 biotic provinces. Like any other developing country, India too has witnessed a rapid growth of human and livestock populations in the past decades, and an ever increasing pressure of land encroachment and unplanned development have ultimately led to the decline and irreparable loss of the country's once extensive wilderness. Of the 10 biogeographic regions, probably the worst affected is the *Terai*, the east-west stretch of the northern alluvial flood plains of the rivers Ganga and Brahmaputra, which once harboured a lush belt of green vegetation dominated by sal (*Shorea robusta*) forests interspersed with tall grasslands and numerous swamps. This vast tract stretches across the northern Gangetic plains from Uttar Pradesh, through the southern Nepalese flood plains to Sikkim Daurs of northern West Bengal, to the floodplains of the Brahmaputra in north-west Assam and south of Bengal as far as Dakha (Wadia 1953; Oliver 1985; Lehmkuhl 1989, 1994; Sharma 1991; Bell and Oliver 1992; Peet *et al.* 1997, 1999; Kumar and Mathur 1998). The characteristics of this tract include a high water table, annual flooding, and the synergistic influence of annual grassland fires. This complex woodland—grassland—wetland ecosystem harbours a variety of floral and faunal life, including several charismatic and obligate species such as the tiger (*Panthera tigris*), Asian elephant (*Elephas maximus*), great one-horned rhinoceros (*Rhinoceros unicornis*), Asian wild buffalo (*Bubalus bubalis*), swamp deer (*Cervus duvauceli duvauceli*), Bengal florican (*Hubaropsis bengalensis*), hispid hare (*Caprolagus hispidus*), and pigmy hog (*Sus salvanius*).

The history of the area, coupled with severe human interference, has changed it into the fragmented landscape it is today. For a considerable time the area remained thinly populated except by local tribal people. However, the entire tract witnessed an immense change during the country's post-independence era as a result of abrupt changes in land use policy, the settlement of refugees, uncontrolled expansion of agriculture by large scale reclamation/conversion of grassland and swamp habitats for agricultural activities, heavy deforestation, increased levels of forest resource dependence, and the resultant abiotic factors like floods and forest fires. These biotic and abiotic factors greatly reduced the wilderness in the Indian *Terai* and it is now one of the most threatened ecosystems in India.

The Indian *Terai* PA Network

In recognition of the rapid decline of this highly diverse and productive complex ecosystem, and with the aim of protecting the endangered populations of prominent mega-herbivores, some large remnant patches of *Terai* forest in different states were declared as protected areas as part of a global network of biogeographically representative protected areas (GOI 1972, 1983; Mackinnon *et al.* 1986; UNCED 1992). The present network of India's protected areas

(PAs), including 85 national parks (NP) and 450 wildlife sanctuaries (WLS), covers an area of 1,449,788 sq.km, or 4.5% of India's geographical area. However, the Indian *Terai* has just 6 national parks and 38 wildlife sanctuaries covering an area of ca. 8,520 sq.km, or a mere 2% of the flood plains of the Ganga and Brahmaputra. The PAs in the Indian *Terai* are in four states—Uttar Pradesh (UP), Bihar, West Bengal, and Assam. The most prominent are Dudwa NP, Kishanpur WLS, Katerniaghat WLS, Suhelwa WLS, and Sohagibarwa WLS in UP; Valmiki NP and WLS and Kabar WLS in Bihar; Mahananda WLS, Gorumara WLS, Jaldapara WLS, and Buxa WLS in West Bengal; and Kaziranga NP and Orang WLS in Assam.

The average size of the PAs in the Indian *Terai* is about 185 sq.km, and like the majority of the PAs in India they also have villages within the PA and/or a large number of peripheral villages that are dependent on the natural resources of the PA. Furthermore, because of the prevailing severe biotic pressure and past management practices, most of these PAs are neither totally 'natural' nor stable (Mathur and Mathur 1999), rather they are largely 'semi-natural' or man altered. Many of the PAs lack contiguous managed forests or other categories of wilderness that can serve as crucial corridors. Thus they are isolated islands of wildlife habitats surrounded by people and incompatible land uses. The priority management issues facing the field managers of these PAs are often related to dependency of people—their rights and concessions; wildlife damage problems—crop depredation, cattle lifting, and even human injuries or kills; and aggravation of habitat loss and fragmentation—mainly by encroachments, flash floods, changing land use, hydrology, extensive farming, and the resultant habitat dynamics (Kumar and Mathur 1998).

Research and Monitoring in PAs

It is evident from the foregoing description that the existing PAs in the *Terai* are too small, in many cases isolated, severely altered, complex, dynamic, and heavily burdened by biomass dependent communities. Restoration, protection, and maintenance of these complex dynamic ecosystems will require effective management interventions, and these call for a better understanding of the various constituents and processes of the ecological systems under the jurisdiction of field managers. In light of the above, the relevance of research and monitoring as integral activities of PA management cannot be over-emphasised, keeping in view the multiple threats to the fragile ecosystem. Well organised rigorous scientific research and an integrated monitoring programme would ultimately help the PA management in several ways: it would enhance bench mark knowledge; facilitate decision making; reduce overall management costs; and enhance ecological integrity through increased public awareness and participation (Mackinnon *et al.* 1986, Mathur and Mathur 1998). It has been well illustrated that research and monitoring are two indispensable arms needed to support and strengthen PA management (Mathur and Mathur 1998). Developing and using an information base is the essential first step in deciding PA management goals and objectives. Evaluation of knowledge gaps helps determine research needs, while the research and monitoring outputs enhance the information base which further assists in redefining objectives, prioritising management issues, and evolving appropriate strategies.

Information Base on the Indian *Terai* — An Insight

In spite of the threats to the entire Indian *Terai*, PAs in this region have received very little attention from the research community; only in the recent past have they attracted some researchers. It is neither intended nor desirable to present here an exhaustive review of published or accessible research and monitoring activities in the Indian *Terai*. In this paper I will present a glimpse of the significant research contributions related to its diverse floral and faunal life and its spectacular landscapes. Most of the existing information is in the form of checklists, inventories, biological surveys, community ecology studies, and species-oriented research on selected endangered mammals and birds. Sporadic studies also exist for selected PAs on resource mapping, socioeconomics, and changes in land use. The most prominent studies and their contributions are described briefly below.

Surveys, Biological Studies, and Ecological Assessments

The majority of the PAs in the *Terai* were carved out from managed forests formerly under the control of State Forest Department(s); thus primary information about each PA comes in the form of old official Forest Department documents. This mainly means Forest Working Plans. These plans largely provide information on the type and extent of forests, taxonomic checklists (plants, birds, and mammals), forest management practices (silvicultural systems, plantations, rights, and concessions), habitat management, and to some extent socioeconomic profiles. Basically, they were management-related records with lots of facts and figures and not based on actual rigorous research. Often the plant checklists excluded lower and aquatic plants, grasses, and other herbaceous vegetation. In spite of this, such records are quite valuable for new managers and researchers to the area as important references. In addition to this, several floristic and faunal surveys have been undertaken throughout the *Terai* by survey organisations such as the Botanical/Zoological Survey of India and other scientific institutions.

Floristic Studies

Prominent floristic—forest/grassland surveys relevant to the Indian *Terai* are Duthie (1883, 1886, 1888), Cowan and Cowan (1929), Raizada (1931), Kanjilal (1933), Kanjilal *et al.* (1934a, b, c, d), Champion (1936), Bor (1941, 1960, 1982), Whyte (1957), Murthy and Singh (1961) Panigrahi and Ram Saran (1967), Panigrahi (1968), Champion and Seth (1968), Chaudhury (1969), Panigrahi *et al.* (1971), Dabadghao and Shankarnarayan (1973), Hajra and Shukla (1982), Singh and Tomar (1983), Chaudhuri and Naithani, (1985), Banarjee (1993), Uniyal *et al.* (1994), Sawarkar and Hussain (1995), and Rawat *et al.* (1997). A good beginning was made by the earlier foresters and botanists in providing checklists, flora, and illustrations, particularly in the case of grasses. However, much needs to be done in the field of community ecology–ecological description and vegetation assessment, classification, phytosociology, biomass production, harvest and use, and consumption by herbivores. Only preliminary research results are available on grassland succession and habitat dynamics. Extensive areas are affected by a variety of weed plants, yet no one has conducted research into this.

Faunal Studies

Faunal surveys and endangered species conservation oriented studies were also initiated a long time ago and these efforts continue. Such surveys and studies largely dwelt upon the status, distribution, and conservation priorities relevant to large mammals and birds. Prominent ones are Blanford (1888), Baker (1906, 1912, 1921), Gee (1964), Schaller (1967), Spillet (1967), Ali and Ripley (1969), Mallinson (1971a, b), Laurie (1978), Oliver (1979, 1980, 1984, 1985), Daniel (1980), Lahiri Choudhury (1980), Inskipp and Inskipp (1983), Singh (1984), Bell (1987), Rahmani *et al.* (1990), Sankaran and Rahmani (1990), Quershi *et al.* (1991), Ghosh (1992), Mathur *et al.* (1995), Javed (1996), Hussain (1997), and Maheshwaran (1998). Most of the recent species-oriented studies on large mammals and birds, *viz.* rhino, wild buffalo, swamp deer, and Bengal florican, highlight the distribution, status, population structure, habitat use, movement pattern and behaviour of the studied species. In many cases, findings are site specific. As the field situations are rapidly changing, constant monitoring and updating of information is mandatory to ensure conservation of such critically endangered species. There are only general accounts in these reports of the effect of grazing, grass cutting, and burning of grasslands on the species of concern. Many studies and reports advocate annual burning of grasslands, but such recommendations are not based on actual experimental studies. In general the published studies fail to provide any insight into ecological relationships and interactions among plants, wild animals, livestock, and humans.

Land Use, Resource Dependence, and Socioeconomic Studies

The entire *Terai* region is under tremendous pressure as a result of the ever increasing biomass-based demands of local people and intensive agricultural development. Even so, only a few sporadic studies have been made on changes in land use (using remote sensing) and a few preliminary assessments made of resource dependence and socioeconomic profiles of selected villages. The prominent studies are those by Parihar *et al.* (1986), Sharma (1991) and WII (1997). In addition to these research studies, the State Forest Departments recently started collecting information for all internal and peripheral villages in and around PAs, on human and livestock population resource dependence and priority village needs using rapid assessment methods such as participatory rural appraisal (PRA) and micro-planning. Visible changes are taking place in tribal and rural systems as a result of sudden and massive inputs by the tribal development agencies, intensive agricultural development, and growing market forces and ecodevelopment activities. Clearly changes in attitude, perceptions, and the overall socioeconomics can be expected as a result. These need to be quantified. Increasingly, wildlife damage problems (crop depradation, livestock predation, and human injuries) are being encountered in and around each PA. It is difficult to find any comprehensive study which addresses this priority management issue in India.

Research Issues

Wildlife or protected area management research is of comparatively recent origin in the Indian *Terai*. The majority of the past investigations and research studies have been of short duration, at the most three to four years. Likewise, the various biological surveys were mostly undertaken only once and a

considerable time has lapsed since they were completed. Thus there is no up-to-date reliable information available on trends. The main research issues are common to almost all PAs in India and have been discussed in detail by Mathur and Mathur (1998) in their report on 'Research Strategy for Protected Area Management for the India Ecodevelopment Project Sites."

The complexity of the terrain in the *Terai*, the poor field research infrastructure, and often the lack of desired management support, have seriously hampered expected research outputs. The concept of planned and coordinated, multidisciplinary research is gaining acceptance and support in other biogeographic zones in India. However, the PAs in the *Terai* region have yet to attract or implement such participatory, inter-disciplinary, and coordinated research activities, and to demonstrate their success and management utility.

Future Research Needs

The following priority research is recommended, taking into acount the existing biodiversity patterns across the Indian *Terai* and the conservation challenges posed by them, while simultaneously recognising the merits and gaps in the available research information,

Flood Plain Dynamics

The majority of PAs in the *Terai* have been affected increasingly in recent years by frequent floods, siltation, inundation, and changes in river course, all of which result in changes in grassland and vegetation succession and in the dynamics of habitat use (e.g., Mohana, Suheli, and Sharda in Dudwa Tiger Reserve; the Torsa river in Jaldapara WLS, and the Brahmaputra in Kaziranga NP). Long-term multidisciplinary studies that can assess river-flow and dynamics, vegetational changes, and the factors responsible are required as a priority to facilitate management strategies for food, cover, and water management—at least for all prominent PAs.

Grassland Experimental Studies

Over the years, a combinations of tools and methods like grass cutting, harrowing, burning, and grass planting, have been used in different PAs to maintain grassland diversity and productivity. Unfortunately, the complexities of different management inputs and their effects on species of concern and overall biodiversity are poorly understood. Experimental studies on grassland management in the Indian *Terai* have been advocated for a considerable time in a large number of past research papers and reports. Some PAs are providing intensive management inputs at a high cost with potential ecological risks involved therein. In spite of this, systematically planned long-term experimental studies are lacking. It was only two years ago that the first experimental study on grassland burning was initiated by the Wildlife Institute of India at Dudwa National Park in UP with the support of the park management. Details of this new initiative are provided in a paper by Kumar in this Proceedings. Such efforts need to be multiplied elsewhere on a long-term basis in order to avoid *ad hoc* and expensive management inputs.

Biological Surveys

Considering the *Terai* grassland diversity and prevailing biotic pressures, it is important to undertake periodic grassland surveys in order to assess the

diversity, distribution, status, and threats not only to the grasslands but also to the associated faunal species. Earlier studies by the Bombay Natural History Society (BNHS), particularly on the Bengal florican, have made a significant contribution to this. However, such efforts need to be strengthened and other endangered species or taxonomic groups addressed (e.g., hog deer, hispid hare, pigmy hog, insects, and birds).

Weed Management

In the last decade, throughout the *Terai*, a variety of terrestrial and aquatic weed plants have gregariously invaded vast areas resulting in the decline of native herbaceous vegetation and overall habitat degradation. Appropriate weed control methods are required immediately. This calls for an assessment of weed types and extent, and specific research studies addressing their control either manually or biologically—as the option of using chemical herbicides has a limited scope in a PA.

Genetic Management

Endangered species that already have a small population or are confined to one or two distant PAs, of which there are a large number, may suffer severely in the future as a result of their potentially low genetic variability and associated genetic disorders. The situation could be further aggravated if the present level of biotic pressure continues in the PAs. A recent study on rhinos in Jaldapara WLS, West Bengal, indicated a high level of homozygosity in the confined population (Ali *et al.* 1999). The genetic interaction between domestic and wild buffaloes (*Bubalus bubalis*) in Kanziranga National Park has been well documented (Mathur *et al.* 1995) and also established by preliminary DNA studies. Although wild buffalo is a species of the highest significance for conservation, much still needs to be done for its conservation in the field—genetic research and subsequent genetic management are needed to ensure the survival of this critically endangered species. While intensive grassland/habitat management is the current priority in several PAs, one can expect that genetic assessment and management of endangered species will become a necessity in the near future. Thus the species that may require such inputs need to be short-listed, selected, and studied for population genetics and genetic variability (using modern DNA technology) so as to provide timely and suitable answers to the complex management challenges while keeping the field realities and other constraints in view.

Resource Dependence and PA-People Conflicts

PAs in the Indian *Terai* are heavily exploited by resource dependent communities. Grass, timber, fuelwood, thatch, and other non-timber forest products, once extensively extracted, are either still removed in bulk legally or illegally or are suddenly not being collected at all, as a result of sudden imposition of restrictions and serious enforcement. A manager needs to understand the impact of both situations, continued biomass removal or sudden protection, on vegetation and fauna. There has been no comprehensive study addressing the issues of biomass production *vs.* consumption in terms of harvest and removal or even loss due to burning or other natural processes like herbivory. It is also necessarily to discover what effect sudden protection has on vegetation and wildlife. Research addressing alternatives to biomass-based

demands is equally important. PA interface conflict is another major issue concerning almost all managers, and it will be difficult for them to control adverse situations if appropriate research addressing park-people conflicts is not undertaken on a priority basis and such issues tackled immediately.

The Impact of Changing Scenarios, Policies, and Programmes

In recent decades, many government and non-government agencies, particularly those related to tribal and rural development, have provided multifarious inputs to villages located in and around PAs. Likewise, at several places, the Forest Department or PA management has started providing ecodevelopment inputs. Thus there is considerable implementation of new policies and programmes. Moreover, there is an increasing trend of exposure to the modern world, with changing life styles and land use patterns and new market forces, that will ultimately bring about changes in attitudes towards, and perceptions of, the protected area and overall village development. There is a need to study these emerging park-people relationships, and also to standardise the methods used to assess such changes.

Long Term Ecological Monitoring

Depending upon the management needs, available resources and staff capabilities, and infrastructure, various kinds of monitoring activities on climatic, vegetation, and animal parameters (predominantly periodic census/population estimation of large herbivores and carnivores/predators), and to some extent socioeconomic aspects, have been initiated in different PAs and continue today. In the majority of cases, however, these studies are not 'diagnostic' in nature and the managers barely benefit from the exercise. Monitoring activities are being carried out in spite of the constraints of staff time and budget for the sake of monitoring, or as a follow-up action to administrative orders. Uniyal and Mathur (1996) and Mathur and Mathur (1999) have reviewed present monitoring activities in Indian PAs and highlighted the strengths and weaknesses of such programmes. There is a need to design and develop a comprehensive and integrated long-term monitoring programme based on 'vital signs', with periodic assessment of various parameters of the population dynamics of selected taxa as described by Davis (1992). At least the prominent PAs should adopt such an approach so as to make the entire monitoring effort interesting and meaningful for PA management. This would require multidisciplinary research inputs, at least at the initial stage of developing the integrated monitoring programme. Richard (1999) strongly recommends that "all research and planning should be part of a flexible and iterative framework, where research is action oriented and designed to monitor impacts of policies and programmes in addition to monitoring bio-physical resources". This lays the basis for emphasising participatory action research (PAR) and participatory monitoring activities involving local people.

Conclusions

The significance of action-oriented research and integrated long-term monitoring programmes as integral activities of PA management cannot be over emphasised. PA managers cannot wait indefinitely for the findings of long-term research; at the same time they cannot afford to ignore the importance of such research, instead they need urgently to recognise that today's investment in

research and monitoring activities will not only help them immensely in future crises but would also help safeguard the fast depleting unique and diverse floral and faunal life in the *Terai*. In short, research, monitoring, and management need to be blended. A concerted effort needs to be ensured at all levels to implement the priority research relevant to the Indian *Terai* successfully.

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