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Contents

Call for Papers

Editorial Board

Information for contributors

Links and Resources

Contacts

Home Page

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Ecological Monitoring Design for the Conservation of Biodiversity in the Great Himalayan National Park Conservation Area, Western Himalaya

P. K. Mathur, V. P. Uniyal, B. S. Mehra and S. Pandey

P. K. Mathur (mathurpk@wii.gov.in)
Professor and Head, Department of Landscape Level Planning and Management, Wildlife Institute of India, Post Box # 18, Chandrabani, Dehra Dun – 248001, Uttaranchal, India. [http: // www.wii.gov.in]

V. P. Uniyal (uniyalvp@wii.gov.in),
Senior Lecturer, Department of Landscape Level Planning and Management, Wildlife Institute of India, Post Box # 18, Chandrabani, Dehra Dun – 248001, Uttaranchal, India. [http: // www.wii.gov.in]

B. S. Mehra (badrishm@yahoo.com)
Tiger Conservation Programe, World Wide Fund for Nature - India, 172- B, Lodhi Estate, New Delhi – 110 003

Sanjeeva Pandey (dirchnp@sancharnet.in)
Conservator of Forests and Director, Great Himalayan National Park, Shamshi, Kullu, Himachal Pradesh, India.

Abstract

PDF

India has established a network of 579 biogeographically representative wildlife protected areas (PAs) comprising National Parks and Wildlife Sanctuaries to conserve the country's rich and unique biodiversity. The paper presents an overview on research and monitoring activities to Indian PAs. Research and monitoring have been recognized as two indispensable activities to support and strengthen the PA management. But they have remained on a low priority than protection, management of endangered species and their habitats, ecodevelopment, and ecotourism even in the prominent PAs. The merits of the two broad monitoring approaches viz., traditional ”blind data gathering” and monitoring of “vital signs (selected taxa)” based on a comprehensive and integrated strategy are discussed. The later approach has been applied for the first time in India in the case of the Great Himalayan National Park Conservation Area (GHNPCA). The monitoring design developed through the cooperative effort of a multidisciplinary research team and PA staff is summarized in this paper. 57 taxa were selected for monitoring out of a known diversity of 1,551 floral and faunal species for the conservation area. Details on monitoring site, periodicity and methods employed are provided. The execution of proposed Long Term Ecological Monitoring (LTEM) programme in its totality is yet to be implemented. However, the baseline information was generated on selected taxa through concurrent multi-disciplinary research.

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Abstract

Key Words

Introduction

Research and Monitoring in Indian PAs

Study Area

Field Parameters and Methods Employed

Conclusions

Acknowledgements

References

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Introduction

Biological diversity or biodiversity is not a simple collection of species but a reference to diversity of life (Noss 1990; Wilson 1992; McNeely 1995; Baydack et al. 1999). Biodiversity on the earth is being impoverished at an alarming rate, just at the time when man needs it most for sustaining its own life (Kim and Weaver 1994; Naveh, 1995; Perrings et al. 1995; Salwasser 1995; Wood et al. 2000; Buck et al. 2001; Laird 2002). In developing countries, pressure on the biodiversity is intense, stemming from rapidly increasing human and livestock populations and diverse demands for economic growth. Thus, the reach of industrial society has extended into the most remote regions of the globe and human-induced habitat conversions and species loss are arguably at record levels (Schelhas et al. 2001). Biodiversity has emerged at the centre of one of the most contentious global debates of this century. It is now well recognised that the well-being of humans and biodiversity are more interdependent than ever before (Laird 2002). Virtually all governments, organisations, and communities have responded to this situation in several ways. Efforts for biodiversity conservation and its related research dominated in the recent activities of international organisations.

Maintaining biodiversity entails addressing resources at various hierarchical levels, including genetic, species, ecosystem and landscape (The Keystone Center 1991; Marcot 1992; Naveh 1995). With impetus of the Convention of Biological Diversity (CBD), the recent conservation policies, strategies and guidelines have emphasised the maintenance of healthy, productive and diverse ecosystems (Davey, 1999; Kumar et al. 2002).

The global or national level conservation strategies therefore, advocated for setting up a comprehensive and well-managed wildlife protected area (PA) system considering it as the most practical way to conserve the greatest amount of world's biological diversity and the ecological processes in in situ condition that define and mould it (MacKinnon et al. 1986; National Forest Policy, 1988; Rodgers and Panwar 1988; Braatz et al. 1992; IUCN, UNEP and WWF 1991; WRI, IUCN and UNEP 1992; UNCED Convention on Biological Diversity, 1992; Biodiversity Guidebook 1995). However, most PAs are like ‘islands’ as their existing boundaries do not cover the complete range of biodiversity values they seek to protect. They are also faced with the situation of reconciling resource needs of various stakeholders and resolving their conflicts. The non-compatible land uses around several of PAs also does not augur well for PA management. Miller (1999) has described seven significant obstacles that limit their capacity to meet growing demands for their full array of benefits and values. The World Bank (1996) stated that PAs can be successful in realizing their long term conservation goals only to the extent that their priorities can become integrated into large-scale land use planning activities and regulations at the local and regional levels. The PAs-and the people responsive for PAs-will have to be more flexible, more responsive and more adaptable than has sometimes been the case in the past. Protected areas need to continue to expand both physically and philosophically, and to connect with each other, the wider landscape and more generally with society and the economy (Dudley et al. 1999). Thus, in recent years several new tools and approaches have been described and efforts for biodiversity conservation have moved beyond PAs to include large human-dominated landscapes, ecoregions, and agroecosystems (Freezailah 1995; Scott et al. 1999; Soule and Terborgh 1999; Miller 1999; Mathur 2002; Mathur et al. 2002).

In India, a network of biogeographically representative PAs comprising National Parks (NPs) and Wildlife Sanctuaries (WLS) has been established (Rodgers and Panwar 1988; Kothari et al. 1989). From only 10 NPs and 127 WLS in 1970, the number of PAs had grown to 86 NPs and 480 WLS (Rodgers et al. 2000). These PAs are located in ten biogeographical zones and represent 4.66% of the country's geographical area. The wildlife law in India (Anon.1972) prohibits human settlement in PAs and allows only regulated grazing in the case of WLS. In practice this is not the ground reality, instead more than 50% of the PAs have human population within them; more than 80% of PAs have human population around them; and nearly 40% have rights and leases for their use by people in and around them. Kothari et al. (1989) in their review on the management of PAs in India have documented that only 40% of NPs and 16% of WLS have completed their legal procedures. Moreover, the Indian PAs face a variety of biotic pressures of human origin, such as poaching, illegal felling, livestock grazing, fire, collection of medicinal herbs and other non-timber forest produces (NTFPs), tourism, pilgrimage, developmental projects, etc. Occasionally prominent natural factors like floods, cyclones, droughts and avalanches also cause havoc. Such natural factors and biotic pressure are detrimental to habitat, species diversity and productivity. In order to overcome these pressures, management of the PAs is required and authorities need to undertake different measures to protect the area; which might include habitat restoration and improvement including plantations, weed control, soil and moisture conservation, water development, prescribed burning; management of rare and endangered species and also management of tourism and pilgrimage. Different levels of management input, in both quantity and quality, are being provided in the different PAs across the country. A beginning has also been made by selected PAs in initiating ecodevelopment activities for reducing the adverse impact of resource dependent people on PAs and vice-versa.

Research and monitoring has been recognised as two indispensable arms, which support and strengthen the management of PAs (MacKinnon et al. 1986; Goldsmith 1991; Spellerberg 1991; Mathur and Mathur 1995). Monitoring and research improve understanding of issues and the development of strategies relevant to PA management and the interactions between the PA and people. Monitoring has been considered as an essential component of any viable strategy to conserve biological diversity because it provides a basis to track the status of various components of biodiversity over time in the context of different management regimes (Common and Norton 1995). Research and monitoring outputs enhance the information base, assist in redefining PA objectives, prioritising management issues and evolving appropriate strategies. Thus, a well-planned, coordinated, research and effective monitoring programme in PAs become imperative for sound management.

Research and Monitoring in Indian PAs - An Overview

It is not intended here to present an exhaustive review of research and monitoring activities in Indian PAs. However, it is considered worthwhile to present an overview on research and monitoring inputs received by Indian PAs, their implications on PA management, constraints and future needs. In general, wildlife research and monitoring activities have lagged behind in the Indian PAs than other activities undertaken by the management of PAs like protection measures, management of species and their habitats, nature education, ecodevelopment, and ecoturism. Until the 1970s, organised wildlife research in India was dominated by ornithological studies (Panwar and Mathur 1993; Mathur and Mathur 1998). Likewise, little attention was paid to create a systematic database of biological resources and management of PAs (Mathur and Mathur 2000). A large number of PAs lack basic inventories or even check lists of different taxonomic groups (Mathur and Mathur 1998; Anon. 2002). Wherever they exist, they need updating and confirmation. On one hand PA-wise inventories on invertebrates, particularly insects, amphibians, reptiles and smaller mammals in a majority of the cases neither exist nor do the current trends indicate their likely availability in the near future. On the other hand, the vastness of the country, rich diversity and inadequate resources poses a great challenge.

Except for large mammals, and to some extent avifauna, existing information on distribution, abundance and status of other taxonomic groups is inadequate. Among plants, much published work deals with timber species or trees in general. Check lists of lower plants, orchids, herbs, shrubs and grasses are needed on a priority in almost all cases. It is only during the last two-three decades that biological and ecological researches on large herbivores and carnivores have been undertaken by various national and state level institutions and some individuals (Joslin 1973; Berwick 1976; Martin 1977; Panwar 1979; Johnsingh 1982; Newton 1984; Kumar 1987; Sinha 1986; Khan et al. 1990; Karanth and Sunquist 1992; Mathur et al. 1995; Sathyakumar 1994: Sankar 1994; Chellam and Johnsingh 1994; Sinha and Sawarkar 1991; Chundawat 1992; Hussain 1993; Ranjitsinh 1989; Gupta and Kumar 1994; Gopal 1995; Rahmani 1996; Bhatnagar 1997; Pandav 2000; Johnsingh and Joshua 1994; Sukumar 1994; Chowdhury et al. 1997. Only a few multidisciplinary, integrated research studies addressing different ecosystems, habitats and associated floral and faunal species, and also interactions among them have been undertaken (WII 1999a; WII 1999b; Mathur et al. 2002 and Kumar et al. 2002). The main thrust until recently has remained on "species oriented" and biological research. A shift towards applied or management oriented and interdisciplinary studies, including socio-economic component, is being advocated in many forums in order to meet the growing challenges (Panwar and Mathur, 1993; Mathur and Mathur 1998; Anon. 2002). One early example of this was the overview on research and monitoring in Tiger Reserves has been provided by Saharia et al. (1979) while Kothari et al. (1989) reviewed the status of research and monitoring in Indian PAs. A review of wildlife research in different States of India carried out in 1994 highlighted gaps in available information and priority research required (Anon. 1994). Mathur and Mathur (1998) reviewed research undertaken in seven India Ecodevelopment Project PA sites. Mathur (2000) reviewed research and monitoring in Indian Terai and recommended for multi-disciplinary and experimental research.

The main challenge for scientists and field practitioners lies in planning and conduct of research studies that use an integrated approach towards natural resource management, while keeping in view the multiple objectives and needs of biomass-dependent people. Like research, different forms and varying levels of monitoring activity can also be observed in different PAs. Monitoring activities mainly carried out by the PA staff can be summarised under the following broad six categories.

(a) Monitoring of large mammals. This is the oldest activity in Indian PAs. Almost all PAs undertake population estimation on periodic basis for select carnivores, primates and ungulates. In some cases, past trends are being maintained on the basis of management units i.e. compartment, block or range. Different methods are being employed (Sale and Berkmuller 1988; Rodgers 1991). Often doubts regarding the accuracy, reliability and robustness of field methods and data collected are being raised (Karanth 1987, 1995; Karanth and Nichols1998). Development of site specific field methods, requisite staff training, data analysis and interpretation of findings are some of the important aspects those need urgent attention and strengthening.

(b) Monitoring ecological changes. A special programme on vegetation monitoring and monitoring changes in prey abundance of the tiger was recommended for implementation in all Tiger Reserves (Sykes and Horrill 1977; Lowe 1977). Only two Tiger Reserves, namely Kanha TR and Melghat TR were successful in implementation of this programme. Problems on account of lack of trained staff, identification of plant species, tedious work, data analysis, etc. have been experienced by concerned PA authorities and probably for these reasons other Tiger Reserves (>25) have been reluctant in implementing this. Sykes and Horrill (1977) suggested periodic measurements on all tree, shrub, herb and grass species occurring in three nested marked plots of size viz., 100mx100m; 10mx10m; and 2mx2m, respectively for recording vegetation and successional changes irrespective of the indicator taxon or selected species ('vital signs') as recommended by Noss (1990), Davis (1992) and Hilty and Merenlender (2000).

(c) Meteorological monitoring. Only a few PAs have established meteorological stations and possess information on past climatic trends (Singh and Kamboj 1996). Lack of required number of representative field stations, adequacy of various parameters studied, seriousness of data collection, analysis and lack of interpretation are some of the factors those have undermined the significance of meteorological information in PA management.

(d) Monitoring of visitors. Wildlife tourists, pilgrims, pastoralists, herb collectors and other forest dependent people visit PAs. Only in the recent past a few PAs have started keeping data on such visitations. However, information greatly lack on the items and quantity of forest produce harvested and taken away by the resource dependent population.

(e) Monitoring of livestock grazing. Small number of PAs collects information on resident and migratory cattle visiting the PAs, cattle transit camps, season and time spent (Mehra and Mathur 2001).

(f) Socio-economic monitoring. Socio-economic monitoring in and around PAs is an activity of recent years. The ecodevelopment schemes are being formulated and implemented. Thus, desired information on demography, resource dependency, etc. is being collected in villages those are within the PA or in its surround. Efforts in this direction need strengthening.

In addition to the above, occasional periodic monitoring activities are also being carried out by interested individuals or scientific groups, for examplethe monitoring of ungulates and pheasants in the Great Himalayan National Park by Gaston and Garson (1992)and the monitoring of water birds in Pong dam reservoir (Pandey 1993; Directory of Indian Wetlands 1993). However, such attempts are sporadic and often inadequately documented.

The above overview reveals that research and monitoring activities have remained on a lower priority even in the prominent Tiger Reserves and other PAs of the country. Noss (1990) has correctly remarked that, "Monitoring has not been a glamorous activity in science, in part because it has been perceived as blind data gathering (which, in some cases, it has been). The kinds of questions that a scientist asks when initiating a research project about causes and effects, probabilities, interactions, and alternative hypotheses-are not commonly asked by workers initiating a monitoring project". It is therefore, evident that the research and monitoring activities are yet to be integrated and geared to pressing requirements of sound PA management.

Ecological Monitoring - An Integrated Strategy

Clearly, monitoring is an essential and integral component of any move to PA management and sustainability because it provides a basis to track fluctuations in stocks and, thereby, evaluate the utility of the regimes adopted for conserving biodiversity (Perrings et al. 1995). PA managers while realising dynamic and complex nature of ecosystems are expected to know: "How healthy are ecosystems?" (Davis 1992). Maintaining healthy ecosystems is a prerequisite for conserving biodiversity (Hilty and Merenlender 2000; Danielsen et al. 2000). The goal of monitoring ecosystem health is to identify chemical, physical, and/or biological changes due to human impacts (Hughes et al. 1992). The term ecosystem health been described and debated in the literature (Jamieson 1995; Lackey 1995; Rapport 1995a; Wicklum and Davies 1995; Callicott and Mumford 1997; Hilty and Merenlender 2000; Danielsen et al. 2000). While some condone complete abdication of the term, ecosystem health remains a widely used concept and several reviewed papers used the term (Hilty and Merenlender 2000). Rapport (1995a,b) defined ecosystem health as the absence of signs of ecosystem distress, an ecosystem's ability to recover with speed and completeness (resilience), and/or lack of risks or threats pressuring the ecosystem composition, structure, and/or function. Often PA managers confront with the following set of problems relevant to the monitoring.

What, Where, When, and How to Monitor?

These are the most difficult and crucial aspects of monitoring. At least two approaches exist in this regard: (i) firstly, periodical `blind' or `total' data gathering on each and every species or element of habitat those are occurring on a fixed, permanent transect, plot, etc., subsequent data analysis and infer what has happened to species richness, diversity, productivity, succession, etc., and (ii) secondly, based on the preliminary knowledge of the study area, selected taxa are identified as "indicator" or "vital signs" for monitoring. The complexity of dynamic ecosystems has forced conservation biologists to develop alternative methods to monitor change that would be too costly or difficult to measure directly (Gerrodette 1987 and 1991; Landres et al. 1988; Kremen et al. 1994; Meffe and Carroll 1997; Vora 1997; Pollisco-Botengan 1997; Margules et al. 1998; Fuller 1998; Dudley et al. 1999; Hilty and Merenlender 2000; Danielsen et al. 2000). Davis (1992) has suggested an analogy between physicians and ecosystem managers. Accordingly "PA managers are essentially family physicians for natural areas. They monitor ecological health to identify impaired natural area resources. A natural resource monitoring programme should provide the same kind of information to ecosystem manager that health monitoring provides to physicians. It should show current health and predict future conditions." Like a physician know what vital signs to monitor in a patient, a PA manager can find parameters that can serve as ecological "vital sign" and define the limits of their normal variation in ecosystems. Further, the measure of population dynamics of selected taxa offer a good solution to monitoring the biological elements of natural area ecosystems.

Parameters of populations such as abundance, distribution, age, structure, reproductive effort, and growth are relatively easy to measure. Many of them are sensitive to subtle, chronic stress, and permit projection of future conditions. This approach is also sensitive to a wide variety of environmental conditions because organism integrates the effects of influence like predation, competition, and pollution. They express their response to these influences as easily measured population parameters. Hilty and Merenlender (2000) have reviewed the criteria for selecting indicator taxa, step-wise process for selection of indicator taxa, and to test the criteria against the indicator taxa that are currently being used to monitor ecosystem health. The review findings revealed that the ambiguous selection criteria and the use of inappropriate taxa have brought the utility of indicator taxa under question. Few vertebrate taxa fulfil multiple criteria, as most are highly generalist that lack established tolerance levels and correlation with ecosystem changes. Most suggested invertebrate taxa also lack correlation to ecosystem changes, but satisfied other selection criteria. The review demonstrated that there is an ample scope for improvement in selecting both vertebrate and invertebrate taxa that better satisfy the criteria put forth in the conservation science literature for identifying useful indicator taxa. Often criteria for selection of indicator taxa are unclear and conflicting in several cases. Using clear and objective selection of indicator taxa was recommended as one way to enhance the utility of indicator taxa. Davis (1992) suggested a criteria for selecting "indicator species or vital signs" or taxa those are: (i) exceptionally common or dominate entire community, (ii) with special status (endangered, rare, keystone, etc.), (iii) endemic or exotic, (iv) harvested, and (v) popularly recognised as heroic species (flagship sp.) for monitoring.

Monitoring Constraints and Success

A successful monitoring programme requires simplicity, reliability, accuracy and repeatability. For continuity on a long term basis it is imperative that monitoring protocols along with details of species to be monitored; location of plots, transects, seasons, methods, measuring frequency and interval, data analysis are well defined and documented. Trained field staff and even in some cases help of specialised technical personnel from nearby universities or scientific institutions are also needed. The overall success largely depends on the available infrastructure, manpower, financial resources and ultimate utility of monitoring findings in the day-to-day management. Hinds (1984) observed that successful monitoring programmes must be ecologically relevant, statistically credible, and cost effective. Caughlan and Oakley (2001) have reviewed the cost considerations for long term ecological monitoring so as to provide a general framework to the designers and managers for building and operating a cost-effective programme. Realistic expectations of costs and benefits will help ensure that monitoring programmes survive the early, turbulent stages of development and challenges posed by fluctuating budgets during implementation. The existing programmes often suffer from one or the combination of problems: (i) blind or total data gathering process, irrespective of well defined objectives and hypotheses; (ii) highly technical nature and difficult to be implemented by PA frontline staff, particularly those are untrained; (iii) inadequate infrastructure, support, proper documentation; (iv) lack of integration - isolated component wise monitoring; and (v) a lower priority received. Danielsen et al. (2000) reports that the achievements of initiatives to strengthen biodiversity conservation in developing countries is often difficult to assess, since most countries have no system for monitoring biodiversity. They have devised a simple system for monitoring biodiversity in protected areas of a developing country and based on lessons learned from PAs in Philippines feel that whilst the monitoring system aims to identify trends in biodiversity and its uses so as to guide management action, it also promotes the participation of local people in management. In addition, it seeks to provide with direction regarding the aims of PAs, and reinforces the consolidation of existing livelihoods through strengthening community-based resource management.

Study Area (GHNPCA) – Location, Diversity, Dependence and Field Realities

Location

The present ecological monitoring design was developed for the Great Himalayan National Park (GHNP), and its surrounds. Hereafter, named as the GHNP Conservation Area (GHNPCA). The GHNPCA represents the Biogeographic zone : 2A North-West Himalaya (Rodgers and Panwar, 1988). The GHNPCA constitutes a large contiguous PA network with the adjacent PAs viz., the Pin Valley NP in the east; Rupibhaba WLS in the south- east; Khirganga Protected Forest and Kanawar WLS in the north-west. The GHNPCA in continuation with other adjacent PAs thus becomes an area of high conservation importance. The GHNPCA is located in Kullu District of Himachal Pradesh (Figure 1), covering a total area of 1,171 sq km and comprising GHNP (754.4 sq km), Sainj WLS (90 sq km), Tirthan WLS (61 sq km) and an Ecodevelopment Zone (265.6 sq km). The study area is characterised by high ridges, deep gorges and precipitous cliffs, craggy rocks, glaciers and narrow valleys; and includes the catchment areas of the Tirthan, Sainj, Jiwa and Parvati rivers which together form the upper catchment of the major river, the River Beas. Much of the eastern part of the GHNPCA is perpetually snow covered. The area exhibits an altitudinal variation from 1,300m to 6,110m.

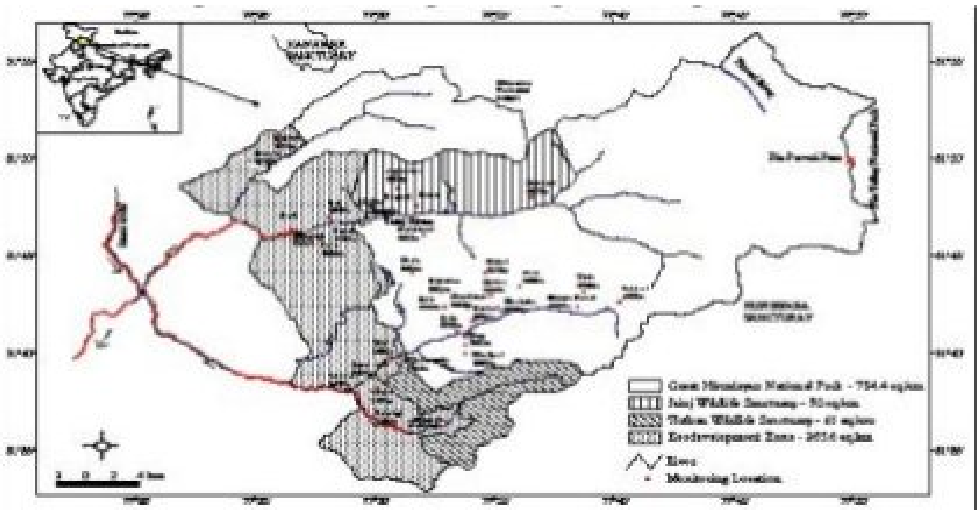

Figure 1: GHNPCA with Long Term Ecological Monitoring Locations

Diversity and Resource Dependence

The GHNPCA due to its typical topography, altitudinal variation, multiple aspect, extreme climatic conditions, past management and resource use pattern provide a diversity of landforms, habitats, floral and faunal species. The preliminary information on the history of the area, legal status, floral and faunal diversity, management history, resource dependence, etc. have been made available by Gaston et al. (1981), Sharma (1987), Singh et al. (1990), Gaston and Garson (1992), Mehta et al. (1993), and IIPA 1995. Negi (1996), Mathur and Naithani (1999), Singh and Rawat (1999), Tandon (1997), DeCoursey (1998), Sharma (1998), Upreti (1999), Garson (1998), Ramesh et al. (1999), Vinod and Sathyakumar; (1999), Dutta (1999), Julka (1999), Uniyal and Mathur (1998), Tucker (1997), Baviskar (1998), Nangia et al. (1999); Kumar et al. (1999), Pandey (1997); Pandey and Wells (1997); Pabla (1996); Mathur and Mehra (1999); Richard (1999); Gaston (1998); and Chauhan (1999) have provided detailed account on the floral and faunal diversity, socio-economic conditions, life style, historic development and man-wildlife conflict. Hence, just an overview on biological diversity and ecological significance in GHNPCA is presented below:

More than 375 faunal species representing 31 mammals, 181 birds, 3 reptiles, 9 amphibians, 11 annelids, 17 molluscs and 127 insects belonging to six orders have been identified and documented so far. Prominent mammalian species of the landscape are: blue sheep (Pseudois nayaur), Himalayan brown bear (Ursus arctos), Himalayan black bear (Ursus thibetanus), snow leopard (Uncia uncia), Himalayan tahr (Hemitragus jemlahicus), musk deer (Moschus chrysogaster), serow (Nemorhaedus sumatraensis), rhesus macaque (Macaca mulatta), langur (Presbytis entellus), barking deer (Muntiacus muntjak), and goral (Nemorhaedus goral). The endangered pheasants are western tragopan (Tragopan melanocephalus), cheer pheasant (Catreus wallichii) and monal (Lophophorus impejanus). Floral diversity representing 69 trees species, 113 shrubs, 493 herbs, 28 climbers, 6 parasites, 96 grasses and sedges, 27 ferns, 192 lichens and about 150 species of bryophytes have been identified and documented.

There are 127 village hamlets with an estimated 1,362 families with a population of about 14,000 living in the ecodevelopment (buffer) zone of GHNPCA. The main occupation is agriculture along with horticulture. However, rearing sheep and goat is an age-old profession and thus pastoralism based on transhumance is the second main occupation. The extraction of medicinal plants and mushrooms are means of secondary income and in some cases may even contribute about 70% of the total income. Horticulture is becoming more popular in the area and orchards of apples, plums, walnuts, cherries, etc. are being developed while crops like maize, wheat and barely are generally cultivated.

The main pressure on different forests and alpine pastures in the GHNPCA are in the form of illegal collection of medicinal herbs and edible mushrooms, grazing of sheep and goat, collection of fodder, fuel wood, non timber forest produces (NTFP), and religious activities. Summer grazing in the alpine pastures influences the short-lived vegetation. About 30,000 sheep and goat are dependent on alpine pastures in the GHNPCA (Mathur and Mehra 1999). In recent years, collection of herbs and edible mushroom has become a major activity. Thousands of people are engaged in this process and they collect more than 60 different species including those are already listed in the IUCN Red Data Book and several of them face local extinction. The mushroom (Morchella esculenta) and its allies are also collected during February to May in the lower elevations and about 1,200 people scan the forest floor (Singh and Rawat 1999) for this purpose.

Prior to the final notification of GHNPCA in May 1999, fodder collection in three PAs has been usual practice. People thus loped trees of Quercus leucotrichophora, Q. floribunda, and Q. semecarpifolia during winter months. Besides Quercus species, grass was also harvested and stored for stall feeding during winter. The other species, which were collected for fodder, are Morus serrata, Celtis tetrandra, Acer sp., and Corylus sp. Some shrubs (Indigofera sp., Desmodium sp.) and bamboo species viz., Thamnocalamus spathiflorus and Arundinaria falcata were also collected. Collection of non-timber forest produces including honey, bamboo, nuts and fruits, leaves of Rhododendron anthopogon and bark of Taxus wallichiana and Betula utilis was made for sustenance use. The villagers also collected fuelwood throughout the year except during January – February but the herb collectors and graziers those visited alpine pastures generally used the sub-alpine species of Quercus semecarpifolia, Betula utilis, Rhododendron campanulatum, and the alpine Juniperus communis and Rhododendron anthopogon as fuelwood. These extraction and collection activities in GHNP were curved subsequent to the notification. However, these activities are now being legally allowed only in two other Pas.

Field Realities

The Director, GHNP, Kullu presently manages the three PAs and also implements various activities of village ecodevelopment, mass awareness campaign and research and monitoring activities. Before providing details on the design and development of the monitoring programme, it is worthwhile to highlight the field situation, accessibility and feasibility constraints in the GHNPCA. A great altitudinal variation, severity of weather conditions, lack of road network, etc. make study area inhospitable. Only narrow bridle paths exist on selected high altitude tracks, otherwise in most of the cases one has to find trails created by migrating livestock, particularly sheep and goat. Usually remote, higher elevation areas are accessible only for 6-7 months during April to October/November. It is therefore imperative to highlight these constraints on the account of inaccessibility, inadequate camping and other field logistics those would otherwise greatly influence any prospective monitoring programme.

The Approach

The main present effort was to consult available literature on the subject and to gain an insight of various methods being used world-wide for the Long Term Ecological Monitoring (LTEM) Programme, their strengths, weaknesses and constraints. An overview of the monitoring activities in different Indian PAs has already been provided. Considering the highlighted field constraints and availability of one of the appropriate examples of a comprehensive, integrated, well documented, and successful monitoring system adopted by the Channel Islands National Park (CINP), Ventura, California, USA, it was decided to use this particular approach for the development of monitoring design in the case of GHNPCA (Davis 1989).

The present output on design forms a part of the cooperative effort of a multi-disciplinary research team engaged in the GHNPCA during 1995-1999 under an externally funded research project. The technical report by Mathur and Uniyal (1999) in this regard makes the basis of this paper.

The expertise available through the multi-disciplinary team concurrent to the present study was extensively consulted and involved in the entire process. Field Workshop approach specifically on the design and development of LTEM was the main feature. The PA staff, consultants, resource persons, researchers, NGOs, local people and other stakeholders were part of this exercise. Thus, the process was highly participatory.

Using the criteria suggested by Davis (1989), an exercise on short-listing of species among different taxonomic groups was undertaken. The Workshop participants and subject specialists constituted smaller groups and based on intensive deliberations, short lists for each taxonomic group were prepared. Out of 1,551 plant and animal species documented for the GHNPCA, altogether 57 taxa representing 10 tree, 10 shrub, 13 herb, 4 mammal, 3 bird, 7 annelid and 10 insect were short listed (Table 1). This constitutes 3.67% of the total floral and faunal species reported so far.

Table 1 - Selected Taxa and Month-wise Monitoring Calendar

Concurrent intensive studies on vegetation, faunal species and specific reports on monitoring such as `Monitoring Handbooks' by Singh and Rawat (1998), Vinod and Sathyakumar (1998), Ramesh et al. (1998), Uniyal and Mathur (1998) and Naithani and Mathur (1998) formed the basis for recommended protocols in each case. Intensive studies also facilitated the identification of appropriate field methods, locations for monitoring, parameters to be assessed and their periodicity.

Monitoring Design

The following sections provide details on the proposed sites, methodology and periodicity for monitoring. The developed design in its totality needs to be executed. However, concurrent multi-disciplinary research team could collect the baseline information on selected taxa during 1998-99 while involving the PA staff. Thus, the recommended design has been validated to a greater extent and baseline information generated.

Monitoring sites

In all, 35 sites in three sub-watersheds viz., Tirthan SWS, Sainj SWS, and Jiwa SWS were included for monitoring various taxa. A list of these monitoring sites along with details on altitude, aspect, and distribution in various administrative constituents of the GHNPCA are provided in Table 2.

Table 2 - Monitoring Sites in the GHNPCA

Figure 1 gives the spatial locations of 35 monitoring sites. Out of this, 40% of the sites were located in the National Park (GHNP) and 17% in two sanctuaries. Considering the greater extent and diversity of temperate forests in ecodevelopment zone and also the bulk of human pressure, 43% of the monitoring sites were located in the ecodevelopment zone. Furthermore, the majority (68% or 24 sites) of the sites were located on the south aspect. This is mainly due to the preponderance of different vegetation communities or diverse floral and faunal occurrence. 21 sites (or 60%) of the sites were located in Tirthan SWS while 34% sites were in Sainj SWS. Sites were proportionately distributed across different altitudinal range. Details about the specific locations for monitoring have been provided at each site, along with a description of taxa (Mathur and Uniyal, 1999).

Field Parameters and Methods Employed

Vegetation Monitoring: Out of 1,174 plant species reported from different altitudinal zones of the GHNPCA, 33 plant species (10 tree, 10 shrub and 13 herb) were selected for monitoring on the basis of their economic importance, conservation significance and threats to survival. The following methods were adopted for monitoring of selected taxa:

I. Tree species

Circular plots of 12.61 m radius (500 m2) was adopted for the monitoring of ten tree species in each of the marked monitoring sites. Number of individuals, GBH (Girth at breast height), height, seedlings, saplings, girdled, lopped and cut individuals of each species were recorded.

II. Shrub species

Plots of 5.65 m radius (100 m2) were adopted for the monitoring of selected shrub species. Counting of individuals, signs of cut or uprooted shrubs, new shoots and phenology of the monitoring species were recorded.

III. Herb species

Square plots of 1mx1m in marked sites were adopted for assessment on herb species. Number of individuals, uprooting signs, cover percentage and phenology of monitoring species were the studied parameters.

Monitoring of Pheasant: Out of the five reported species of pheasants, three pheasants viz., Himalayan monal (Lophophorus impejanus), western tragopan (Tragopan melanocephalus) and koklass (Pucrasia macrolopha) were selected for monitoring. These pheasants required specific techniques for monitoring owing to their elusive and sulking behaviour (Gaston 1980). The following methods were used for their monitoring:

I. Encounter Rate

This method involved walking on selected trails and counting of pheasants on both the side of the trail. Encounter rate is expressed as ER = n/L, where n = Number of groups or individuals seen and L = Distance covered.

II. Call Count
Western tragopan and koklass are elusive in nature and are often found in thick undergrowth of forests that make direct sightings difficult. Counting of calls of the pheasants give useful index of the population in the area. The call count method recorded call of pheasants from a fixed radius plot laid all along the trail or from selected vantage points.

Monitoring of Mammals: Thirty-one mammalian species were included in the monitoring programme. Following methods were used for monitoring of these mammals.

I. Direct and Indirect Sightings
This technique involved recording of presence or absence of monitoring species based on the direct sightings, indirect evidences such as pellets, scats, tracks, scrapes, hoof marks, etc.

II. Encounter Rate
Encounter rate (ER) is a simple expression of number of animals encountered per unit effort. ER can be based on direct sightings or indirect evidences such as pellet group and other signs and could be expressed as number/km walk.

III. Scanning
This technique involved careful scanning of habitats of interest for a fixed time with a binocular or spotting scope from a ventage point. In the GHNPCA, goral (Nemorhaedus goral), Himalayan tahr (Hemitragus jemlahicus), blue sheep (Pseudois nayaur) were effectively monitored by scanning. The results usually expressed in number of animals seen/scan, number of animals seen/km2 or number of animals seen/hour of scan.

IV. Silent Drive Count
It is a kind of block drive population estimate within the habitat of musk deer (Moschus chrysogaster). A base line was identified and 10 persons (Beaters) were spaced at interval of 30 to 50 m. Three to five persons (observers) were placed above vantage point to record the animal which might have got flushed undetected. The beaters were asked to move quickly through the patch at a fixed time and record all the animals sighted. Data on species time, number, sex, location, activity and direction of movement were recorded.

V. Line transect Sampling
This method was used for monitoring of goral which involved walking along the monitoring trails and counting of animals sighted on both sides of the trail.

Monitoring of Annelids: Annelids constitute a major component of soil invertebrates. Out of 14 species of annelida (11 earthworms and 3 leeches) those were recorded in the GHNPCA, 7 species (Plutellus sp. nov.1, Plutellus sp. nov.2, Allolobophora parva, Aporrectodea caliginosa, Aporrectodea trapezoides, Dendrodrillus rubidus and Octolasion tyrtaeum) were selected for monitoring. Following methods were employed for their monitoring.

I. Digging of soil
Seven species of earthworms were monitored by a simple process of digging top layer of soil with the help of a shovel or any other similar equipment from diverse habitats with some moisture, i.e. litter in broad leaved and coniferous forests, under stones and decaying logs, mosses on wet rocks, top soil and sub-soil, cow dung, cultivated land, roadside clearings and nurseries. Colour, and number of individuals were recorded

in the monitoring locations.

Monitoring of Insects: Selected insect species were monitored in early hours of the day because most of the beetles and butterflies are usually active at early sunrise and it is easy to observe them. Methods viz., hand picking and aerial netting were used.

Periodicity
Monitoring periodicity for monitoring of 57 selected taxa varied from fortnightly to 5-yearly based on the nature of taxa, its status and requirement (Table 3). Accordingly, only 10 tree species are required to be monitored at an interval of every 5 years. The majority of selected taxa (i.e. 42 or 73.6%) are required to be monitored annually. Two taxa viz., Musk deer and Himalayan tahr, were recommended to be monitored bi-annually. Three taxa included for fortnightly monitoring were three pheasants.

Table 3 - Monitoring Periodicity of Selected Taxa

Periodicity	5 - Yearly	Annually	Bi-annually	Fortnightly	Total
No. of Taxa to be monitored	10	42	2	3	57

Monitoring Calendar
Month-wise plan for monitoring of 57 taxa is presented in Table 1. Most species would require monitoring either in April-May or August-September. The monitoring report by Mathur and Uniyal(1999) contains a description of each selected taxa and illustrative plates for identification purpose.

Execution and Baseline Information
Concurrent multi-disciplinary research and monitoring studies in the GHNPCA and their outputs as detailed assessment reports on vegetation, livestock grazing, pheasants, ungulates, annelids, insects, and socio-economics made the foundation for the present monitoring design. Exclusive execution of the developed monitoring design in its entirety is yet to be accomplished. However, simultaneous study reports provide baseline data on selected floral and faunal taxa duly analysed and interpreted site, vegetation, PA, sub-watershed, and disturbance zone wise. Singh and Rawat (1998; 1999) provide baseline information on vegetation by forest/community wise. Mathur and Mehra (1999) also collected field data on selected 32 floral species for monitoring while assessing impact of grazing by migratory livestock. Thus, they provided baseline information on all the selected taxa under the four categories viz., Village Surrounds (VS), Migratory Routes (MR), Transitory Forest Camping Sites (TFCS), and Alpine Pastures (AP). Baseline information on density and abundance for select 10 tree species revealed that majority of the selected tree species occurred in low abundance, except in the case of Quercus semecarpifolia and Cedrus deodara (Table 4). The values for lopped trees at six monitoring sites ranged from 12.8% to 26.3%, the minimum in the case of Shilt while maximum at Kharongcha (Table 5). Density and abundance values for selected seven shrub species are given in Table 6. The values of percentage frequency of occurrence of herb – Polygonum polystachym varied from 9.0% (Bheemdwari) to 17.7% (Gumtarao). Higher values of herb density and abundance at Gumtarao indicated higher pressure of livestock grazing (Table 7).

Baseline information on density estimate (#/km2) for selected three ungulates and encounter rate estimate (#/km walk) for three pheasant species based on studies by Vinod and Sathyakumar (1999) and Ramesh *et al.* (1999) are presented in Table 8 and Table 9, respectively.

Conclusions

Almost three years have passed after the multi-disciplinary research team left the GHNPCA on completion of this major project. The period of their leaving coincided with the issuance of the final government notification of the national park that curbed the traditional practices viz., grazing by migratory livestock, and collection of forest resources including medicinal herbs in GHNP area over night. This sudden development led to a disturbed environment owing to hardships faced by the local people and conflict with the park management. However, conditions have gradually improved and by and large the local people have realised the implications of sudden notification and adjusted with the compelled situation. Under these circumstances, it is more pertinent to make use of the present LTEM programme and institutionalise the entire process.

The baseline information generated will help in detecting the changes taking places due to the abrupt closure of livestock grazing, collection of medicinal herbs and ban on entry by people in the largest constituent area i.e. the national park on one hand. While on the other hand, recommended monitoring will allow a greater understanding of the negative effect of overburdening of limited resources in two other PAs and the ecodevelopment zone. Despite the initial conflict between the PA and local people, in recent years the park management and local people are now working together on various ecodevelopment activities. It seems that with a little more effort by the management and the associated scientific community, it would be possible to involve the local people in implementation of the long term ecological monitoring design and it will ultimately become a highly successful, fully participatory programme. There are at present only a handful examples of LTEM worldwide and several programmes have suffered on the account of various reasons as discussed above. In this case, proper and participatory execution of the proposed LTEM is called for.

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