



The Terai Arc Landscape in India

Securing Protected Areas in the
Face of Global Change



Report by : Rajeev L. Semwal

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Foreword

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The Terai-Duar Savanna Ecoregion is spread over the southern slopes of the Himalayas in India, Nepal, Bhutan and Bangladesh. The Terai Arc Landscape (TAL) lies within this ecoregion covering an area of approximately 49,500 sq km in India and Nepal stretching from the Bagmati River in the East to the Yamuna River in the west. There are 13 existing Protected Areas (PAs) that fall within this landscape and the TAL is the best surviving remnant of the once extensive alluvial grassland and forest ecosystems in the ecoregion. The landscape is also home to some of Asia's largest and most well-known wildlife such as tigers, elephants and rhinos along with a large variety of other rare, endangered and endemic wildlife species.

The TAL in India covers an area of approximately 30,000 sq. km across the states of Uttaranchal, Uttar Pradesh and Bihar. The area within TAL that is covered by forests is roughly 15,000 sq. km. The TAL consists of the Shivalik hills, the adjoining *bhabhar* areas and the *terai* plains. These three strata are in the form of narrow strips running parallel south of the main Himalaya. Less than 50 years ago, the TAL was a contiguous expanse of dense forests and tall grasses. The land use now varies between patches of forest in various conditions (including 9 PAs), agricultural fields, urban settlements, as well as an infrastructure network. The PAs are mainly just isolated refuges and do not currently provide the connectivity required for key wildlife species to maintain their natural ecology and behaviour, and for important ecosystem processes to be sustained. The biological vision for the TAL therefore, is to restore and maintain habitat connectivity in this landscape.

This study, which focuses on key global change phenomena affecting the TAL has identified two specific biophysical factors for analysis: increasing habitat fragmentation and proliferation of invasive species. Based on existing scientific information, management plan of the PAs, working plans of the reserve forests as well as direct interaction with various stakeholders, the report builds a framework for understanding these issues in the context of the West-Central TAL. It outlines some of the underlying drivers leading to these global change factors as well as discussing ongoing and potential responses to address these. This important study should contribute a great deal towards ongoing efforts in developing an integrated conservation and development approach for the TAL in India.

Dr. Sejal Worah
Programme Director
WWF-India

Background

The present short-term study is based on the secondary information pooled from various published sources (scientific papers, reports, articles, management plans of Protected Areas and working plans of Managed Forests) as well as those collected during interactions with the stakeholders. Most of the facts described in the present report are well known yet an attempt has been made to bring together the available information on the Global Change Factors, i.e. Habitat Fragmentation and Invasive Species impacting the PAs and corridors in the west and the central parts of the Terai Arc Landscape. The document still requires more information, inputs from the stakeholders and also rigorous analysis. Nevertheless, it is hoped that it will help the concerned agencies and individuals in prioritizing the immediate actions and future strategies to manage the biodiversity of this globally important landscape.

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**Forests & Biodiversity Conservation Team
WWF-India**

Introduction

India is one of the twelve-mega biodiversity countries recognized throughout the world and harbours two of the 25 identified global 'hotspots' of biodiversity - the eastern Himalaya and the Western Ghats. The country holds 8.1% of the world's total biodiversity. The rich biodiversity of India, to a great extent, owes its existence to the age old cultural values of the society, wherein, protection of the various life forms was emphasized by creating *Abhayaranya* (Sanctuaries) as mentioned in Kautilya's *Arthashastra* (the old Indian Sanskrit classic on governance written as far back as 4th century BC). The presence of many Sacred Groves throughout the country, surviving even today, validates the rich cultural heritage and environmental prudence of the Indian society. However, in recent times, when population is increasing at an alarming pace, socio-economic aspirations are changing and consumerism is growing, conservation requirements are bound to change to face the new challenges.

India is divided into ten bio-geographic zones namely the Trans-Himalayan, the Himalayan, the Indian deserts, the semi-arid areas, the Western Ghats, the Deccan peninsula, the Gangetic plain, north-east India, the islands and coasts (Figure 1).

Nearly 45,000 plant species are found in the country, of these, 15,000 are flowering plant species and some 33% of them are endemic. Similarly, faunal species also exhibit a great degree of diversity. A total of 81,250 faunal species comprising 372 mammals, 1228 birds, 2546 fishes, 446 reptiles, 204 amphibians and remaining invertebrates including protozoa, insects, mollusks, crustaceans, etc. have been recorded from the country (Ministry of Environment and Forests (MoEF), 1999). To protect and manage this diversity, a huge network of the PAs comprising 89 National Parks and 482 Sanctuaries has been created mostly during the last three decades. The PAs currently cover more than 8 million ha, which is about 5% of the country's total geographic area, and about 14% of the forest area. (WII, 2000).

1.1. National Environmental Policy and Legal Framework

India is unique in having legislation for forest management since the 19th century. The first organized scientific approach to managing forests in India was initiated way back in 1861 during the Colonial rule. The Government Forest Department was established in 1865 (Forest Research Institute

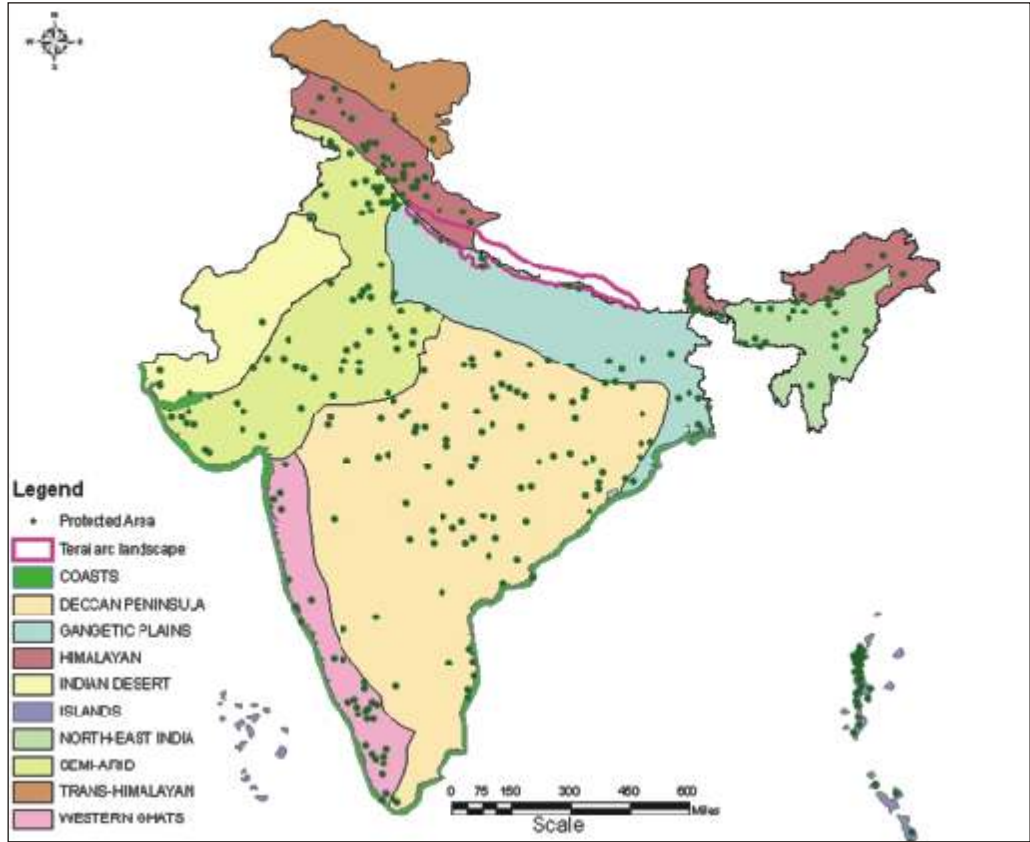


Figure 1

Bio-geographic zones in India with Protected Areas

Prepared by IGCDC Division, WWF-India, 2005 Based on WII, 2000

(FRI), 1961). The first Forest Policy of 1894 as well as the second National Forest Policy, formulated few years after independence, in 1952 did not put much value to wildlife conservation or the ecological significance of the forest ecosystems. For almost a century and until 1988, the policy was to use forestland for commercial purposes, and look upon the people as a liability. Forest management strategies were distinctly in favour of commercial and industrial exploitation, with little attention paid to sustainability or equity and to social justice. Paradigm shifts in the policy took place in 1988 when the planners acknowledged the need for involving local communities in protection, regeneration and management of the forests taking into account that over 100 million forest dwellers live in and around forests and another 275 million are substantially dependent on them for their livelihoods (Lynch, 1992).

Initially, when the Indian Constitution came into effect in 1950, little attention was given to detail out environment protection. However, in the next few decades the expanding awareness among the people led to certain aspects related to environment protection being incorporated in the constitutional framework. In 1976, protection of forests and wildlife found a place in the Directive Principles of the State Policy, the Fundamental Duties and in the Concurrent List. Article 21 of the Constitution dealing with 'the Right to Life' has served the cause of environmental protection in India significantly through jurisprudence (Singh, 2002).

The present Indian Forest Act was formulated in 1927 during the colonial rule itself. After independence in 1947, according to the new constitution, forests and wildlife were placed under the state list wherein the state legislatures had the primary right to make laws (Seventh Schedule of the Constitution, List-II, entries 19 and 20). Later, in 1976, these (forests and wildlife protection) were added to the Concurrent List of the Constitution giving the Central and State governments shared responsibility on the forest and wildlife related matters (presently the Central Government does have the power to make laws on forestry issues but only after due consultation with the State Governments). Almost all forest land (76.53 million ha) is under government control, which is about 23% of the country's geographical area (MoEF, 2002). An important dimension was added to forest conservation in the form of the

Forest Conservation Act, 1980, to regulate the diversion of forestland for non-forest purposes. The National Environmental Protection Act, 1986 (Environment Impact Assessment Notification, 1994), makes it mandatory to seek environmental clearance for infrastructural development. The recently passed Biological Diversity Act, 2002 provides for conservation of biological diversity, sustainable use of its components and equitable sharing of benefits arising out of the use of biological resources including agrobiodiversity.

Though a robust mechanism to involve communities in the protection and management of forests and wildlife is still to be found, the process has begun in the form of Joint Forest Management (JFM) in Managed Forest (MF) areas, and the Ecodevelopment Programme in the PAs. Village Forest Protection Committees (VFPCs), under JFM, and Eco Development Committees (EDCs), under the Ecodevelopment Programme, have been formed at the village level. The experiment is little over a decade old and has so far shown mixed results throughout the country. Successful examples of achieving community development on the one hand and biodiversity conservation on the other are still difficult to find.

1.2. Forest and Wildlife Management

Working plans have been governing the management of forests in India since the 1870s (FRI, 1961). The first attempt to bring wildlife management under an explicit wildlife plan materialized in 1972 when it was made compulsory for the tiger reserves established under Project Tiger in 1973.

It is interesting to mention here that unlike the working plans (Mathur, 1982), there was no set of laws that could be followed by wildlife planners until the WII published a manual for the purpose in 1995. The manual addresses the management of wildlife in PAs and in Managed Forests (MFs) outside the PAs (Sawarkar, 1995).

1.3. The Protected Areas (PAs) System

The Wildlife (Protection) Act (WLPA), 1972, consents to the creation of three categories of PAs viz., Wildlife Sanctuaries (section 18 to 34A), National Park (section 35), and Closed Areas (now repealed by Act 16 of 2003) until the recent amendment in 2002. Chapter IV (section 18 to 38) of the WLPA, 1972, apart from the creation of Wildlife Sanctuaries (WLSs) and National Parks (NPs) also deals with creating two more categories of PAs, namely, Conservation Reserves and Community Reserves (Wildlife Protection Act, 1972 amendment, 2002, section 36A to 36D). Most of the rules and regulations applicable in case of WLSs are also applied to these new PA entities while giving more representation to local communities in management. The former (Conservation Reserve) is created on government forestland, preferably linking two important areas/PAs, and the latter (Community Reserve) could be declared on community land or private land where a community or an individual voluntarily comes forward to conserve wildlife and its habitat.

It should not take more than two years to complete the formalities to declare a potential area of adequate ecological, faunal, floral, geomorphological and natural significance as a PA. According to this, the State Government may, by notification, declare its intention to constitute any area other than area comprised within any reserve forest or the territorial waters as a Sanctuary. Several legal steps have to be followed before a WLS/NP is finally notified. Legal procedures are considered completed for a sanctuary if all the rights and leases had been settled, either under the 1972 Act, or any other previous Act under which the sanctuary was declared and no final notification was required. However, for a National Park, the completion of procedures was achieved only when the final notification was issued. According to amendments in the WLPA in 1991, procedures for setting up a WLS have been outlined which are similar to that of a National Park. However, the District Collector, in consultation with the Chief Wildlife Warden (CWLW), can permit the continuance of any rights of persons in and over the land falling within the limits of a Sanctuary (section 24 (2) c of WLPA). The WLPA, after the 1991 amendment, has

exempted areas (for creating a PA) that are already Reserve Forests (RFs) as according to the Forest Act, 1927, while bringing in any forest under the RF category, settling of rights has to be carried out before declaring the area as RF.

The PA network in India is helping to conserve the rich biodiversity of the country in all the 10 bio-geographic regions. This is in spite of the fact that over 65% of the PAs are under the direct influence of human population in terms of settlements and resource use. Until 1970, the total number of PAs in the country was merely 65 comprising 6 NPs and 59 WLSs. The number increased, as mentioned above, to 571 by 2000 (WII, 2000). A majority of the NPs in the country are divided into a core zone and a tangential buffer zone, which can be either a WLS or a RF. Regulated resource use in the PAs has been restricted to the buffer zones while core areas are completely closed. There exist some non-formal entities like Biosphere Reserves, Tiger Reserves and Elephant Reserves in the country to effectively protect and manage the wildlife and the habitats following the Landscape approach.

1.4. The Institutional Structure

The highest authority dealing with wildlife conservation in the country is the Union Ministry for Environment and Forests (MoEF). A minister in charge heads the ministry who is supported by a secretary, and an Additional Director General of Forests (Wildlife). The Additional Director General is the highest wildlife official in the country. The Central Government, for the purpose of this act, appoints a Director of Wildlife Preservation and other officers and employees as may be necessary. In the states, the Forest Department is headed by the Principal Chief Conservator of Forests (PCCF). The PCCF is assisted by a number of Chief Conservator of Forests (CCFs). The CCF (Wildlife), also designated as the Chief Wildlife Warden (CWLW), heads the Wildlife Wing and is assisted by the Conservator of Forests (CFs), the Deputy Conservators of Forests (DCFs), and the Assistant Conservators of Forests (ACFs), in charge of Wildlife Circles, Divisions, and Subdivisions, respectively. The front-line or ground staff consists of ACFs, Rangers, Foresters, Forest Guards, and other designations, which differ from state to state (Kutty and Kothari, 2001). An Honorary Wildlife

Warden, who represents the civil society of the concerned locality in wildlife management and protection, is also appointed. With the commencement of the Wildlife (Protection) Amendment Act, 2002, (Chapter II, Section 5A-8) the Central and State Governments have to constitute a National and State Board, respectively, for Wildlife wherein the Prime Minister and the Chief Minister are the Chairpersons at the National and State levels, respectively. The functions of the abovementioned boards are to take every possible measure to promote the conservation and development of wildlife and forests in the country.

1.5. The Terai Arc Landscape (TAL)

1.5.1. Ecological Context

The Terai-Duar Savanna Ecoregion is spread over the southern slope of the Himalaya spreading across India, Nepal, Bhutan and Bangladesh. In India and Nepal, the ecoregion is represented by the TAL, a green necklace around the foothills of the Himalaya along the border of the two countries from the river Bagmati in the east to the Yamuna in the west. The total area of the landscape is about 49,500 sq. km of which 30,000 sq. km lies in India. The TAL is the best surviving remnant of the once extensive alluvial grassland and forest ecosystems in the ecoregion. This is an important

Forest view of the Shivalik-Bhabar tract in CNP



Tall grasses are the characteristic feature of the natural ecosystems of terai



national, regional and global centre of biodiversity.

There are 13 PAs in the entire TAL, from the eastern most Parsa Wildlife Reserve in Nepal to the Rajaji National Park in India in the west, catering to the need for protection of 3 of the 5 terrestrial flagship species viz., the tiger (*Panthera tigris*), the Asian elephant (*Elephas maximus*) and the Greater one-horned rhinoceros (*Rhinoceros unicornis*). The TAL harbours one of the highest tiger densities in India.

In India, the landscape represents the upper Gangetic plain biogeographic zone and the vegetation is mainly tropical moist and dry deciduous type. It is spread over two distinct physiographic zones viz., Shivalik-bhabar on the one hand, characterized by hilly terrain with coarse soil and boulders with relatively drier conditions in the western side, and on the other the *terai* (the Gangetic Plains) zone characterized by fine alluvium and clay rich swamps with a shallow water table in the eastern side. As described by Johnsingh *et al.* (2004) the TAL includes 23% closed forest, 7% open forest and 0.4% scrubland. There are 17 forest patches of size more than 100 sq. km; forming 90% of the landscape, most of the patches are less than 5 sq. km in extent particularly in the eastern portion of the landscape. Thus, the landscape is highly fragmented, particularly in the eastern part beyond Katarniaghat WLS (Figure 2).

In the west the Shivalik-bhabar portion of the landscape is composed of sal (*Shorea robusta*) mixed and miscellaneous vegetation and *terai* is dominated by a variety of tall grasslands and sal forests representing the central and eastern portions of the landscape. The forests of the TAL are made up of many economically important species such as *Shorea robusta*, *Dalbergia sissoo*, *Terminalia tomentosa*, and *Acacia catechu* with other associated tree species like *Butea monosperma*, *Bombax ceiba*, *Sterculia urens*, *Aegle marmelos*, *Terminalia alata*, *T. arjuna*, *Adina cordifolia*, *Syzygium cumini*, *Azadirachta indica*,

Reintroduced population of Rhinoceros in DNP

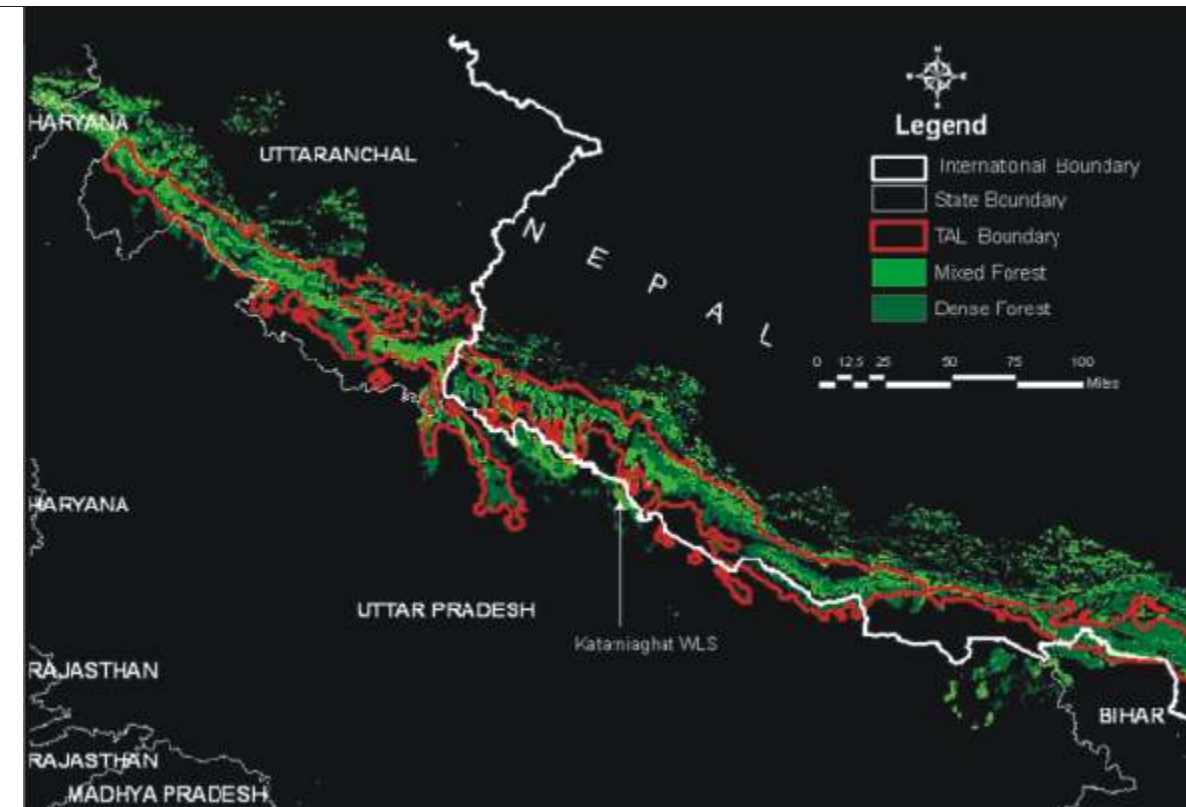


Figure 2

Forest Boundaries in TAL

Prepared by: IGCMC Division, WWF-India, 2005
Data Source: WII, Maps

Mallotus philippensis, and *Lagerstroemia parviflora*. Tall grasses like *Themeda*, *Saccharum*, *Phragmites*, *Vetiveria* and several others also characterize the *terai* portion of the landscape. Though the vegetation structure is highly heterogeneous throughout the landscape it could roughly be classified under eight types of homogenous communities. Champion and Seth (1968) identified twenty seven types and sub-types of vegetation based on their association with soil and rainfall in the Indian side of the landscape. Sal (*Shorea robusta*) dominated and mixed forests cover 25% of the forests. The other prominent tree species in this landscape are *Mallotus philippensis*, and *Syzygium cumini*. Plantations of economically important trees like Teak, Shishoo, Eucalyptus, Acacia, Poplar, etc. cover a sizeable area of the landscape where about 250 sq. km is under monoculture plantation of the three species viz., *Acacia catechu*, *Dalbergia sissoo* and *Syzygium cumini*. Among shrubs *Murraya koenigii* is the most ubiquitous species in the landscape. Once famous for its extensive tallest grasslands across the globe, the landscape now has only less than 500 sq. km of such grasslands left and that too in a highly fragmented state (Johnsingh *et al.*, 2004).

1.5.2. Scientific Information

Scientific studies on the PAs of the landscape on the Indian side are sporadic and scanty, carried out generally by individuals or organizations driven by their own or donors' priorities. Large flagship species have been the focus of research and management including swamp deer (Holloway, 1973; Schaaf and Singh, 1976; Sale, 1986; Sale and Singh, 1987; Singh, 1971, 1978, 1982, 1984,

1993; Sankaran, 1990; Qureshi *et al.*, 1991a, b; Bhaduarua and Singh, 1994; Sunderraj *et al.*, 1995; Javed, 1996; Sawarkar, 2000; De, 2001; Mathur, 2000; Williams *et al.*, 2001; Johnsingh *et al.*, 1990; Joshua and Johnsingh, 1995; Johnsingh and Negi, 2003; Johnsingh *et al.*, 2004). Some of the other important studies on various aspects in TAL are Singh (1982), Chaturvedi and Mishra (1985), Rodgers *et al.* (1990), Rawat *et al.* (1997) on grasslands; Singh *et al.* (1995), Agni *et al.* (2000), Pandey and Shukla (2003), Rawat and Bhainsora (1999) on woody vegetation; Pant and Chavan (2000) on vegetation mapping in Corbett National Park; Kumar *et al.* (2002) on a variety of ecological aspects including grassland management in Central TAL; Rahmani *et al.* (1989) on Bengal florican; Javed *et al.* (1999) on Swamp francolin; Naoroji (1999) on Raptors; Pandey *et al.* (1994) on the birds of Rajaji National Park; Panwar (1985) and Tilak and Sinha (1987) on the conservation issues, and Khati (1993), Sharma (1995) and Badola (1998) on sociological aspects of some of the PAs of TAL. More problem solving researches are required for the better management of the PAs and corridors in the landscape to cope with the global change factors such as habitat fragmentation and biological invasion.

1.5.3. Socio-economic Context

The Indian side of the TAL has a complex history of human settlement and land use by the communities. About 70% area of the landscape is under direct human use for agriculture and settlements. Over the last two centuries, and even at present, high population growth and associated agricultural expansion and changing



A highway passing through a forest, near CTR



Irrigation canal inside forests fragments the habitat



Uncontrolled grazing degrading the forests of North Kheri FD

socio-economic aspirations are some of the crucial challenges that impinge on the forest management in the landscape (Johnsingh *et. al.*, 2004). The incredible population increase of 130% from 1881 to 1981 and the associated infrastructural development such as road and rail network and irrigation and hydroelectric projects have put terrific pressure on the forests of this area. The TAL is among the most densely populated areas of the country. The average population density (543 individuals/sq. km) is far higher than the national average (323 individuals/sq. km). At present, the total population of the landscape is about 23 million. During the last two decades (1981-2001), the population has increased by an unusual 54.19%, which is 9% above the national average. Weaker sections of the society comprise 23% of the population and 67% livelihood earning means are dependent on the surrounding natural resources. In spite of being a highly fertile land, less than 10% households could avail the alternatives of fuels such as LPG, coal and kerosene across the TAL (Johnsingh *et. al.*, 2004).

Among the local communities, the Tharus are the oldest tribal inhabitants living in Baharaich, Gonda, Gorakhpur and Kheri districts of UP, Nainital district of Uttaranchal, and West Champaran district of Bihar. The Tharus practice settled agriculture and also inhabit the other side of the international border in Nepal. In the western part of the landscape, i.e. in Uttaranchal, the pastoral Gujjars rear a large number of livestock, mostly buffaloes, for milk production. Selling milk and milk products in the nearby market centres is the way of earning subsistence for this community. There are about 2346 families of Gujjars inhabiting this part of the landscape with over 19,000 buffaloes (Anonymous, Forest Department Report, Uttaranchal). The Oraons, the tribal group in Gorakhpur and West Champaran districts practice settled agriculture and also work as wage labourers. There is yet another group of people called the Taungyas who were engaged in timber (sal) plantations in forests and in lieu were allowed to grow crops within forest areas. This agroforestry system is widely known as Taungya cultivation introduced by the British. Across the TAL, there are a number of unsettled Taungya villages within forests as the practice is no more in vogue. In addition to the aforementioned groups, refugees from Bangladesh

settled here in large numbers during early 1970s. Over the last four decades, people from adjacent mountain areas, farmers from Punjab and the prosperous Rai Sikh community have also constituted a sizable part of the population among migrants who settled in the west and central parts of the TAL (Johnsingh *et. al.*, 2004).

Owing to high soil fertility, replenished naturally by the sediments brought down by numerous rivers originating in the Himalaya, intensive agriculture is practiced by a large number of people inhabiting the landscape. The exponential growth in population coupled with in migration, the Indian side of the TAL witnessed a large-scale conversion of forestland for agriculture, settlements and infrastructure development in the recent past. Illegal encroachment of forest tracts by migrant labourers is also common. Notwithstanding its richness of natural resources, poverty is rampant in the TAL and, therefore, a sizeable section of the society is heavily dependent on the forests for fuel wood, fodder, timber, and NTFPs, apart from being used as grazing grounds for a large number of livestock. All these factors, along with some others like forest fires, illegal logging, floods, and proliferation of invasive alien as well as native unpalatable species, are causing degradation of corridors in the TAL. Degrading corridors, widespread poaching and killing of wildlife during conflicts are detrimental for the long-term survival of the mega species in the landscape.

1.5.4. The Protected Areas of TAL India

The entire stretch of the landscape is a little over 800 km in length and 50-60 km in width in which the nine PAs (four NPs and the remaining five WLSs) are located. The landscape in India is

People in TAL, heavily dependent on forests for fuel wood



mainly spread over three states viz., Uttaranchal, Uttar Pradesh (UP) and Bihar from west to east. But Johnsingh *et. al.* (2004) have also included Kalesar WLS in the state of Haryana and Simbalbara WLS in the Himachal Pradesh state located on the west bank of the Yamuna in the landscape based on the tiger movement in these areas. There are three Tiger Reserves viz., Corbett (Corbett NP, Sonanadi WLS and the RFs in the buffer zone); Dudhwa (Dudhwa NP, Kishanpur WLS, Katarniaghat WLS and the RFs in the buffer zones); and Valmiki (Valmiki NP and Valmiki WLS) in the landscape. In addition, the Shivalik Elephant Reserve (SER) covering the Rajaji NP (RNP), the Sonanadi WLS, the Corbett NP (CNP) and spreading partly/fully into 13 Reserved Forest Divisions including 43 forest ranges has also been declared in 2002 in the western part of the landscape. The CNP, created on 8 August 1936 in the foothills of Nainital and Pauri districts of Uttaranchal, is the first National Park in India. This is also the site for the launch of the Project Tiger in the country. The IUCN commission on National Parks and PAs held its 25th working session in CNP in 1986 to draw an action plan for PAs of the Indo-Malayan region. This plan is known as the Corbett Action Plan (Anonymous, 1999). The one hundred tigers in the CNP in 1997 constitute one of the largest populations of tiger anywhere in the world. This population, together with the tigers found in RNP, represents the north-western most limit of tiger distribution in the Indian subcontinent and the oriental realm and also that of the Asiatic elephants. The PAs also provide protection not only to the prey species like swamp deer, barking deer, spotted deer, wild boar and other ungulates but are also important for other endangered species like the hispid hare, Bengal florican, to name a few.

The Dudhwa NP (DNP) and the Kishanpur WLS were brought under the Project Tiger Scheme in 1987-88. The DNP (490 sq. km), the Kishanpur WLS (204 sq. km) and the Katarniaghat WLS (400 sq. km) constitute the PA cluster of the Dudhwa Tiger Reserve (DTR) in the central part of the TAL. These PAs fall within the Biogeographic Province 07A, the Upper Gangetic Plain. They represent 12 major vegetation communities and contain at least 24 plant species of conservation importance. The endangered species of animals include 12 mammal, 29 bird, and 5 reptile species. The DNP has a reintroduced population of *Rhinoceros unicornis* and Katarniaghat is contiguous with the Royal Bardia National Park in



Jharital area in Kishanpur WLS still supports a sizeable population of endangered Swamp Deer

Nepal and harbours a sizeable population of Gangetic dolphins and two species of fresh water crocodiles known as the Ghariyal and the Maggar. The DTR supports the single largest viable population of swamp deer on the Indian side of the Terai. Some small populations have also been reported from the Pilibhit Forest Division. Table 1 depicts some of the general characteristics of the PAs while Table 2 shows the general features of the non-formal PA entities i.e. Tiger and Elephant Reserves in TAL.

Table 1
General Characteristics of the PAs on the Indian side of the TAL

Name of the PA	Location	Area in ha	Year of Notification	Forest Type	Geomorphology	Focus Species
Rajaji National Park	Dehradun, Haridwar and Pauri Districts of Uttaranchal	82042	1983	Broad leaf dry and moist Deciduous, southern slopes are rich in bamboo	Shivaliks and tracts of Bhabar	Elephant
Sonanadi WLS	Pauri District of Uttaranchal	30100	1987	Broad leaf deciduous and semi evergreen	Shivaliks and tracts of Bhabar	Elephant and Tiger
Corbett National Park	Nainital and Pauri Districts of Uttaranchal	52082	1936	Broad leaf Moist Deciduous, Dry Deciduous	Shivaliks and tracts of Bhabar	Elephant and Tiger
Kishanpur WLS	Gola Tehsil of Lakhimpur Kheri, and Powayan Tehsil of Shahjahanpur, Districts, UP	20341	1972	Broad leaf Moist Deciduous and Semi-evergreen	Terai flood plains	Tiger and Swamp Deer
Dudhwa National Park	Nighasen Tehsil of Lakhimpur Kheri District of UP	49029	1977	Broad leaf Moist Deciduous and Semi-evergreen	Terai flood plains	Tiger and Swamp Deer
Katarniaghat WLS	Nanpara Tehsil, Baharaich District of UP	40009	1976	Broad leaf Moist Deciduous and Semi-evergreen, Canebrake	Terai flood plains	Tiger, Ghariyal (<i>Gavialis gangeticus</i>), Gangetic Dolphin and Otter
Suhelwa WLS	Balrampur and Shravasti Districts of UP	45247	1988	Broad leaf Moist Deciduous and Semi-evergreen	Shivalik, Bhabar and Terai flood plains	Tiger
Sohagibarwa WLS	Maharajganj and Deoraia Districts of UP	42820	1987	Broad leaf Moist Deciduous and Semi-evergreen, Canebrake and Swamp Forests	Terai flood plains	Tiger, Leopard and other prey species
Valmiki National Park and Valmiki Sanctuary	West Champaran District of Bihar	88078	1990	Broad leaf Moist Deciduous and Semi-evergreen	Shivalik and Dun	Tiger

Table 2
General Characteristics of non formal PA entities in the TAL

Name of the PA entity	Area (sq. km.)	Year of Declaration	PAs and Managed FDs
Corbett Tiger Reserve	1286	1973*	CNP, Sonanadi WLS, and buffer carved out from Kalagarh, Ramnagar and Terai west FDs.
Dudhwa Tiger Reserve	1362	1987**	DNP, Kishanpur WLS, Buffer zone from North and South Kheri FDs and Katarniaghat extension.
Valmiki Tiger Reserve	840	1994	Valmiki WLS and Valmiki NP.
Shivalik Elephant Reserve	5405	2002	RNP, CTR, and FDs (Partly/Fully) namely Kalsi, Dehradun, Haridwar, Narendranagar, Lansdowne, Ramnagar, Terai west, Terai central, Terai east, Haldwani and Champawat.

* From 1973 to 1991 the CNP and CTR were synonymous having the same area 520.82 sq. km. In 1991, parts of Kalagarh, Ramnagar and Terai west FDs were added as the buffer zone making the present area of the reserve.

**The Katarniaghat extension has recently (1999-2000) been brought under the DTR increasing the area from 884 sq. km to 1362 sq. km.



The Learning Site - West-Central TAL India

Of the entire Indian portion of the TAL, the west-central stretch between the Rajaji NP (RNP) and Katarniaghat WLS has been identified for detailed analyses. The selection of the learning site has been made on the basis of WWF-India's interventions and presence in the area since 1997 owing to its immense wildlife significance in two distinct physiographic zones, i.e. the Shivalik-Bhabar and the Gangetic Plain (Terai), respectively, representing west and central portions of the TAL.

The selected area in the landscape encompasses six PAs (RNP, Sonanadi WLS, CNP, Kishanpur WLS, DNP and Katarniaghat WLS) and many Reserve FDs acting partly/fully as corridors between 29° 56' to 27° 55' N and 78° 01'15" to 81° 25' E. The total area of this stretch is roughly about 8500 sq. km of which 32% is under the above mentioned PAs. In addition, if the area under the Elephant Reserve (SER) and Tiger Reserves (Corbett and Dudhwa) is also taken into account, then around 80% of this section of the TAL is currently under formal (PAs) and informal (Tiger and Elephant Reserves)

protection regimes and therefore shows its conservation importance.

Though the WWF is working in the landscape since 1997, its role has been mainly to facilitate PA managers in the protection of wildlife by providing some crucial infrastructural support to the PAs. However, WWF-India has been coordinating bigger TAL programmes aimed at the long-term conservation of the West-Central TAL - a fertile, diverse and resilient area, since 2003. Under the programme, a framework for implementing conservation activities during the next 3 years (2004-2007) has been developed, following a number of detailed discussions among the important stakeholders (the Forest Department, Research Institutions and NGOs). Based on the above discussions, four critical sites have been identified between the RNP and the Katarniaghat WLS for immediate action during the first phase of the programme implementation to protect and manage the mega species along with their habitats in the landscape (Figure 3 & 4).

PAs, Critical Sites and Forest Boundaries in TAL

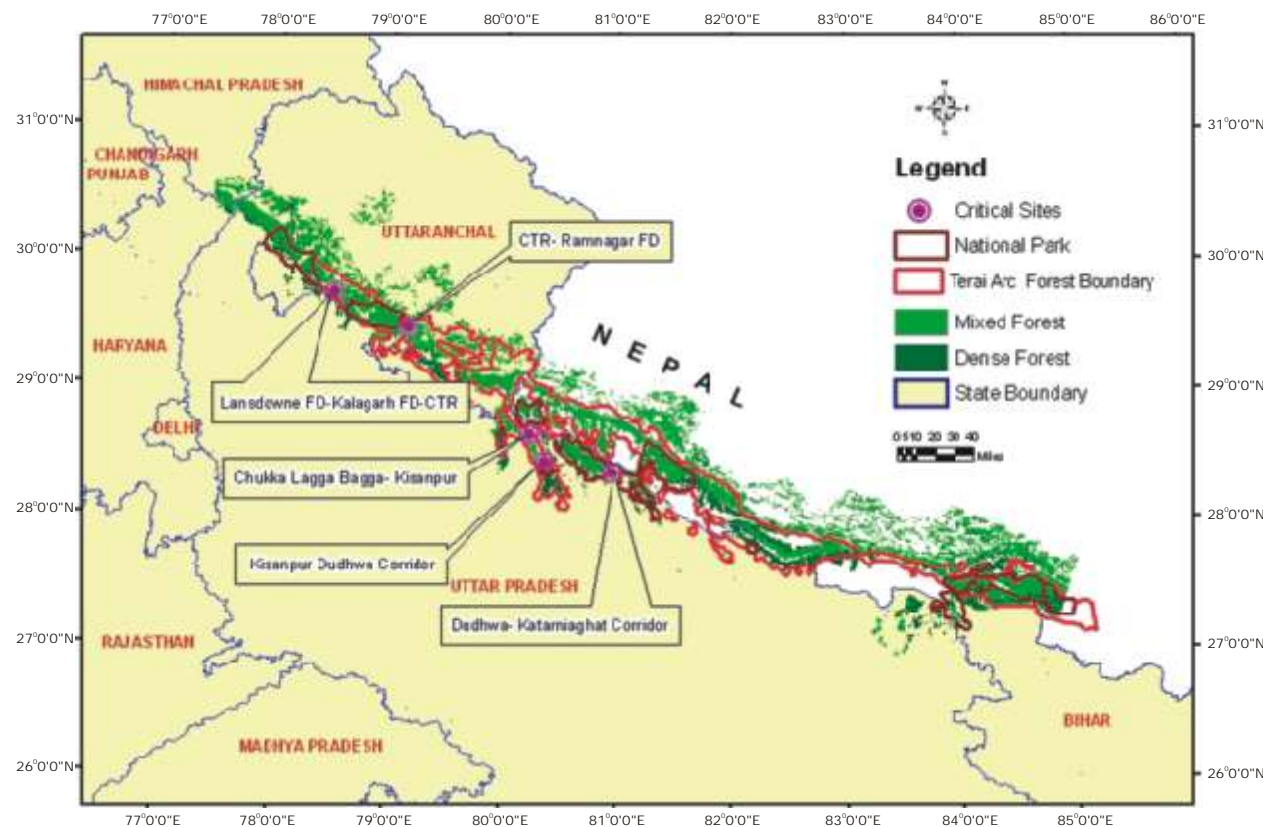


Figure 3

Prepared by: IGCMC Division, WWF-India, 2005 Data Source: WII, Maps

Study Area and Critical Sites (Rajaji NP to Katarniaghat WLS)

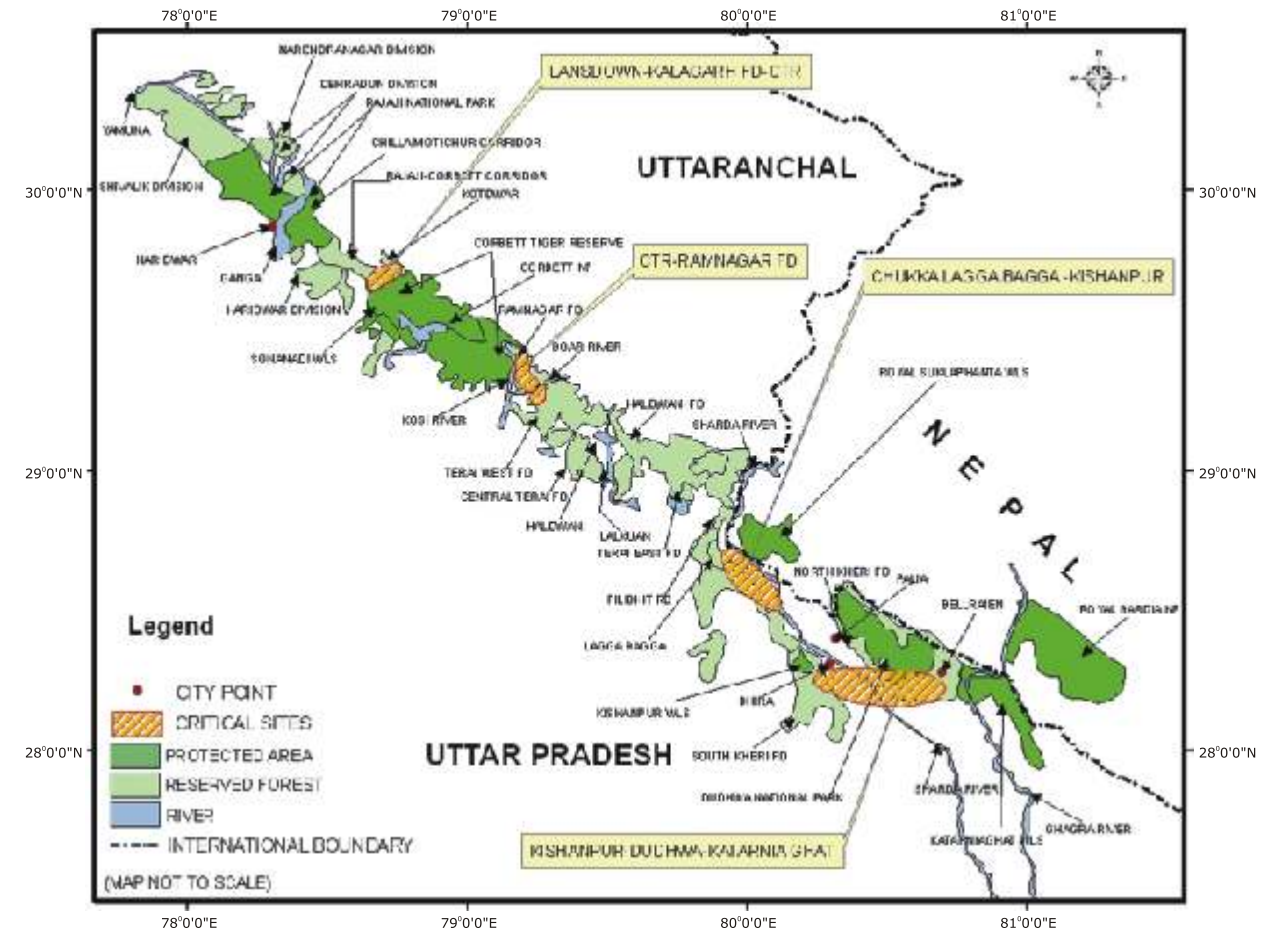


Figure 4

Map prepared by IGCMC, WWF-India Based on Johnsingh and Negi, 2003 and Johnsingh et. al., 2004 (Map Not to Scale)

The identified corridors are:
 Lansdowne FD - Kalagarh FD-CTR
 CTR - Ramnagar FD
 Chukka-Lagga Bagga-Kishanpur WLS
 Kishanpur WLS-DNP-Katarniaghat WLS.

2.1. Rajaji NP-Sonanadi WLS-Corbett NP, nearby Reserved Forests and Corridors (Western TAL)

During the present study the key stakeholders (PA managers including frontline staff, territorial forest staff, researchers, NGOs and local communities) were consulted individually or in small groups across the abovementioned stretch between the RNP and Katarniaghat WLS. The abovementioned critical sites where WWF-India is currently implementing the various conservation measures represent some of the important corridors suggested by Johnsingh et. al. (2004) (Please see Annexure - 8.2).

The learning site, as described above, could be categorized into two broad site complexes (PAs, RFs, Critical Sites and Corridors) representing western and central TAL located in Uttaranchal and Uttar Pradesh states, respectively (Figure 4). The general characteristics of these two site complexes are described below.

The elephant population in RNP, Sonanadi WLS, CNP and adjoining areas forms 90% of the 750 elephants in the north west of India in this Shivalik-Bhabar physiographic zone (Johnsingh and Joshua, 1994). This is one of the five major elephant populations of the country. The RNP-CNP Tiger Conservation Unit is one of the 11 Level-I Tiger Conservation Units (TCU) identified in the Indian subcontinent for the long-term conservation of the Tigers (Dinerstien et. al., 1997). This, TCU of about 7,500 sq. km stretches from the Yamuna River in the west to the Sharda River in the east. About 30% of this TCU comes under PA network (RNP-820 sq. km and CTR-1286 sq. km comprising 521 sq. km CNP, 302 sq. km Sonanadi WLS and 463 sq. km buffer area carved out from Kalagarh, Ramnagar and Terai west FDs) and the rest are under 12 RFs from west to east. The RFs are Shivalik, Dehradun, Narendranagar, Haridwar, Lansdowne, Bijnor, Terai west, Ramnagar, Terai central, Haldwani, south Pithoragarh and Terai east. Apart from the 520 sq. km core area of the

CNP which is free from human disturbance, the rest of the area is subjected to various types of pressures for fuel wood, fodder collection and grazing both from the Gujjar community living inside the forests and the villages located at the periphery of the PAs (Johnsingh and Negi, 2003).

Many of the reserved FDs in the area such as Haridwar (part), Bijnor, Terai west, Terai central and Terai east consist of large-scale plantations (e.g., *Eucalyptus spp.*, *Ailanthus excelsa*, *Populus ciliata*, *Acacia catechu*, *Dalbergia sissoo*, *Tectona grandis*) which were raised in the 1960s to meet the industrial needs, at the cost of the natural mixed forests and grasslands. Due to fragmentation of habitats, three secluded populations of tiger occur in the area described above. According to Johnsingh and Negi (2003) the ever increasing biotic pressure rendering the Rajaji-Corbett corridor poor in tiger population and may further fragment the habitat which was an unbroken stretch of approx. 300 km long sal dominated (*Shorea robusta*) forest just three decades ago.

Over the years, the increasing human population and its demand for more land for agriculture and various development-related infrastructural projects have broken the forest connectivity at several locations along the west bank of the river Ganga and along the Kathgodam-Haldwani-Lalkuan Highway. The high day and night vehicular traffic and human settlements along the various highways passing through this section of the landscape are a constant threat to wild animals (Johnsingh and Negi, 2003). In the RNP at present over 10,000 cattle heads belonging to the Gujjars, the Taungiya and the Gothiyas, and about 50,000 livestock of the local people use the PA daily. The density of cattle population is 77.41 cattle/sq. km. As much as 86% of the park area is open to the Gujjars for lopping and grazing (Pandey, 2001).

Corbett NP

Around the CNP, the construction of the 80 sq. km Ramganga reservoir, and the Kalagarh township and encroachment in the early 1970s have broken down the wildlife habitat connectivity between the CNP and the south-western part of the Tiger Reserve. The Gujjar settlements along with their buffaloes in large numbers are spread across the elephant range except in the CNP. Besides, the growing population of the nearby villages and townships also puts additional pressure on the

elephant habitat for resources. A study of the four villages near the Rajaji-Corbett corridor reveals that the forests of the corridor cater to 95% of the fuel wood needs of the villagers besides fodder requirement (Badola and Mishra, unpublished data as quoted by Johnsingh and Joshua, 1994).

Sonanadi WLS

The Sonanadi WLS extending to 302 sq. km area is one of the prime habitats of elephants in the landscape and also called a Tiger Nursery. This sensitive area is also not free from human disturbances. Though relocation is being proposed, about 184 Gujjar households were recorded living inside the sanctuary.



Buffaloes of the Gujjars, near RNP

Important Reserved FDs

Lansdowne, Ramnagar, Haldwani, Terai west, Terai central and Terai east are the important RFs in this stretch of the study site. Large-scale commercial plantations raised during the 1960s have been responsible for the habitat degradation and weed infestation in this area. However, now these FDs being the part (partly/fully) of the SER, the commercial plantations are gradually getting less emphasis and the working plans now also emphasize on mixed plantation of native species and Assisted Natural Regeneration (ANR). The Ramnagar FD boasts of the presence of 26 tigers and regular elephant movements in spite of being a territorial division. However, the presence of the resident Gujjar population inside forests, encroachments (approx. 100 sq. km, maximum being in Terai east FD), conversion of forest land for motor roads and other infrastructure development in the new state of Uttaranchal, large number of resident population of once migratory Khatta (cattle camps) holders, soil erosion, fuel wood and fodder extraction at commercial scale from nearby towns and boulder mining are fragmenting the forests. In open and degraded forests, particularly in the Terai west FD, *Lantana* and *Parthenium* have already covered a sizable forest area. There is a complete dearth of scientific studies on the abovementioned aspects from these

FDs. It is hard to find the baseline information on various issues that affect the forest ecosystem structure and functioning of the FDs. The importance of these RFs in the overall scheme of landscape level conservation initiatives is immense and has been highlighted by Johnsingh *et. al.* (2004) (Annexure - 8.2).

2.2. Kishanpur WLS, Dudhwa NP, Katarniaghat WLS, nearby Reserved Forests and Corridors (Central TAL)

As has already been stated, this site complex represents the Gangetic plain (Terai) physiographic zone in the study area. The Surahi range of Terai east FD in Uttaranchal links the landscape to Mahab and Mala ranges of Pilibhit FD of UP through forested corridor in the east. Elephants from the CNP have been reported migrating to Pilibhit through this corridor. The total area of the Pilibhit FD is 710 sq. km. This is the largest territorial division in the state of UP and alone contributes about 10% of the total revenue generated by the state from forests (Harish Kumar, Personal Communication). Despite being a territorial FD, the forests and grasslands of the Pilibhit support a number of wild animal species including tiger, sloth bear, and hog deer. The Lagga-Bagga Forest Block, in particular, supports populations of swamp deer, migratory rhinos from Nepal's Suklaphanta Reserve and rare hispid hare. There are some areas subjected to illegal grazing in this division. People from far and wide maintain Gauris (cattle camps) inside the forests. A huge reservoir, of many sq. km in extent called the Sharda Sagar has engulfed many prime habitats in the distant past and now the ever growing human population around it is posing further threats to wildlife and habitats.

Moving further towards the east from Pilibhit FD into alluvial plains of Lakhimpur Kheri and Shajahanpur districts, land use policies, extended history of forest management, settlement of refugees, uncontrolled expansion of agriculture and the associated large scale reclamation/conversion



Grassland in Lagga-Bagga, Pilibhit FD



Sharda Sagar is a huge water body created to cater to the irrigation needs in central TAL, many decades back

of grassland and swampy habitats, enhanced resource dependence and factors like fire, livestock grazing and flash floods have greatly reduced the once extensive Terai ecosystems into smaller forest fragments. The major portion (about 97%) of this stretch of the study area comes under the Lakhimpur Kheri district of UP. The DNP, Kishanpur WLS and MFs of North and South Kheri FDs are located in a matrix of private agricultural lands. The forestland in the above stretch covered 1,726.5 sq. km of which little over 50% is under PAs (883.7 sq. km) and the other half under MFs (842.8 sq. km). Habitats are changing very fast even for large species viz., swamp deer, rhinoceros, elephant and tiger. Critical habitats are threatened by the spread of alien weeds and also by native unpalatable species (Kumar *et. al.*, 2002).

This central portion of the TAL mainly includes the four types of land: i) forestland (PAs and MFs) owned by the Forest Department, ii) state owned revenue land, iii) community owned Panchayat land, and iv) private lands. Agriculture is now the core economic activity in the area and 60% of the land is net sown. The history of the forest in this area dates back to the 1860s and the forests in this tiger reserve zone can be divided into two broad types: i) RFs and ii) Erstwhile Private Vested Forests. The old RF and Vested Forests were managed separately until 1970; however, thereafter both the categories are being managed as RFs. In comparison, the Vested Forests were heavily exploited in the past by erstwhile Zamindars (landlords), whereas the old RFs were commercially exploited (Kumar *et. al.*, 2002).

The scientific assessment and forest spatial heterogeneity of this part of the landscape revealed that the area could be divided into two broad categories, forestland (25.8%) comprising PAs and MFs and agriculture matrix (74.2%). The forestland consists of a few larger dense forest blocks or several smaller and isolated forest fragments. The area included extensive private agricultural lands, community lands, and scattered government lands. Once, widespread grasslands and swamps covered just 2.8% and 0.5% area of the landscape, respectively. Detailed estimation using remotely sensed data identified 17 categories of land use/land cover types that include nine-forest types, two grassland types, forest plantations, and five other non-forest categories. A total of 44.5% of the forestland was

occupied by five sal dominated forest types. Four other important forest types together covered 19.3% area comprising moist mixed deciduous, khair and sissoo, tropical seasonal swamps, and tropical semi-evergreen forest covering, 9.3%, 6.9%, 2.5% and 0.6% area, respectively, of the forested tract. About 6% of the forestland was found encroached upon and under illegal cultivation, this includes the extremely encroached (approx. 100 sq. km) North Kheri FD. Interspersed grasslands, plantations, rivers and swamps covered 12.8%, 7.7%, 2.9% and 0.7% area of the forestland. Dense sal and tropical semi-evergreen forest types occurred in DNP only (Kumar *et. al.*, 2002).



Once extensive swamps were common near DNP which are no more now (Photograph taken 20 years back)

Similarly among the two categories of the grasslands about 25% of the upland grasslands and almost 50% of the lowland grasslands were confined to the DNP only. The Kishanpur WLS did not have dense sal, tropical semi-evergreen and khair and sissoo forest types. About 90% area of khair (*Acacia catechu*) and sissoo forests and almost 50% moist mixed deciduous forests are recorded in the North Kheri FD. South Kheri FD is characterized by more or less dense sal and open sal forests, and extensive plantations. Approximately 63% of the total recorded plantation, of the above stretch of the study site in TAL, is alone represented by this division. A comparison of the two categories of management, i.e. the PAs and the MFs reveals many characteristic features on the presence/absence and extent of particular vegetation types in them. Three prominent forest types viz., dense sal, sal mixed, and tropical semi-evergreen forests types remained unrepresented in the MFs. The actual extent of five sal forest types in the PAs was as high as 61.3% while various sal dominated forests covered just 37.9% area of the MFs. Instead, MFs possessed a much higher percentage of moist mixed deciduous and khair and sissoo forest types.

The PAs had a larger chunk (>60%) of tropical seasonal swamp forests than the MFs. The PAs also had 17.6% of their actual area covered by two types of grasslands while the two MFs together had only 7.7% of area under grasslands (Kumar *et. al.*, 2002).

Extensive sampling by Kumar *et. al.* (2002) in the above area of the central TAL recorded a total of 259 plant species. It was found that the DNP was the most diverse among the four areas (i.e. DNP, Kishanpur WLS, North Kheri FD and South Kheri FD) while the North Kheri FD was the least diverse forest area. The South FD had the highest shrub species richness. Thus PAs were richer in species diversity than MFs.

Dudhwa NP and Kishanpur WLS

All the forests in this *terai* zone of the study site were once famous for tiger hunting. The importance of the area as habitat for the swamp deer was realized almost a hundred years ago. The Wildlife organization of the UP forest department took the first step to form the Sonaripur Wildlife Sanctuary in September 1958 in order to protect the swamp deer. Initially, the area of the sanctuary was only about 64 sq. km. Later, in December 1968, an area of 212 sq. km was declared to constitute the Dudhwa WLS to protect the largest population of swamp deer in the Indian sub-continent. In fact, it was the single largest population of the deer in the world. Further in 1977, the DNP was created and in 1987 the 200 sq. km Kishanpur WLS south of the DNP (the second most important habitat of the northern swamp deer in the country) were together declared as the DTR. The DNP and Kishanpur WLS are separated by a complex of sugarcane fields, swamps, the township of Paliya and 12 other villages.

The swamp deer is the main inhabitant of the *terai* grasslands and swamps and is one of the most endangered deer species in the world (Holloway, 1973; Schaaf and Singh, 1976 and Sawarkar, 1988a). In 1980, the swamp deer population in the DNP was estimated at nearly 2,100 individuals, in 1988 it was about 1,000, and by 1998 it was estimated to lie between 700 and 750 (WII, 1998). In the past, the Sathiana grasslands of the park used to harbour 60% of the swamp deer population of the park. In 1963, George Schaller encountered a herd of 800 in Ghola and Gajraula in around 52 sq. km area (Schaller, 1984) of which



Swamp Deer habitat Jharital in Kishanpur WLS in DTR

only 30% is left at present. There are no more than 150 swamp deer left in Sathiana at present, compared with more than 900 in 1980 (Singh V. P. Personal Communication). The swamp deer population of the Kishanpur WLS has fortunately remained stable at 400-500, mainly around one large swamp grassland locally called as Jharital. However, a frequent change in the water course of the meandering Sharda River is a constant threat to the habitat. The flood plain grassland habitat of the Ull River in the sanctuary needs to be secured for the future of this species.

Swamp Deer in Jharital



Katarniaghat WLS

Further, to the east of the DNP, the Katarniaghat WLS (400 sq. km) has recently been incorporated in the DTR. Protection has helped in increasing the number of mega species in the WLS and also attracting elephants and rhinos from across the northern international border from Nepal's Royal Bardia NP. Thus, the northern portion of the WLS is relatively undisturbed. However, the southern side is heavily disturbed by road and rail traffic. Over-grazing is one of the serious threats to the habitats of the PA. It supports 10 times more cattle than stipulated by its management plan. About 20% area (mostly grasslands) of the sanctuary is infested by *Lantana*. Pressure for fuel wood and fodder from the surrounding 25 villages and also from the Nepal side is responsible for the poor

quality of the habitat. Forest fires in vulnerable areas such as extensive Canebrakes along Gerwa and Kaudiyala rivers destroy the habitats, sometimes permanently. There are some Forest villages (erstwhile Taungya villages) and a Central State Seed Research Farm near Girijapuri (covering 38.42 sq. km) located inside the WLS. These villages and the farm create continuous disturbance to the wildlife. Several requests to close down the farm from the park management have not been heeded to as yet.

Fire destroyed the forests along Gerwa River, Katarniaghat WLS



Global Change Factors Affecting the Learning Sites

Global Change is a term intended to encompass the full range of all ecological and socio-economic changes with significant implications for environmental quality and sustainable economic development on a global scale.

As it is amply clear from the foregoing that among the Global Change Factors, Habitat Fragmentation and Biological Invasion have been identified as the most important factors affecting the selected key sites in the TAL.

3.1. Habitat Fragmentation

Habitat fragmentation is widely regarded as a major threat against the viability of wildlife populations (Lovejoy *et al.*, 1986; Rolstad, 1991; Fahring and Merrium, 1994; Wiens, 1995 and Andreassen *et al.*, 1998). The nine PAs in the Indian side of the TAL are like isolated islands of biodiversity in the vast sea of humanity. In spite of suffering from habitat fragmentation owing to factors like encroachment; conversion; heavy pressure in terms of fuel wood, fodder and grazing; flooding; weed infestation; mining, etc. and poaching, retaliatory and accidental killings of wildlife, so far, somehow, the PAs and the MFs have been able to contribute to the protection of the mega species in the landscape. However, long-term survival is uncertain.

3.1.1. Biophysical Drivers

Pressures and threats to the ecosystem are numerous in the study area. De (2001) and Anon. (2002) have summarized the primary threats to wildlife as habitat change, illicit felling, encroachment, grazing, and fire. The spread of weeds, invasion of woody species in grasslands and changes in composition from short to tall coarse grasses threaten grasslands. *Lantana camara* invasion is alarming in forested buffer zones. Changes in hydrology and associated siltation, both natural and man-made, are causing changes in forest and grassland composition and structure. These lead to undesirable succession in grassland habitats. Passive or inappropriate management of forests in the PAs has resulted in increasing



Passive management is responsible for *Tiliacora acuminata* infestation in DNP

dominance of unpalatable and other undesirable species. Fire occurs over almost all the area either as controlled burns in grasslands, or uncontrolled surface fires in forests.

The "edge effects" of habitat fragmentation are many. Poaching is a potential threat, primarily for animals that venture out of fragmented forest areas, and along the international border with Nepal. Illicit felling of trees on the periphery of the PAs and within the MFs is a great concern, especially with ever increasing population density. Though large-scale timber removal is not very common, small-scale felling for household use is often practiced. Encroachment on forestlands for agricultural expansion is a continuous pressure (Rawat, 1996). Grazing, lopping for livestock fodder, fuel wood collection, mainly for household consumption and sometimes for commercial benefits, are crucial issues. Disease from livestock is a concern for wildlife together with human-wildlife conflict, as natural habitats are increasingly being fragmented and encroached upon. Encroachment of forest lands increases the interactions between wildlife and humans and livestock in the learning site complexes.

Rajaji NP, Sonanadi WLS, Corbett NP, Corridors and adjoining FDs

In this western complex of the learning site, i.e. in the Uttaranchal part, infrastructure development projects have contributed to habitat fragmentation and resulted in widespread human-elephant conflict (Johnsingh and Joshua, 1994). The development projects taken up during the 1970s, and large scale plantations (e.g., *Eucalyptus* spp, *Allanthurus excelsa*, *Populus ciliata*, *Acacia catechu*, *Dalbergia sissoo*, *Tectona grandis*) raised during



Lantana camara invading degraded forests and grasslands in RNP



Woody succession in grassland in CNP

the 1960s in many of the reserved FDs such as Haridwar (Part), Bijnor, Terai west, Terai central and Terai east to meet the industrial needs, replaced the mixed forests and grasslands. These monoculture plantations have changed the habitat composition drastically for the wildlife. *Lantana camara*, *Parthenium hysterophorus*, *Adhatoda vasica*, *Cannabis sativa* and *Cassia tora*, are multiplying throughout in this area, which reduce the suitability of the habitat for wild herbivores. Due to the fragmentation of habitats, three isolated populations of tiger are found in the above described area. Over the years the increasing human population and its demand for more land for agriculture and various development projects have broken the forest connectivity at several locations along the west bank of the river Ganga and along the Kathgodam-Haldwani-Lalkuan Highway (Johnsingh and Negi, 2003). More than 200 cases of poaching of wild animals have been reported during 1987-88 to 2000-2001, and also 7030 recorded illicit felling cases during the same period in the RNP. Huge quantity of baib grass (*Eulaliopsis banata*) about 232.5t is harvested from the park every year. Illegal removal of grass is also an issue, nearly 2565 cases of illegal harvesting amounting roughly to 103t of grass during 1987-88 and 1995-96 have been recorded. The Railway line passing through the park is a serious hazard for the wild animals. As many as 20 elephants have been killed in train accidents while crossing the railway line during last 15 years (1987-2002) (Pandey 2001). The other prominent threats and pressures are: existing monoculture plantations, proximity of the RNP to the pilgrimage towns of Haridwar and Rishikesh and the state capital city of Dehradun, state highways, i.e. Delhi-Mussoorie and Haridwar-Dehradun, a massive collectorate complex adjacent to the park near Haridwar, and human settlements inside the PA.

The shrinking wildlife habitat in the landscape is the result of exponential growth in human population and the associated requirements of agriculture and infrastructural development. For instance, enormous population growth around the RNP between 1951 and 1991 is responsible for the loss of 70 sq. km of forestland to townships and development projects. A power channel that runs parallel to the left bank of the Ganga River has drastically reduced elephant access from Chilla forest area to the river. The channel and encroachment together have rendered 15 sq. km habitat inaccessible to the elephants (Johnsingh and Negi, 2003).



Motor road construction destroyed the forest, near CTR



Recurring floods erode forest and grassland habitats in central TAL



Labourers create temporary huts along dry river courses for boulder mining in western TAL and thus responsible for habitat fragmentation



Recurring man-caused forest fire is one of the factors responsible for forest degradation in west-central TAL.



Irrigation canal inside forests fragments the habitat

In the RNP, non-palatable shrubs occupy 57% of the total shrub cover. The areas near riverbanks subjected to intensive grazing have been invaded by weed species like *Cassia tora*, *Parthenium hysterophorus*, *Cannabis sativa*, *Pogostemon benghalensis* and *Sida rhombifolia*. None of these species are palatable. According to the Management plan of the park *Lantana* infested areas in the park and its rough extent are Ramgarh range (2831 ha), Kansrao range (3695 ha), Motichur (3589 ha), Chillawali (4239 ha), Dholkhand (4821.51 ha), Haridwar (2625.80 ha), Chilla range (4896.15 ha) and Gohri (2816.15 ha).

Corbett NP

The construction of the 80 sq. km Ramganga reservoir across the Ramganga River in the early 1970s, and the Kalagarh Township and the large scale encroachments on the south western side have broken down the elephant habitat connectivity between the CNP and the western part of the CTR. Encroachments along the Kosi River that flows between the CTR and the Ramnagar FD break the habitat connectivity at several places. Many open forest areas and the grasslands locally known as Chauras are reported to be gradually being invaded by *Lantana camara* and *Cannabis sativa*.



Sambars crossing the dry river bed near Bijrani in CNP

Important Reserved FDs

The other important FDs in the western part of the study site are Ramnagar, Haldwani, Terai west, Terai central, and Terai east. All these territorial divisions have extensive commercial plantations of varying sizes to cater to the industrial requirements raised during the 1960s as has already been mentioned above. The presence of the resident Gujjar population inside forests, encroachment, conversion for motor roads and other infrastructure developments including sterling resorts in the new state of Uttaranchal, large number of resident population of once migratory Khatta (cattle camps) holders, soil

erosion, and large-scale fuel wood and fodder extraction at commercial scale from nearby towns are degrading the forests of the area. In the open and degraded forests particularly in the Terai west FD, *Lantana* and *Parthenium* have claimed a sizable forest area. Heavy vehicular traffic and boulder mining from the rivers such as the Gola River, involving a large number of migrant labourers, contribute to habitat fragmentation in the area.

Kishanpur WLS, Dudhwa NP, Katarniaghat WLS, nearby Reserved Forests and Corridors (Central TAL)

In Lagga-Bagga area of the Pilibhit FD 1000-2000 cattle graze round the year except during the rainy season. Encroachment, mainly of swamp areas, is also a problem. *Cymbopogon martinii*, an unpalatable grass species has been found to be invading the grasslands of Pilibhit FD. A huge reservoir, the Sharda Sagar, has already engulfed many prime habitats in the past and now the human population around it, growing exponentially, poses even greater threat to wildlife and their habitats in the area.



Cymbopogon martinii grass replacing the palatable grasses in central TAL due to frequent floods, silt deposition and maybe policy restrictions on regulated grazing

Moving further towards the east from Pilibhit FD into North and South Kheri FDs, frequent changes in river courses, associated siltation and prolonged water logging are continuing to erode and alter the forest and grassland composition. Passive management of forests in the DNP due to policy restriction has resulted in increasing dominance of undesirable succession in grasslands and weed proliferation in forests (Kumar *et. al.*, 2002). About 6% of the forestland was found encroached upon and under illegal cultivation, this includes the massively encroached (approx. 100 sq. km) North Kheri FD. Extensive sampling by Kumar *et. al.* (2002) reveals that the late successional non-palatable *Tillacora acuminata* occurred in as many as 52.3% plots in the DNP while its frequency values in two MFs, i.e. North Kheri FD and South Kheri FD were much lower. This amply indicated that relatively open canopy and regular

removal of the species by local people for making ropes kept its spread and density lower in MFs than PAs. The frequency of *Lantana camara*, an exotic woody shrub, was 5.7% of the plots sampled in the area. This is an early successional weed and relatively prefers open and dryer sites to colonize and multiply. This species was almost absent in dense sal while khair (*Acacia catechu*) and Sissoo forests of North Kheri FD favoured this weed. In South Kheri FD many ranges, particularly the Mohamadi range, is badly infested with *Lantana*. The density of *Helicteres isora* increased considerably from dense to open sal forests. *Cassia tora* and *Ageratum conyzoides* were the densest non-palatable weeds in this zone of the landscape (Kumar *et. al.*, 2002).



Tillacora acuminata invading every possible space in DNP



Tillacora acuminata collected from MFs is used for rope making by local people

Dudhwa NP and Kishanpur WLS

The DNP and Kishanpur WLS are separated by a complex of sugarcane fields, swamps, and the township of Paliya along with 12 other villages.

In the past, Sathiana grasslands of the DNP harboured about 60% of the swamp deer population of the park. It was observed that prior to the flooding during the rainy season, this population of the swamp deer used to disperse to the upland grasslands of Gholia and Gajraula and the swampy grassland patches interspersed within the sugarcane fields. This period coincides with the peak fawning during June and July. The deer



Railway lines passing through PAs pose a serious threat to wild animals, including elephants



An elephant knocked down by a speeding train in DTR area

remain outside the park till late January/early February and are most vulnerable to poaching as these habitats have already been lost to encroachment. The vast stretches of sugarcane fields adjacent to forests are many times used as surrogate habitat by wild animals including tiger. The swamp deer population of the Kishanpur WLS has fortunately remained stable at around 400-500, mainly around one large swamp grassland, Jharital. A railway line about 31 km long and a public highway 40 km long pass through the DNP. Similarly, an 18 km long railway track and an equally long public highway run through the Kishanpur WLS. A number of wild animals, including the large mammals get killed every year in rail and road accidents in the park. The road and railway network within the park area has many times proved beneficial for the poachers. The 56 km long porous International border is yet another threat to the resources of the DNP. The DNP faces almost all types of human as well as natural threats (biophysical and socio-economic) that are prevalent in the landscape.

Katarniaghat WLS

Approximately 20% of the area consisting mostly of the grasslands is infested by *Lantana* due to over grazing and other human induced disturbances, including fire. The PA also experiences pressure for fuel wood and fodder



Seed farm, Katarniaghat WLS



Ghariyal in Gerwa River, Katarniaghat WLS

from the adjoining 25 villages and also population on the Nepal side. There are some forest villages (erstwhile Taungya villages) and a Central State Seed Research Farm near Girijapuri situated inside the WLS covering 38.42 sq. km area that cause considerable disturbance to the wildlife, creating a break in the forest connectivity.

3.1.2. Socio-economic Drivers

Though the magnitude and causes responsible for habitat fragmentation vary across the sites, yet the root cause is the burgeoning human population and the accompanied needs for resources and services. The ever increasing human requirements result in forest encroachment and conversion for settlements, agriculture, plantation, infrastructure development (dams, roads, rails, irrigation canals, urbanization, etc.), massive use of fuel wood and fodder, over grazing, recurring man-caused forest fires, legal and illegal timber harvesting, boulder mining, etc. The socio-economic issues causing habitat fragmentation and weed proliferation in the identified study area according to the site complexes are described below.

Rajaji NP, Sonanadi WLS, Corbett NP and adjoining FDs and Corridors (West TAL)

In the western part of the study site, apart from the 520 sq. km core area of the CNP which is free from human disturbance, the rest of the area is under several types of pressures for fuel wood, fodder collection and grazing both from the pastoral Gujjar community living inside the forests and the villages located at the periphery of the PAs. The habitat has been fragmented by development projects and hence human-wildlife conflicts are widespread (Johnsingh and Joshua, 1994). Cattle grazing by the Gujjars living in large numbers (2346 households with over 19,000 livestock heads) inside the forest, and also from

villagers from outside are detrimental to forest resources. As much as 86% of the RNP is open to the Gujjar community for lopping and grazing. Indiscriminate lopping year after year results in tree mortality and weed infestation. In the past, the Gujjars used to leave their dwellings in the landscape with the advent of summer around April for high altitude meadows in the Himalaya, where they would stay until October. However, now partly due to the fact that local communities in the Himalaya do not want to share the resources with the Gujjars and partly owing to socio-economic changes within the community itself, most of the Gujjars have abandoned this traditional migration. The stopped migration has resulted in their increased demands on the habitat in the landscape. Besides, the growing population of the nearby villages has also put pressure on the elephant habitat for resources. A study of four villages near the Rajaji-Corbett corridor reveals that the forests of the corridor cater to 95% of the fuel wood need of the villagers in addition to fodder requirement (Badola and Mishra unpublished data as quoted by Johnsingh and Joshua, 1994).

In the Rajaji-Corbett area more than 200 cases of poaching of wild animals have been reported during 1987-88 to 2000-2001, and also 7030 recorded illicit felling cases during the same period in the RNP. A huge quantity (232.5 t/yr) of baib grass (*Eulaliopsis banata*) is harvested from the park every year. According to the management plan of the RNP controlled removal of baib grass, to reduce the fire hazards and at the same time to benefit the local communities, who have had

A large number of the Gujjar households live inside forests in western TAL



A large number of the Gujjar households live inside forests with their buffaloes in western TAL



customary rights to do so in the park, is permitted. However, the grass is removed illegally also, 2565 cases of illegal harvesting amounting roughly 103t of grass during 1987-88 and 1995-96 had been recorded. At present, over 10,000 cattle heads of the Gujjars, the Taungiya and the Gothiyas and about 50,000 cattle head of local people use the PA daily. The density of cattle population is 77.41 cattle/sq. km.

Important Reserved FDs

The presence of resident Gujjar population inside forests, encroachment, conversion for motor roads and other infrastructure development in the new state of Uttaranchal, large number of resident population of once migratory Khatta (cattle camps) holders and Gujjars, soil erosion, large scale fuel wood and fodder extraction at commercial scale from nearby towns are degrading the forests of the area. The importance of these managed forests in the overall scheme of landscape level conservation initiatives is immense as they act as critical corridors as identified by Johnsingh *et. al.* (2004) (Annexure - 8.2). The increasing human population, coupled with changing socio-economic aspirations, often exerts a variety of pressures on the forests in terms of increased needs and infrastructural development.

DNP, Kishanpur WLS, Katarniaghat WLS, nearby Reserved FDs and Corridors (Central TAL)

The Pilibhit FD connects the central TAL with the Uttaranchal part of the landscape in the west and Suklaphanta Wildlife Reserve, Nepal in the north. Some areas of the FD are subjected to illegal grazing practiced by cattle camp (locally known as Gauris) holders. These people are not local and come from outside the area. The Gauris (cattle camps) are maintained inside the forests. As reported by the local people there are several Gauris in the forests. Each cattle camp comprises

Large numbers of cattle graze inside forests in the west-central TAL



Sustained pressure causing degradation of forests in South Kheri FD

200-250 livestock, which are mainly buffaloes. Over grazing and unplanned irrigation canals constructed inside the forests, degrade habitats of wild animals leading to man-animal conflicts in terms of increased instances of crop raiding, livestock depredation and human killings by wild carnivores. During the last year alone, as many as 15 people have been killed by tigers and leopards in the area. Around 70% of the above incidents took place at forest-agriculture interface particularly in sugarcane fields. Sometimes people resort to retaliatory killing of wildlife.

Sugarcane field-forest interface areas are prone to human wildlife conflict in the TAL



Pressure in terms of fuel wood collection, grazing and encroachments are the real issues in the area. The pressure is not uniform throughout the FD, it is high in some selected pockets. The Government of India's scheme of linking every village with motorable road in the country can also cause habitat fragmentation in the near future. So far, the constructed roads have not affected the forests but there are apprehensions that in due course of time there might be demands from local people to link every end of the road through forests. The protection of wildlife and habitat management are the prime activities according to the working plan, yet, being a territorial division, the focus remains on silviculture and protection.

The North and South Kheri FDs are facing tremendous pressures from a large human population (a growth rate of 32% has been recorded between 1991 and 2001 in Lakimpur-Kheri district) in relation to grazing, firewood collection, fodder collection, encroachment and infrastructural development.

Dudhwa NP and Kishanpur WLS

Despite rights and concessions being withdrawn in the case of the NP area and greatly curtailed in the case of the WLS, local people illegally collect various forest resources and graze their livestock. Presently, there are no major habitations in the NP,

except a small remaining Tharu population in the Surma village which should have been rehabilitated in the best interests of park. The Tharu tribals who inhabit the thirty-seven villages located on the northern side (northern buffer) of the DNP till 1975 were having the status of forest settlements. Subsequently, these were declared revenue villages. The tribals were totally dependent on the surrounding forests for their subsistence. After the changed status of the area, the conservation policies brought hardship to these people though PA officials within the permissible legal limits allowed them to use resources such as firewood, thatch grass and other minor resources. Other non-tribal villagers were allowed these facilities on payment basis. After the creation of the National Park, all concessions were done away with. Only collection of firewood was permitted during winters till 1983 on payment. The villagers were given this concession on the condition that they would help park management in fire fighting. Similar concessions were continued in the case of the Kishanpur WLS. However, after the amendment in the WLPA, 1972 in 1991, these concessions were required to be seized in the Kishanpur WLS except regulated grazing. The WLS has two villages Chaultua and Kishanpur and except for 34 ha under encroachments, rest of the area is free of habitation. About 40,000 cattle graze in the buffer zone of the DTR. Some efforts have been made to promote wildlife tourism in order to benefit the local people, however, participation of the people in this sector remained negligible. At present the eco-development programme is being run through 61 EDCs around the DNP. The EDCs in Tharu villages, apart from performing the routine activities to minimize biotic pressure on the park, have also taken up some innovative activities like organic farming including vermicomposting.

Katarniaghat WLS

Over grazing is one of the serious threats to the habitats of the PA. It supports 10 times more cattle than stipulated by its management plan. 20% of the area, mostly grasslands, of the sanctuary is infested by *Lantana*. Pressure for fuel wood and fodder from the surrounding 25 villages and also from the Nepal side is also responsible for the poor quality of the habitats in the southern side of the WLS. Forest fires in vulnerable areas such as extensive Canebrakes along Gerwa and Kaudiyala rivers destroy the habitats sometimes permanently. The aforementioned rivers together form the bigger Ghagra River. The Gerwa River



A Canebrake along the Gerwa River, Katarniaghat WLS



Ghariyal and Otter in the Gerwa River in Katarniaghat WLS

stretch, with in the WLS, is one of the best fresh water habitats of freshwater dolphins, crocodiles (Ghariyal and Maggar), and otters. The WLS has a great potential to become an ecotourism site with the creation of some basic infrastructure and training.

3.1.3. Institutional Drivers

Though it is difficult to describe conclusively the institutional drivers that have caused habitat fragmentation or helped in biological invasion in the study sites, indirect inferences could well be drawn. The policy to allow the refugees to settle down in the landscape in the past, weak regulation to check further in migration coupled with low motivation to adopt family planning measures led to the unprecedented population growth in the landscape. High human and livestock populations together put tremendous pressure on forests and also lead to encroachments and thereby exacerbated the fragmentation. A number of sugar mills (4 mills alone are located around DTR) in the landscape promote sugarcane cultivation in vast tracts of the available arable lands and often many people encroach upon more forestland and swamps to raise the cash crop. Tourism is being vigorously pushed in the newly created Uttaranchal and also in UP to provide benefits to local



Sugarcane being carried to sugar mills near DTR area



Teak plantation in CTR area

communities. However, reckless tourism creates more problems in terms of infrastructure development and often provides more opportunities to economically richer sections of the society rather than benefiting the local communities. Tourism has increased manifold around the CTR, where a strip of agricultural land between the Kosi River and Ranikhet road from Dhikuli to Garjia has been affected by this activity. In 1994 only four tourist resorts were operating in the area, the numbers have risen to more than 10 at present. In many FDs though mixed plantation is being emphasized yet the past commercial plantations and few newly selected commercial species like teak are also causing habitat fragmentation. There has been a continuous degradation of the elephant habitat in western TAL due to infrastructure development in the growing townships such as, Raiwala, Rishikesh, Kotdwar, Ramnagar, Kaladhungi, Haldwani, Tanankpur, Kashipur to name a few. The Banbasa Hydro Electric project and Sharda Sagar and their canals have also led to the loss of forest areas in western and central TAL, respectively. Similarly, the barrage on the Suheli River near the DTR caused inundation and loss of habitats in the study area. Sometimes the conflicting policies also hamper the conservation. For instance, the Uttaranchal government mining policy, 2001 permits scientific extraction of minor minerals in Gaula, Sharda, lower Kosi, Dabka and Yamuna rivers flowing in



Intensive agriculture is practiced in central part of the TAL where sugarcane has become the obvious choice of farmers to realize quick monetary benefits



Tourist huts are coming up in sensitive areas around Corbett TR

Reserved Forest areas in the western TAL.

The WWF is trying to play the role of a catalyst to bring together different agencies including the forest department, revenue department, police, industries, tourism, agriculture, irrigation and public works departments, research organizations such as the WII, Universities, NGOs and village councils, known as panchayats, to discuss the problems and evolve a strategy to minimize conflicting interests, and in this manner, forest degradation.

3.1.4. Inadequate Scientific Understanding

There are many other facets of the fragmentation, which need further scientific information and understanding to develop the most desirable state of the habitats in the landscapes in different parts of the world to work out effective conservation strategies. The available scientific information on this issue is still not conclusive as is evident from the facts being mentioned here briefly. Habitat fragmentation is widely regarded as a major threat against the viability of wildlife populations (Rolstad, 1991; Fahring and Merrium, 1994; Wiens, 1995), little is known about the immediate mechanisms on population responses to fragmentation (Wiens *et. al.*, 1993; Diffendorfer *et. al.*, 1995; Ims, 1995). Therefore, issues like processes involved and magnitude of the fragmentation (Wiens, 1989), large-scale habitat fragmentation affecting metapopulation dynamics (Hanski and Gilpin, 1996), and processes such as exchange rates between populations (Ims and Yoccoz, 1997), have received most of the current research. Small-scale fragmentation that may change the spatial structure of local populations is also important (Rolstad, 1991, Wiens, 1995) in that it creates situations applicable for the concept of patchy populations (Harrison, 1991), where it may change the behaviour of individual animals. Obviously, uniqueness of patchy populations such as natural growth and dispersal rate, and social organization (Foster and Gaines; 1992, Ostfeld, 1985; Bowers *et. al.*, 1996) are expected to come out how the individuals use patchily available resources and how exchanges among the individuals (aggressive or accommodating) are modified by the spatial arrangement of habitat patches (Cockburn, 1988; Lomnicki, 1988; Bowers *et. al.*, 1996). However, how individual qualities develop to varying sizes of habitats and how such developed qualities translate into population level phenomena (e.g., social

organization) are yet to be explored (Sutherland, 1996).

The basic aim of most ecological studies concerning habitat fragmentation is to show how the demography of the target population may be affected. Based on various studies, individual level responses, in addition to social behaviour, may be involved in determining the effect of fragmentation on a population of mega species in TAL. However, information in this regard is totally superficial as it is based mainly on observations. Long-term studies are required. Right now we are not in a position to state what kind of individuals of a species inhabiting the different habitats of the landscape are forced/opt to come out from the intact habitats to the degraded forests or agricultural land. How the behaviour of the individuals or the populations is changed or affected by various disturbances leading to habitat fragmentation is not yet understood. There are a number of questions that the future researches have to answer for the better management of the wildlife in the landscape.

Based on the available scientific information, habitat fragmentation due to various factors relevant for the present study sites, as described above, and biological invasion in some critical areas seem to be threatening the long term survival of the species and the PAs in the TAL. Fragmented habitats have serious implications for population viability of most wild animals, especially for large mammals; wide ranging species, and rare, endangered and habitat obligate species, all of which are represented in the *Terai* (Harris, 1984; Decker *et. al.*, 1991; Qureshi and Sawarkar, 1991; Morrison *et. al.*, 1998).



Ipomoea invading open and mesic areas in central TAL



Lantana camara invading degraded forests and grasslands in CTR area

3.2. Biological Invasion (Invasive Species)

Invasive alien species are an increasing ecological as well as economical threat being identified throughout the globe, particularly in the tropics. The economic cost of the impact which invasive species cause is colossal and the ecological and economic effects of the invasion will soon impinge on all countries and societies. Throughout the world, over 40% of the species on the list of threatened and endangered species are there due to the impact of invasive species (Sharma *et. al.*, 2005). About 18% of the Indian flora constitutes adventive aliens, of which 55% is American, 10% Asian, 20% Asian and Malaysian, and 15% European and Central Asian species (Nayar, 1977). During the last 15 years, international efforts under the Scientific Committee on Problems of Environment (SCOPE) gave great international visibility, and induced local initiatives to cope with the threat of biological invasion. However, the ecosystem level effects of invasion are little understood and there is an urgent requirement of scientific studies on invasion in India (Sharma *et. al.*, 2005).

3.2.1. The Extent and Impacts

Among the invasive species, *Lantana camara* has already invaded a sizeable chunk (roughly 30%-40% area) of the RNP and CTR and also many reserve FDs in the western part of the TAL. *Ipomoea* is dangerously invading the swampy habitats near agriculture and forest interface in the alluvial plain part of the landscape. Water hyacinth, locally called Jalkumbhi, is choking many wetlands and water bodies in the central part of the landscape, especially near agricultural fields.

Sesbania aculeata called Dhencha used by the locals for rope making is infesting many wetlands in the PAs and MFs in this part of the learning site due to flooding. Floodwater carries the fruiting bodies to the natural wetlands such as Jharital, Banketal, Bhadital and many other mesic sites in DTR. Siltation, coupled with infestation by water hyacinth, is affecting the swamp deer habitat in the DNP in Ranwastal and Bhadital.

The Chandia-Hazara water body is an example in the Pilibhit FD where 8-10 sq. km area is totally covered by water hyacinth (Harish Kumar, Personal Communication). As a result, migratory birds, including the Siberian crane, have stopped visiting this site. The infestation by the hyacinth also adversely affects the fish production from these water bodies. Among other important weeds that are proliferating in the area are *Parthenium* and *Eupatorium*. The former generally occupies the open and dry forest sites while the latter open and moist sites in the landscape. The under storey of practically all sal forests in the DNP is infested with the unpalatable *Tiliacora acumenata* locally called as Rangoi and is affecting spotted deer habitat severely. The Sathiana range of the DTR used to be one of the best breeding grounds of swamp deer but due to siltation and water logging, the palatable grass such as *Imperata cylindrica* has been replaced by the unpalatable coarse grasses like *Cymbopogon* sp. and *Saccharum* sp.



A Hyacinth infested water body in central TAL

3.2.2. Lack of Scientific Understanding

The inability to control weed proliferation is greatly due to the lack of scientific knowledge related to the structure and functioning of ecological systems. For instance, in the absence of scientific information, it is difficult for the managers to determine a desired successional forest state for

maintaining the wildlife and other ecosystem values. For example, increasing dominance of *Tiliacora* with the closure of the sal canopy in the DNP is bad for ungulates but at the same time it might have great value for species other than ungulates. Nothing is known whether or not, this is the natural state of sal forests which exists once the human induced disturbances are stopped. What is the role of *Tiliacora* in the ecosystem functioning under natural condition and what would happen if its removal were initiated to suit the fodder requirements of the wild ungulates and how fire could play a role in the ecology of sal forests in this situation? (Kumar *et. al.*, 2002.) Several questions are still to be answered through targeted research. Similarly, lack of scientific knowledge on the ecology of *Lantana* is responsible for the prevailing myth on its usefulness and harmful effects on ecosystems in general and wildlife in particular.

Response to Cope with the Change Factors

Though the management plans of the above PAs and working plans of the RFs have not been specifically oriented to cope with the identified Global Change Factors *per se* yet many activities are taken up to minimize the factors that contribute to habitat fragmentation and infestation of invasive species. Major factors responsible for the fragmentation are:

- burgeoning human population (and therefore the escalating pressure for resources),
- changed socio-economic scenario (e.g., changed lifestyle of the Gujjars and Khatta holders; therefore overgrazing, over cutting of firewood, timber and fodder species),
- encroachment of forest lands (by agriculture, monoculture plantation and other land use),
- infrastructure development (like rail, roads, hydroelectric and irrigation projects),
- various illegal/legal activities (timber harvesting, boulder mining in river beds),
- sectoral approach of various departments,
- lack of proper awareness among key stakeholders,
- little/no community participation,
- obsolete policies less amenable to adapt to changes and
- lack of adequate scientific knowledge and proper monitoring plans.

The magnitude of the above problems leading to habitat fragmentation and biological invasion varies in different locations within the landscape and therefore there are different responses from various stakeholders. The government forest department and local communities are the main stakeholders that largely manage and use the natural resources of the landscape. There are some broad responses, which could be generalized across the sites.

4.1. Judiciary Processes and Enforcement

The Judiciary has been found very supportive of the cause of conservation as many illegal encroachments have been successfully removed from critical corridors across the landscape through judicial intervention. The Hon'ble Supreme Court has instituted a special committee called the Central Empowered Committee (CEC) to investigate cases related to environment and conservation. A case involving the RNP is an example of the role played by the judiciary in

favour of conservation in the TAL. Mr. Jaya Prakash Dabral, working with Uttarakhand Jan Jagriti Sansthan, an NGO, filed a case against the Power Grid Corporation of India Ltd for felling of trees in the RNP for the construction of an 800 KV transmission line. On the recommendations of the CEC, the RNP has received interim compensation (Anonymous, 2003). The CEC is currently investigating a number of cases relevant to the present learning site complexes in the landscape including construction of a black top road in Ramnagar FD, Non-Forest activity in the vicinity of the CTR in relation to setting up of a civil construction (Hot Mix plant) related plant in Lal Dhang village.

Cases are filed with the Sub Divisional Magistrate, Kotdwar to evict the encroachers from the Kalagarh corridor. A case in Kashipur court favoured eviction of settlements along the Kosi river corridor in 1992 but is yet to be enforced in totality. Construction of Sterling Resorts has been stopped by the Supreme Court in the Boar river corridor near the CTR. Encroachment by nearly 2000 Bengali settlers was removed from the core area of Lagga-Bagga block of the Pilibhit FD by the Forest Department. Encroachment of about 176 ha forest land in Pharsayia area has been brought back to the DNP through the judicial process very recently (Deputy Director, DNP, Personal Communication). Relocation of some of the Gujjar households from the RNP has also been facilitated by court orders in 1990.

The Indian Forest Act, 1980 helps the Forest Department to protect forest conversion for non-forest activities. It is just impossible for the private parties to get conversion sanctioned. In the Uttaranchal part of the landscape, i.e. from the RNP to the Terai east FD, the state government has advised the district administration to hold regular meetings of officials to look into the speedy solutions of the issues pertaining to forest land conversion, encroachment and other forest related offences. The revenue, police and forest department represented, respectively by the District Magistrate, the Senior Police Superintendent and the Divisional Forest Officer (DFO) hold such meetings generally at monthly intervals in the state.

4.2. Policy and Planning

4.2.1. Joint Forest Management (JFM) and Eco-development

Since 1991, the Govt. of India has been providing financial assistance, particularly to PAs, to implement ecodevelopment activities with the basic objectives of minimizing pressures on the natural resources. Ecodevelopment is a location-specific, conservation-friendly package of actions for village development and use of natural resources by local people so as to contribute to the PA conservation. The programme attempts to create an environment for people's participation in conservation while addressing improvement in the livelihood of local communities. It tries to compensate local communities for the lost access to resources inside the PAs and the damage by wildlife. JFM in Uttar Pradesh and Uttaranchal was initiated in 1997 under the UP Forestry Project as Uttaranchal was a part of UP at that point of time. Both the programmes were initiated with the help of the World Bank in the beginning and now being funded by the central government. To restore the degraded forest land with clearly defined targets JFM is now being supported by creating Forest Development Agency analogous to the District Rural Development Agency. In the earlier phase, local NGOs have the well-defined role in the implementation of the JFM along with the local communities whereas in the present phase this is not necessarily mandatory. However, the success is still very limited, as the nearly decade-old programme has still to show real example of effective partnership and benefit sharing arising out of forest resources. Many bottlenecks are still to be cleared before the approach shows some positive results. In the landscape, CTR site could achieve some success in devising the mechanism to benefit local communities through eco-tourism. Around the CTR, under the Ecodevelopment Programme, a number of village youths were trained to act as wildlife guides to promote eco-tourism. The activity has so far remained beneficial for both the key stakeholders, i.e. the local people and the park managers because the fact that the CTR is considered to be one of the best managed PAs in the country. About 61 EDCs working around the DNP are engaged in various livelihood earning activities including organic

farming. As informed by the Deputy Director of the DNP, some of the EDCs are doing excellent work particularly in tribal Tharu villages (Singh, P. P. Personal Communication). There are 29 EDCs functioning in the Katarniaghat WLS and 19 EDCs working around the RNP. Alternative livelihood means such as bee keeping is being promoted. The EDCs help the park managers in the protection and management of wildlife.

4.2.2. Trans-boundary Cooperation

The representatives from the Ministry of Environment & Forests, Government of India (in the Department of Forests and Wildlife) and His Majesty's Government of Nepal, Ministry of Forest and Soil Conservation (Department of National Parks and Wildlife Conservation) met at Kathmandu from 3rd to 5th January, 1997 for the 1st trans-boundary consultative meeting on biodiversity conservation and resolved the following:

- Create awareness of the existence of illegal trade of timber, wild flora and fauna, including their parts and products.
- Realizing the importance of trans-border protected area network for comprehensive ecosystem protection.
- Considering various steps taken by both India and Nepal with respect to the extension of the PA network and control of illegal trade in flora and fauna in their respective countries.
- Noting that there are still some gaps in the methods and systems to address the trans-border illegal trade of wild flora and fauna and their products.
- Appreciating the necessity of a comprehensive trans-border PA network and installation of suitable mechanism for effective control of illegal trade in timber, wild flora and fauna and their products.

4.2.3. The Environment Protection Act

Under the Environment Protection Act, 1986, the Doon valley notification 1989 put ban on certain kinds of infrastructural development, land use, mining and grazing detrimental for the environment of the Dehradun valley in the Uttaranchal.

4.3. The Landscape Approach to Ecosystem and Species Management

4.3.1. Tiger and Elephant Reserves, Wildlife Corridors

Considering the fact that the PAs in this human dominated landscape are themselves isolated habitats, the Government, with support from other stakeholders, has created two Tiger Reserves viz., the DTR and the CTR and the Shivalik ER in the west-central TAL to give further impetus to species protection and habitat management beyond PA boundaries. Funds are made available through various schemes (Project Tiger and Project Elephant) by the central government for habitat management work in these non-formal PA entities covering the formal PAs like the WLSs and NPs. The concept of corridor is gaining ground in the MFs. These MFs, which were mainly managed to fulfill the industrial needs, have also initiated wildlife protection and habitat management as essential activities. Instead of focusing on timber production through raising exotic tree species, focus is also on habitat management by promoting Assisted Natural Regeneration (ANR) and plantation of mixed species. In the SER, infrastructure is being built and bamboo plantation and digging of water holes have begun in MFs also.

4.3.2. Trans-boundary Landscape Management and Creation of new Community PAs

Illegal grazing, poaching and timber harvesting across the border from Nepal are discussed in the trans-boundary cooperation meetings between the Indian Forest Department and Forest Institutions of Nepal which are helpful in bringing down the illegal activities such as timber harvesting, grazing and poaching especially around the DTR. To maintain habitat integrity, the Forest Department and other civil society groups have proposed as many as two Community Reserves and a Conservation Reserve in central TAL. The proposed Chukka-Lagga Bagga Conservation Reserve in the Pilibhit FD will link the division with the Suklaphanta Reserve in Nepal and the Kishanpur WLS in the DTR. The proposal has strong endorsement from WWF-India. In Sampurnanagar and Paliya ranges of North Kheri FD between the DNP and the Kishanpur WLS, and Nighasan range of North Kheri FD between the DNP and

Katarniaghat Wildlife Division, two Community Reserves are being proposed. These are the new formal categories of PAs according to the WLPA, 1972 amendments 2002.

4.3.3. Assisted Natural Regeneration, Habitat Management, Species Reintroduction

PAs get recurring annual grants for habitat protection and management. With the improved scientific understanding, habitat management is also being practiced in reserved forests acting as corridors between the PAs. Monoculture plantations of economically important trees are gradually less emphasized, rather, Assisted Natural Regeneration (ANR) by keeping away disturbances like fires and grazing are being promoted in many territorial divisions of the study sites. ANR helps in improving the quality of forests, as mixed vegetation is regenerating. Ramnagar and South Kheri FDs could be cited as successful examples in ANR, in western and central TAL, respectively. The Forest Department, in the last 5-7 years, is trying to enhance tree cover in degraded forest patches. Disturbances such as fire and grazing are being kept out by erecting stone walls in the Bhabar tract and digging trenches in the alluvial plain part of the landscape around the degraded forest patches. The soil seed bank and vigorous coppice from the old tree stumps after protection have been able to give rise to successful forest regeneration as mentioned above. Often Forest Protection Committees, under the JFM programme, are involved in implementing the activity. Activities like bamboo plantation and digging of waterholes in the forest areas falling under Tiger or Elephant reserves are also taken up. In central TAL, particularly in the DNP, grasslands are managed through burning and harrowing treatments to maintain the habitat needs of wild ungulates like swamp deer and hog deer.

Assisted Natural Regeneration taking place in Ramnagar Forest Division



A desilted water channel in DTR



Desilting operation is on using modern machine in DTR

The influence of rivers on the grasslands of the *terai* may be seen from two angles as the floods may create many new types of grasslands and also may destroy well-established grassland habitats at the same time. However, frequent floods and changes in river courses (Sharda and its tributaries) around the DTR are serious threats to the grasslands and other habitat types. The floodwater annually erodes several habitats and deposits large amount of silt over the vast tracts of grasslands resulting in the change in the vegetation composition (palatable grasses are being replaced by coarse grasses like *Cymbopogon martinii*) as is happening in the Sathiana range of the DTR. Recurring floods and associated siltation around the DTR is also responsible for the unpredictable change in forest species composition. The park management does take up a variety of activities to cope up with the phenomenon right from desilting the riverbeds to restocking of grasslands with palatable species. Desilting of natural water bodies is also carried out to make them suitable for the migratory birds flocking numerous water bodies like Banketal, Kakrahatal and many others in the DTR.

Efforts have also been made to reintroduce the lost species. Reintroduction of the rhinoceros could be cited as an example. Rhinos went locally extinct (Misra, 1989; Kumar *et al.*, 2002) from the Indian side of the central TAL. Reintroduction initiated in 1984 has remained successful in the DNP and at present the number has gone up to over 20 individuals in the park.

Reintroduced population of Rhinoceros in DNP is increasing in size



4.3.4. Human-Wildlife Conflict Management

Most of the human killing during the recent past occurred outside the PAs either in corridors or in the sugarcane fields in the vicinity of the forests suggesting that habitat fragmentation makes humans as well as wild animals vulnerable in the landscape. Crop raiding by wild herbivore is quite common throughout the study area. Apart from this, livestock depredation and human killing by carnivores also takes place which antagonizes the local people. Sometimes they resort to retaliatory killing of the carnivores as well as crop raiding herbivores. In the Pilibhit FD and the DTR area during the past one year, 23 people were killed by tigers, leopards, and rhinos. Tigers killed as many as 12 people while 9 individuals were killed by leopards in Pilibhit FD and in the vicinity of the DTR. Two people were killed by a rhino near the DTR. In all these cases WWF-India helped the Forest Department give immediate financial support to the kith and kin of the killed individuals. All of these incidents took place outside the PAs either in corridors or in sugarcane fields. Similarly, crop raiding and livestock depredation are common in around other PAs such as the RNP, CTR and in the territorial divisions that connect the PAs. Earlier, trenches were dug out and now solar powered electric fences have been erected along the park boundary to avoid man-animal conflicts in the DNP and few other locations in the learning site. Around the RNP, during the last three years (2001-2004), over 900 cases of crop raiding by elephants were compensated. A total of over Rs. 1,500,000.00 was spent on the crop compensation. There were more than 100 cases of livestock killing reported in the RNP while elephants also killed two humans. In case of human death and permanent injuries Rs. 50,000.00 is paid to the family members of the deceased or the severely injured person.

4.3.5. Capacity Building and Partnerships

Frontline staff is being given orientation courses in wildlife protection and management. The Forest Training Institute at Haldwani, and the Corbett Centre for Conservation at Kalagarh, with the help of experts, train the staff, and local people in

activities relevant to forests and wildlife conservation, and PA management such as ecotourism, wildlife protection and ecodevelopment activities in the landscape. International and national funding agencies are being roped in through various partners like the WWF and the WII, and also through the government to get different types of support for the management requirements. Other national and local NGOs and individuals are supporting the management in conducting research, resource generation, implementation of conservation activities, and also help build the bridge between the Forest Department and local communities, education, awareness generation and capacity building of communities to earn a livelihood.

4.4. Regulating Impacts of Infrastructure Development

Railway lines and motor roads/highways running through the parks like the RNP, Kishanpur WLS, DNP, and many other critical areas need serious attention from all concerned to come out with feasible alternatives. Huge financial costs together with public and political support are involved to select drastic measures such as realignments of the above infrastructural facilities in favour of wildlife and forest conservation. For the time being, PA managers in the RNP and DTR are seeking help from the railways to regulate the speed of the trains and mandatory whistle blowing while passing through the parks to minimize accidental killings of wildlife. To sensitize the railways and other transport staff towards wildlife conservation, passengers being requested not to throw food leftovers within the park area, proper signage along the motor roads passing through wildlife sensitive areas are some of the measures that are being implemented at some locations while also being contemplated for other sensitive areas. Though wildlife scientists have suggested several alternatives including underpasses at some locations, these are still far from being implemented in the TAL. As per the National Environment Protection Act, 1986 (Environment Impact Analysis Notification, 1994), it is mandatory to perform environment impact assessment before any infrastructural projects are given the green signal. Awareness among all stakeholders needs to be raised to minimize accidental road killings and also to minimize disturbance to the wild animals. The Hon'ble

Supreme Court stopped the construction of Sterling Resorts and ordered dismantling of building around Boar river corridor near CTR (Johnsingh *et. al.*, 2004).

4.5. Control of Invasive Species

Lantana at many places is physically removed every year and planted with some palatable grasses and bamboos. In the PAs, *Lantana* and other weeds including woody succession are removed from the grasslands locally known as Chuars in Uttaranchal and Phantas in Terai parts of the landscape. In the DNP, *Lantana* has completely been removed from the core zone. Grassland management in the DNP is done through cutting, burning, harrowing treatments and also in various combinations of these treatments. The management plans of the PAs do recognize removal of eucalyptus from the PAs, prohibit raising new commercial plantation and recommend non-commercial thinning in the old teak plantations. Woody successions of *Bombax* and shisoo are generally removed from the grasslands to maintain the desirable state of succession. Restocking of the grasslands is practiced in the DNP to promote palatable species by planting species like *Cynodon dactylon*, *Dicanthium annulatum* and *Trifolium sp.* These types of grassland management so far have been showing good results in maintaining the herbivore habitat.

4.6. Research and Monitoring

A few research organizations did carry out research activities in the PAs but these were mainly donor driven and the methods suggested are rarely monitored yet there are examples of location specific studies from the RNP, the CTR and the DTR carried out to benefit the respective PAs. For instance, the management plan of the RNP benefited by the studies carried out in the past by J. B. Sale, A. J. T. Johnsingh, S. Choudhary, A. Rajbanshi, J. Jashua, J. and A. U. Khan on elephant movement and habitat utilization; study of interrelationship between the village ecosystems and elephant corridor in the forest linking the RNP and the CNP by H. S. Panwar, A. J. T. Johnsingh, Koshore Rao, B. K. Mishra, R. Badola, S. F. Wesley and S. Raj; the dependency of the local people on

the resources of the RNP by H. C. Raizada, K. Berkmullar, B. C. Das, and S. Bhatnagar, and investigation of the habitat types of the RNP and their occupancy by large mammals by W. A. Rodgers, V. B. Sawarkar, A. J. F. M. Dekker, and G. S. Rawat. Further, the socio-economic status of the local people living in and around the RNP FD was investigated by H. S. Maindola, migration pattern of Tigers in RNP by C. P. Goyal and H. S. Maindola (Pandey, 2001). Similarly, grassland management in the DNP also benefited by several studies carried on burning, grass cutting, grazing within the PA, in other parts of the country as well as those carried outside the country (Daubenmire, 1968; Dabadghao and Shankarnarayan, 1973; Pandeya *et. al.*, 1977; McNaughton, 1979; Mishra, 1982 and 1984;

Brown, 1997; Karki, 1997; Lehmkuhl, 1989; Peet *et. al.*, 1997; Bell, 1986; Laurie, 1982 and Dinerstein, 1987).

The role of WWF-India has been that of a facilitator, considering the vastness of the landscape and availability of the resources, four critical sites were selected for direct intervention. This was decided during the stakeholders' workshops. The responsibility of monitoring the different aspects of the interventions and their impacts was decided and accepted by the stakeholders. Pertaining to the monitoring plan related to habitat loss in the critical sites, the framework proposed by the stakeholders is as follows (Table 3): Scientific information on the grazing, fodder and

Table 3. Monitoring Plan

Hierarchy of Objectives	Indicators ¹	Means of Verification	Baseline Data ²		Responsibility ³		Frequency ⁴
			Where	How	Baseline	Monitoring	
To reduce the degradation and loss of forest quality and quantity due to human dependence (fuel wood, fodder, thatch grass and timber)	Multi-strata regeneration of key species in corridors	Plot sampling	WII (partial)	Identify sites & set up plots	Expert team (NGOs/FD/Research Inst.)	Expert team	Every 2nd yr
	Regeneration of trees, fodder grasses in critical areas	Plot sampling		Identify sites & set up plots	Expert team	Expert team	Every 2nd yr
	Lopping status	Plot sampling		Identify sites & set up plots	Expert team	Expert team	Every 2nd yr
To minimize the negative impacts of livestock grazing within critical areas	Change in no. of cattle in critical areas	Transects and direct counts for livestock and ungulates	WII (partial)	Transects and direct counts	Expert team	Expert team	Every 2nd yr
	Presence of wild ungulates in critical areas	Transects and direct counts	WII (partial)	Direct counts	NGOs	Expert team	Every 2nd yr
	No. of cattle camps in critical areas	Direct counts				NGOs	Every 2nd yr

¹All indicators are expressed as neutral variables that indicate a change from the baseline situation.

²In this column the "where" indicates the location of the data if it already exists. If it does not exist then the "how" column indicates the model of collection. Therefore either one of these columns will be filled in.

³This column is divided into two-responsibility for collating/collecting the baseline data and responsibility for the monitoring analysis.

⁴Frequency to be determined through sampling methodology to ensure recording of seasonal/annual change.

fuel wood removals, habitat changes, socio-economic changes, impact of intensive agriculture on surrounding forest ecosystems, weed infestation and mining is extremely scanty. Impact of development related infrastructure such as road, railways, canal, and factories (a number of sugar mills encourage farmers to raise sugarcane and the incentives sometimes result in encroachment of forest land swamps to enhance the profit) have also been not studied scientifically. In this situation, there are chances of an environmental shock even in the near future. Seepage from the canal destroys agricultural crops and creates water logging in the forests and consequently is responsible for habitat change for many wildlife species. At present, these concerns are tackled through routine methods depending upon the situation. Most of the managers and scientists agreed that there is a clear need for further research and monitoring plan to develop the understanding on these issues.

4.7. Community Awareness and Outreach

Help from the NGOs and community representatives is taken to increase conservation awareness among the local people in particular and other stakeholders in general through several outreach programmes. Every year during the wildlife week, in the first week of October, it is important for the Forest Department to organize several awareness activities in each division. Moreover, villages having EDCs and VFPCs comprehend conservation requirements better than those where these do not exist. There are examples within the learning site in the landscape where erstwhile poachers are now helping the Forest Department in conservation efforts. Some of these institutions are functioning excellently and trying innovative methods to improve livelihoods while majority work as per schedule and lack enthusiasm. It is interesting to mention here that the EDCs with tribal dominance such as the Tharus around the DNP are the ones which could be considered the best entities.

4.8. Addressing Human Population Pressure



Every single scientific document and forest managers hold population growth responsible for the present state of forest and other natural resources in the West-Central TAL. However, there is a complete lack of strategy to tackle the problem. Population growth certainly requires attention at policy level. Conservation efforts should incorporate promoting family planning methods as an integral part of the implementation strategy as well as also minimizing further in migration/influx of people from other areas of the country. Though the health and family planning department promotes the measures to control population, limited resources hamper the widespread adoption of the measures amidst vast majority of the people living in poverty. Illiteracy, lack of awareness and age old traditional norms among the poorer sections of the society in the landscape are some of the stumbling blocks in controlling population explosion.

5

Lessons Learned and Guidelines

5.1. Landscape Approach to Ecosystem and Species Management

It is heartening to learn that policy-makers and wildlife managers have understood the fact that merely protecting the PAs would not be adequate to secure the key species in the long-term and threats also exist beyond PA boundaries. Identification of the CTR, the DTR, and the SER as management entities shows that gradually landscape approach is being adopted for effective protection of wildlife and management of their habitats in the landscape. Instead of emphasizing plantation of economically important species grassland management is gradually taking up the edge in PAs and also in MFs. Working plans of RFs now also incorporate activities for the protection and management of the habitats of mega species in the Elephant and the Tiger Reserves. The concept of corridors needs further attention from all stakeholders and also wide publicity as critical areas for the long-term survival of the species and as an essential prerequisite for the better management of the PAs and the RFs that link them. This has been achieved mainly due to the availability of new research findings that are helping in better understanding of wildlife protection and management requirements in the recent years. Further research and monitoring is required to meet the future challenges effectively.

Jurisprudence is helping in maintaining the habitat integrity in the landscape. As in the recent past, judiciary (from lower to higher levels) has helped in evicting the encroachments, stopped forest conversions, stopped some developmental activities which are detrimental from conservation point of view, and the relocation of some forest dwelling communities outside the forest while ensuring their proper rehabilitation. In Chilla corridor a breeding tigress has been observed after relocation of the Gujjars from the area. It is one of the best lessons learnt that nature bounces back if the disturbances are removed. Therefore, efforts should be made to create disturbance-free corridors between the PAs (Johnsingh, Personal Communication). Though difficult to achieve in some locations, it warrants detailed research and baseline data to suggest alternatives to relocation, habitat improvement, restoration and find out other potential corridors. Boulder mining should be immediately stopped in all critical corridors

mentioned above to maintain habitat connectivity.

5.2. Exclusion versus Participation

The fundamental approach of the Forest Department is still a traditional one in which the management aims to protect the forests and PAs from people living in surrounding areas in a situation where ninety million cattle graze inside the forests, 62% fire wood demand is met from the forests and 65% PAs are characterized by human settlements and resource use (Kothari *et. al.*, 1989). In such a condition attempts to guard PAs and forests from human use by relying exclusively on law enforcement, often results in vindictive attitudes of local communities towards forest and PA management and forest staff and most of the time leads to conflicts (Gadgil and Guha, 1992).

Exclusion is not necessarily beneficial for the resources of PAs as is happening in the DNP where *Tiliacora acuminata* is proliferating under the sal canopy in the absence of its regulated use. Studies have also shown certain habitats improve under regulated human use and that disturbances are the integral part of the ecosystem evolution. Successful resource management systems allow disturbance to enter on a scale that does not disturb the structural and functional performance of the ecosystem and the goods and services it provides (Arhem, 1985; Balee, 1989; Homewood and Rodgers, 1991; Ramakrishnan, 1992 and 2001; and Berkes and Folke, 1998). The villagers of Mallapur Khajuria located in the Pilibhit FD based on their empirical knowledge also corroborated that total exclusion of humans from the forest is not necessarily beneficial for certain ecosystem types. Similarly, the reduction in swamp deer population in Sathiana in the DNP could be attributed to the fact that apart from siltation and prolonged inundation which induced changes of vegetation composition, a total ban on grazing might be responsible for the declining number of deer because in the neighbouring Kishanpur WLS, where grazing is still continued, swamp deer are increasing in number. Detailed location-specific research is needed before arriving at a final conclusion in this regard.

5.3. Joint Forest Management and Eco-development

Natural resource conservation and management through JFM in managed forests and Eco-development in and around the PAs is a response that, to a certain degree, fulfils the valid demands of the local communities to participate in activities that impinge on their socio-economic development. Ecodevelopment is being implemented in and around the studied PAs in the TAL through the EDCs, however, examples that show concrete success of community participation in conservation while satisfying its needs are still difficult to find. The model suffers from some intrinsic problems such as the present tenural arrangements, which still rely on diverting local people from the PAs instead to work towards modifying the land tenure legislation. Tenure uncertainty is one of the biggest stumbling blocks to achieve success in participatory forest management. Policy interventions in terms of redefining tenural rights are an essential prerequisite for greater people participation in the conservation efforts so that short-term and long-term tangible benefits could also be shared with the communities.

Moreover, there is a lack of proper understanding of the eco-development concept among the local communities and also among the frontline staff. For the field staff, the eco-development activities are extended duties that too without adequate training, capacity and remuneration. The dual role to draw out the participation of local people on the one hand and protect the forest resources on the other from the same set of people, is a difficult job for which the department is, so far, ill equipped. The concept of eco-development also looks for inter-departmental cooperation but the legal, policy and administrative mechanisms to ensure this are not in place properly. Often, the PA management does not control the conservation activities in the corridors and many other critical areas, which are most of the time with the territorial divisions where the management objectives are different. Further, the lack of effective funding mechanism remains a bottleneck that exists at all levels of management.

Studies carried out on socio-economy and conservation in some parts of the landscape reveal that to benefit the local communities various

programmes such as the JFM, ecocodevelopment and ecotourism are being promoted, yet their impacts on the well being of the local people are still hardly noticeable at the landscape scale. The relationship between the local communities and Forest Department cannot be considered very cordial. Generally, communities feel that the department policies are high handed and that the department is an obstacle in their socio-economic development rather than a partner (e.g. conversion of forest land for road or other development infrastructure required by any village is opposed by the Forest Department). It is important to understand that communities must feel that the forests belong more to them rather than the forest and PA managers, and that protection and better management of these resources will ensure their long-term livelihood security.

The awareness among the local communities in particular and other stakeholders in general on conservation issues is low. Though local people do feel that rich biodiversity is always going to benefit them if a proper mechanism is evolved to involve them to share the long- as well as short-term benefits. Creating a sanctuary or RF without proper settlement of the rights and concessions, has generally led to complications and animosity in many parts of the country including the TAL (Kutty and Kothari, 2001). In addition, resource regeneration to fulfill subsistence needs of fuel wood, fodder and minor forest products of the local people may be given priority and the changed aspirations should also be taken into account by providing tangible economic benefits from conservation efforts.

Communities should be given direct benefits even in the short run, e.g. fodder, fuel wood, and NTFPs, as well as benefits from eco-tourism. Detailed research is needed to collect the baseline information and design the suitable natural exploitation regimes. In India, Panchayats, the legal grassroots level institutions can offer scope for people participation in conservation, especially after the 73rd amendment to the Constitution. However, it must be noted that in the TAL the situation is at a point where further experiments based on untested assumptions and piecemeal approach must be avoided. Resource regeneration on community and private lands and also in the degraded forestlands should be given priority. Agroforestry, fodder cultivation, grazing regulation, soil conservation are some of the feasible options

that could be promoted with the village-level institutions.

With the creation of tiger and elephant reserves in the landscape, there is emphasis on reduction of threats, improvement in habitats and creation of corridors for the mega species beyond the PA boundaries. However, the increased human wildlife conflicts such as crop raiding by wild herbivores, and cattle lifting and particularly human killing by the carnivores must be tackled effectively. Cash compensation schemes and prevention techniques such as habitat management, solar powered electric fencing and digging of trenches are among the few strategies that could be taken up at a larger scale.

5.4. Scientific Basis for Habitat, Species and Weed Management

In spite of the lack of sufficient scientific data on various issues leading to habitat fragmentation and biological invasion, the number of mega species is static or increasing in this human dominated learning site complexes in the landscape. However, long-term survival cannot be guaranteed. According to the Tiger census report, in the CNP the number increased from 44 tigers in 1972 to 137 in 2001-2002 while in the DNP the number is fluctuating between 90 in 1989 and 104 in 1997. Rhinos reintroduced in the DNP in 1984 are doing fine and the number is continuously increasing.

Based on the empirical knowledge and also some scientific experiments, mainly cutting and burning are practiced to maintain grassland diversity and productivity to meet the fodder requirements of wild herbivores and subsistence needs of the dependent people. It has been observed that the above treatments favour the improvement of habitat for wild ungulates, particularly swamp deer and hog deer if the treatments were given during the summer season.

The impacts of various management practices on ecosystem structure and functions are not properly understood and hence debatable. The studies carried out so far have limited scope to be followed for maintaining a whole range of biodiversity in the TAL. It could be rectified through developing a good scientific understanding of the natural interactions between forest and grassland ecosystems to determine the desired successional

state for all species for their long-term benefit. Well-planned and targeted studies are needed on several factors contributing to habitat fragmentation. Research also needs to understand the status, ecology and habitat needs, and population and management strategies for the other less dominant species that contribute significantly to enhance the biodiversity.

Many of the responses described in the earlier sections have shown encouraging results in maintaining habitat integrity yet some of them, such as desilting of rivers in the DTR area and manual removal of weeds such as *Lantana*, *Parthenium* and *Sesbania* are time- and resource-consuming activities and may not necessarily be yielding the desired results. Robust monitoring programmes are needed to test and support the assumptions for activities being taken for the management of PAs.

Scientific researches can provide answers to various problems relating to weed management e.g., *Tiliacora*, *Lantana*, *Parthenium*, water hyacinth, *Eupatorium*, etc. So far, lack of reliable scientific information on the weed species is leading to the generation of many myths among the management staff. In the RNP, *Lantana* has been used as a biofence to raise fodder species namely *Dendrocalamus strictus* and *Zizyphus mauritiana* for elephants on demonstration basis in 10 ha area in Ramgarh range (Johnsingh, Personal Communication). This is one of the few examples where a constraint has been changed into an opportunity, albeit at present mainly for the sake of demonstration, and success would be measured only after its large-scale replication. Different techniques and methods are being adopted for the management and control of *Lantana* and other weeds in different locations in the West-Central TAL, yet proper monitoring is lacking. A comprehensive scientific database is required for better management of the weeds in the landscape that sometimes seriously threaten the habitat integrity within as well as outside the PAs.



5.5. Management Capacity and Partnerships

Age profile of frontline staff is a big challenge. New recruitments are few and therefore most of the frontline staff is over aged to withstand the vagaries of field responsibilities. The staff requires proper training to implement ecodevelopment and JFM with local people, in the PAs and territorial divisions, respectively. Many approved positions at various levels are lying vacant which should be filled as soon as possible. There should be a proper mechanism in place to receive the feedbacks from frontline staff to be incorporated in the management plans of the PAs and the working plans of the territorial divisions. The feedbacks would definitely help in improving the management in the ever-changing ground situation. Community participation is indispensable to reduce the cost of conservation and at the same time improve the management of PAs for longer periods of time. In this connection the ground that has already been made by creating institutions like VFPCs and EDCs needs further strengthening. Specialist voluntary organizations should also be roped in to work as partners.

5.6. Guidelines for Stakeholders

For Forest Department and PA Managers

- i) Should consider local communities as real partners in the Forest and PA management and try to evolve effective location-specific strategies to seek it through JFM and ecodevelopment programmes. Utmost care is needed while developing the micro plans.
- ii) Working plans of territorial divisions and management plans of PAs may be developed taking note of the latest scientific information and also views of key stakeholders to make them more participatory and adaptive. The working and management plans may also benefit from the experiences of frontline staff.
- iii) Young and motivated staff should be recruited to cope with the arduous field duties and trained manpower should be enhanced to perform the specialized jobs.
- iv) Problems of encroachment, forest conversion, illegal logging, poaching of wild animals need swift

action and support from key stakeholders. Develop effective community outreach programme for proper communication, environment awareness and education.

- v) There should be a mechanism to seek regular training to build capacities of the frontline staff to execute the new programmes.

For Policy Makers

- i) Develop an integrated, adaptive and implementable policy plan that looks into conservation, livelihood and development problems simultaneously as these issues are closely linked. This could be through developing mechanisms for proper institutional arrangements and cooperation among various institutions and line agencies at intra- and inter-state levels.
- ii) Develop incentive-based systems for family planning, controlling in-migration, managing livestock populations and unregulated grazing, and ensuring sustainable resource use considering landscape approach.
- iii) Evolve plans to ensure equitable distribution of costs and benefits of wildlife conservation to the local communities in order to enlist their long-term support.
- iv) Develop mechanisms for suitable tenural arrangements so that VFPCs and EDCs become formal grassroots level conservation entities.

For Research Organizations

- i) Applied research to be carried out for the better management of existing forest and grassland resources, regeneration and restoration of corridors and mega species conservation.
- ii) Research may also target to explore the linkages between social and ecological systems in order to manage habitat fragmentation, weed proliferation, forest fires, over grazing, human-wildlife conflicts, etc.
- iii) Scientific validation on the various activities (responses) that are implemented to protect, manage and restore the forests and wildlife according to the working and management plans.
- iv) Also to help develop implementable monitoring plans.
- v) Develop a plan to facilitate speedy incorporation of research findings in the working and management plans of territorial FDs and PAs, respectively.
- vi) To initiate studies on some natural forest disturbances such as floods and diseases to minimize the negative impacts.

For NGOs

- i) Work with the Stakeholders and develop strategies to facilitate effective implementation of various conservation initiatives and also to provide feedback to the relevant stakeholders.
- ii) Work as a facilitator to find out problems, suggest solutions, generate resources and support in advocacy and lobbying for achieving conservation successes.
- iii) Support development of plans to strengthen the partnerships among the key stakeholders and spreading awareness and education and also the conservation successes among the wider sections of the society.
- iv) Amidst complexities, help the conservation fraternity in prioritizing and streamlining policies and actions.
- v) Facilitate financial and technical support from international organizations to relevant agencies to cope with the global change factors, i.e. habitat fragmentation and biological invasion in the critical areas in the landscape.
- vi) To increase conservation understanding among political representatives in order to generate political will to achieve conservation and development goals.

Conclusions

The CTR can be adjudged as a PA, managed better than the other PAs in the West-Central TAL. The increasing sizes of mega species populations, together with increasing preferences to eco-tourism (around 40 to 50 thousand tourists visit CTR every year), are indicative of this. The DTR and the RNP, on the other hand, currently supporting many charismatic species, are facing unsustainable levels of human interference which are aggravated by natural processes operating in these PAs. The entire West-Central TAL comprises agricultural lands, urban and semi-urban areas, PAs, and forests/fragmented habitats that differ in structure and biodiversity due to human use. Unplanned development and inadequate management interventions have led to undesirable agriculture expansion and intensification, inappropriate infrastructural development, encroachment of forest land, over grazing, illicit timber harvesting, boulder mining and weed proliferation. These factors are responsible for reduced forest area and degraded forest quality resulting in habitat fragmentation in the landscape. Habitat fragmentation is the root cause of declining wildlife populations, increasing human-wildlife conflicts, and relentless losses of biodiversity and associated ecological goods and services.

A variety of approaches is needed to minimize further habitat fragmentation and to restore degraded forest areas taking into account the diverse socio-ecological situations and stakeholders' needs and preferences. Thus, the interventions should be such that biodiversity conservation is linked with improved supply of subsistence goods and ecological services. However, identification and implementation of such interventions are the challenges of the day. At present, the level of understanding about the dynamics of ecological systems at the landscape scale is extremely inadequate. Interactions and feedbacks between ecological and socio-economic systems remain poorly understood, and therefore, participation of local communities in Forest and PA management and development planning is limited. Participatory and inter-disciplinary research and monitoring programmes are essential to understand the ecological and socio-economic interactions, guide the management regimes and to track the effectiveness of the interventions for continued improvement in the biodiversity. This approach may also help ensure sustainable livelihoods in this human dominated landscape.

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8

Annexures

8.1. Abbreviations Used

ANR	:	Assisted Natural Regeneration
CEC	:	Central Empowered Committee
CNP	:	Corbett National Park
CTR	:	Corbett Tiger Reserve
CWLW	:	Chief Wildlife Warden
DFO	:	Divisional Forest Officer
DNP	:	Dudhwa National Park
DTR	:	Dudhwa Tiger Reserve
EDC	:	Eco-Development committee
FD	:	Forest Division
ER	:	Elephant Reserve
JFM	:	Joint Forest Management
MF	:	Managed Forest
MoEF	:	Ministry of Environment and Forests, Government of India
NGO	:	Non Government Organization
NP	:	National Park
NTFPs	:	Non Timber Forest Products
Range	:	Forest range within a FD
RF	:	Reserved Forest
RO	:	Range Officer
RNP	:	Rajaji National Park
SDO	:	Sub Divisional Officer
SER	:	Shivalik Elephant Reserve
UP	:	Uttar Pradesh State
VFPC	:	Village Forest Protection Committee
WII	:	Wildlife Institute of India, Dehradun
WLS	:	Wildlife Sanctuary
WLPA	:	Wildlife Protection Act, 1972
WWF	:	World Wide Fund for Nature

8.2. Critical Corridors in West-Central TAL

The critical corridors identified by Johnsingh *et. al.* (2004) of Wildlife Institute of India, Dehradun in the above stretch of the landscape are being reproduced below:

Kansrao-Barkote Corridor (Barkote range Dehradun FD and Kansrao range RNP)

This 2 km stretch that connects the above forest area is under pressure arising out of wood cutting and grazing. The proposed 4-lane Delhi-Hardwar-Dehradun highway will further threaten the

viability of this corridor.

Chilla-Motichur Corridor (Motichur RNP and Chilla RNP)

The expansion of the Hardwar, Rishikesh townships and Raiwala village, army ammunition depot and Hindustan antibiotic factory near Raiwala, settlements on the west bank of the Ganga River for the evacuees of Tehri Dam hydroelectric project being constructed up in the Himalaya, and construction of the 14 km long Rishikesh-Chilla power channel on the east bank have resulted in the disruption of habitat connectivity in this corridor. When we are thinking about maintaining the habitat connectivity for the mega species like elephants in the TAL conservation, this corridor is of great importance. If the corridor is not maintained the close elephant and tiger habitat on the west of Ganga will remain an isolated habitat of smaller size in the landscape.

Rajaji-Corbett Corridor (Chilla RNP and Corbett NP)

Two ranges of the Lansdowne FD, namely Laldhang and Kotdwar form the above corridor between the RNP and CTR in the west and east, respectively. Agriculture expansion and human settlements have disrupted the connectivity in the foothills between the PAs. The remaining connectivity is only through hills which is also facing pressures like grazing and other human disturbances due to Gujjar (203 Gujjars and 330 buffaloes), Bhotiya (17 bhotiyas and 800 sheep and 250 goats) and settlements and villages situated on the northern and southern (15,000-20,000 people) in a 3-km stretch boundary of the corridor.

Kalagarh Corridor

The Kalagrah reservoir across Ramganga, constructed during the 1970s, and the Kalagrah Township (90 sq. km) have reduced the movement of tigers across the river, south of the reservoir, from the CNP to the Sonanadi WLS. The limited movement is from Sukha sot area which is under great pressure due to fuel wood collection and encroachment. The cases are filed with the Sub Divisional Magistrate Kotdwar to evict the encroachers.

Kosi River Corridor (Corbett NP and Ramnagar FD)

The river flows between the CTR and Ramnagar FD. Encroachment in Sunder khal, 3.5 km long, at

present, started in 1974. The Court located at Kashipur favouring eviction is yet to be enforced in totality. The encroachers also put pressure on the CNP for fuel wood and fodder.

Boar River Corridor

Burgeoning tourism and big resorts and other infrastructural development may jeopardize the connectivity. Construction stopped by Supreme Court.

Nihal-Bhakara Corridor (Ramnagar FD and Terai central FD)

This corridor, which is 4 km wide between Boar River and Gola River, connects the Ramnagar FD with Terai central FD. Clear felling for agriculture besides legal and illegal commercial felling, village settlements and large cattle population are some of the problems being faced in the long term maintenance of the corridor.

Gola River Corridor (Terai Central FD and Terai East FD)

Bustling growth of the Haldwani Township and Lal Kuan Industrial complex on the southern edge of Haldwani has broken the habitat connectivity. Heavy vehicular traffic along the road and large-scale boulder mining involving hundreds of labourers along the Gola river from October to June, have also contributed to this fragmentation. The firewood and other demands of these migrant labourers could finish the forests of Doli Range of Terai east FD and Tanda Range of Terai central FD.

Kilpura-Khatima-Surai Corridor (Terai East FD)

Encroachment and infrastructure development have caused a distinct break in the tiger habitat in the Khatima Forest Range, between Kilpura and Surai Ranges of Terai east FD. The forests of Khatima range are a crucial link in the chain of connectivity between the Haldwani FD, Pilibhit FD and the forests in Nepal, and can serve as a corridor for several large mammal species, including tigers and a population of approx. 30-40 elephants that are currently confined to the Haldwani FD and Terai east FD. The Terai east (Bindu Khatta encroachment) FD faces severe encroachments, wood cutting. The Army camp, the Banbasa Hydel project, Sharda sagar and Sharda canal constructed in 1955-56 to 1959-60 have led to the loss of forests areas. The Surahi range connects the Uttaranchal part of the landscape to

the Mahob and Mala ranges of Pilibhit FD in Uttar Pradesh.

Lagga Bagga-Suklaphanta-Tatarganj Corridor (Pilibhit FD-Lagga Bagga-Barahi range, Pilibhit FD and Tatarganj Block, Sampurnanagar range North Kheri FD to Kishanpur WLS)

The Lagga Bagga forest block of 5.9 sq. km is a part of the Barahi Range of Pilibhit FD and situated at the left bank of the Sharda River. So far, it is contiguous with the Suklaphanta Wildlife Reserve of Nepal in the north. Tatarganj of Sampurnanagar range of North Kheri FD, a narrow stretch of forest, along the left bank of Sharda, provides connectivity between Suklaphanta WLR and Haripur range of Pilibhit FD across Sharda. There are settlements of over 100 households between Lagga Bagga and Tatarganj, which have led to habitat loss between the above. Encroachment by nearly 2000 Bengali settlers which began during August-September 1996 was subsequently removed from the core area of Lagga Bagga. However, in spite of relocation they continue to exert pressure on the forests of Lagga Bagga for firewood and cattle grazing. Change in the course of the Sharda also disrupts the forests at times.

Kishanpur-Dudhwa Corridor (Kishanpur WLS and Dudhwa NP)

Increasing human habitations, encroachments, and vehicular traffic, particularly along the Paliya-Sampurnanagar road, have disrupted the connectivity between Kishanpur WLS and Dudhwa NP. As a result of this, according to the local people, NGOs and FD personnel, tigers occasionally move between the PAs using vast sugarcane fields. There is a 56 km long porous international border which is heavily populated. Besides, a 31 km long rail line and 40 km public highway pass through the core zone of the DNP. An 18 km railway line and a public highway pass through the Kishanpur WLS.

Dudhwa-Katarniaghat Corridor (Dudhwa NP and Katarniaghat WLS)

Isolated forest blocks of different sizes in north Nighasan Range (north Kheri FD) amidst agricultural matrix give connectivity between Belrayan range of DNP and Katarniaghat range of Katarniaghat Wildlife Division, along two corridors. Twenty-one villages located in this corridor have encroached upon nearly 16 sq. km of the forest. There is a gap of 6-7 km between Ramnagarh and other forest patches close to Katarniaghat. The gap

is dominated by agricultural areas, largely sugarcane and wheat and habitation of Tharus and Punjabi settlers. During the last eight years, 1.71 sq. km encroached area has been evicted and afforested at the cost of Rs. 34,00,000. Elephants from the Bardia NP in Nepal have started moving to Katarniaghat Wildlife Division through riverine forest and degraded forests interspersed within the larger agricultural matrix.

8.3. Stakeholders' Consultations

WWF-India is directly involved in the facilitation of conservation activities in the TAL since 1997. Conservation measures have already been prioritized and a monitoring plan is in place for the next three years (2004 onwards) for the above mentioned critical sites. These have been developed with the help of key stakeholders including FDs, research organizations and local NGOs. Habitat fragmentation has been identified as one of the major factors that threaten the long-term survival of the mega species in the landscape during the consultations. The present report substantially benefited from these consultations. During the course of the present project three extended field visits were made to the landscape between Rajaji NP and Katarniaghat WLS. The following stakeholders were consulted individually and sometimes in small groups to elicit their views on the change factors and responses to cope with the identified factors.

Prof. A. J. T. Johnsingh (Wildlife Institute of India, Dehradun)
 Dr. Qumar Qureshi (Wildlife Institute of India, Dehradun)
 Mr. G. S. Pande (Director, Rajaji National Park)
 Mr. M. S. Maindola (Range Officer, Ramgar Range, RNP)
 Mr. S. P. Saklani (Range Officer, Kansrau Range, RNP)
 Mr. Vivek Pande, (Deputy Director, CNP)
 Mr. Kapil Lal (DFO, Working Plan, Ramnagar)
 Ms. Neena Grewal Lal (DFO, Ramnagar FD)
 Mr. Rasaily (DFO, Terai west FD)
 Mr. A. Prasad (SDO, Terai west FD)
 Mr. Surendra Mehra (DFO, Haldwani)
 Mr. N. C. Pant (Range Officer, Gola Range, Terai east FD)
 Mr. H. L. Yadav (SDO, Terai east FD)
 Mr. Gyan Sharin (Corbett Foundation, Ramnagar)

Mr. Neeraj Yadav (DFO, Pilibhit FD)
 Dr. V. P. Singh (Tarai Nature Conservation Society)
 Dr. Harish Kumar Guleria (WWF-India, Pilibhit Field Office)
 Dr. Badrish Mehra (WWF-India, Ramnagar Field Office)
 Mr. D. C. Upadhyay (Frontline Staff, Terai central FD)
 Mr. Kailash Tiwari (Frontline Staff, Terai central FD)
 Mr. P. P. Singh (Deputy Director, DNP)
 Mr. R. C. Jha (DFO, North Kheri FD)
 Mr. B. N. Singh (SDO, South Kheri FD)
 Mr. B. N. Singh (Range Officer, Katarniaghat WLS)
 Mr. P. R. Maurya (Wildlife Warden, DNP)
 Mr. Dabir Hasan (Katarniaghat Welfare Society, Bichia)
 Mr. Akhtar Miyan and Mr. Shoib Rizvi (Turquoise Society Pilibhit)
 Mr. Ramnath Kushwaha, Mr. Ram Kumar Pal, Mr. Sriram and many other villagers (Mallpur Khajuria Village, Pilibhit)

Apart from the above, views of a number of frontline staff posted in various FDs and PAs along with many villagers were also recorded during the field visits.