Assessment of Corridor Viability and Habitat Restoration between Dudhwa N.P. and Katerniaghat WLS and it s Management in Western Terai Rhino Conservation Unit, Kheri District, Uttar Pradesh, India

FINAL DRAFT REPORT

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Introduction

Preamble

The terai is one of the worlds most specticular landscapes, encompassing the tall grasslands and sal forests of the southern slopes and foothill valleys of the eastern Himalyas. This biologically diverse lanscape spans as area of approximately 12.3 million acres (5 million hectares) from Nepal s Bagmati River in the east to India s Yamuna River in the west. The Terai is home of endangered wildlife such as the tiger, Greater One-horned rhino, Asian elephant, sloth bear, gaur and Gangetic river dolphin and also contains vital migratory and breeding habitat for over 500 bird species.

In fact, the Terai lanscape is one of the last few places in the world where rhino, elephants and tigers coexist and offers exciting and urgent need for conservation. This landscape contains two Asian Rhino and Elephant Action Strategy (AREAS) priority populations of Greater Indian One horned Rhinos.In fact, terai landscape area supports the second largest population of Greater One-horned rhinos in the world along with three reintroduced rhino population.

Fifty years ago, terai (In Sanskrit for lowlands) stretched across 1,600 kilometers of rich forests and tall grasslands. Since than, the exploitation and unsustainable management of forest resources has led to fragmentation and degradation of natural habitat. Approximately 3 million people, of which 50 percent subsist below the poverty line, live in this lanscape and depend on its resources for their livelihood. In addition to the degradation of habitat, specific threats to the lanscape, and to its rhinos, elephants, and tigers, include poaching and illegle wildlife trade, as well as human- wildlife conflict (WWF-Nepal Terai ARC).

Corridor plays an important role in management of landscape, by linking fragmented forest patches and provides accessibility to alternative habitat for long ranging animals. It also helps in maintaining gene flow as it is required to prevent inbreeding depression thus causing extinction (Harris, 1984). In recent years a

number of wildlife habitat have under gone or are threatened with fragmentation due to various anthropogenic factors and this has actually affected large mammal population residing in them (Johnsingh et al 1990, 91).

Dudhwa National Park and Katerniaghat Wildlife Sanctuary are important habitat for large mammals like rhino, elephant, tiger, swamp deer and other wild animals found in the terai and bhabar range. Once these areas had abundant population of rhinoceros (Laurie, 1978), linked with each other, now has reintroduced and isolated populations. A number of rhinoceros have been reintroduced in recent past from Pobitara Wildlife Sanctuary, Assam and The Royal Chitwan National Park, Nepal to Dudhwa in India (Sale and Singh, 1987, Sinha and Sawarkar, 1993) and from the Royal Chitwan National Park to Royal Bardia National Park in Nepal (Barner, 1988, Mishra and Dinertein, 1987, Jnawali and Wegge, 1993) to establish new viable breeding populations and safeguard this species from various threats. The Katerniaghat Wildlife Sanctuary has three rhinos dispersed from Royal Bardia National Park to Katerniaghat Wildlife Sanctuary.

The corridor between Dudhwa National Park and Katerniaghat Wildlife Sanctuary has been disrupted due to continuous biotic pressure and human settlements. The situation of corridor between Katerniaghat Wildlife Sanctuary and Royal Bardia National Park is more or less similar. In the past corridors were safer passages for animals while movement from one place to other. Records on the regular movements of tiger, elephant and rhino from Katerniaghat Wildlife Sanctuary to Dudhwa National Park are limited. But movement of elephants and rhinos takes place between Royal Bardia National Park and Katerniaghat Wildlife Sanctuary, which is restricted to certain areas. In such situation, revival of corridors is very important for survival of these three isolated wild animal population including rhinos, tiger and elephant.

In the past entire terai area had rhino, elephant and tiger population. In due course of time due to rapid growth of human and livestock population, establishment and growth of cultivation and rehabilitation of displaced population during partition of India brought to bear immense pressure on the land and

gradually link between Dudhwa National Park and Katerniaghat Wildlife Sanctuary lost its integrity and identity. Currently wildlife population is restricted to two different PA. In both the areas rhino, tiger and elephant occur with other sympatric larger mammals. If the habitat of the corridor is restored the connectivity will promote genetic exchange not only between Dudhwa National Park and Katerniaghat Wildlife Sanctuary but also with the Royal Bardia wildlife Sanctuary, Nepal. This possibly may reduce the Man-Animal conflict. Currently number of tigers, wild pigs and seasonally elephants and rhinos are seen in the cultivated areas between Dudhwa National and Katerniaghat Wildlife Sanctuary. Keeping these problems in mind this study is justified in carrying out the assessment of corridor viability and habitat restoration between Dudhwa National Park and Katerniaghat Wildlife Sanctuary and its management in Western Terai Rhino Conservation Unit.

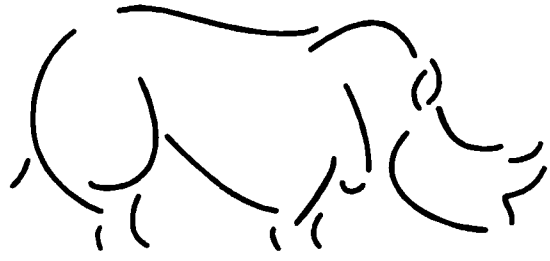
In the current study, assessment of corridor areas between Katerniaghat WLS and Bardia WILS was not included. In 1999, these areas were covered in a preliminary survey. Considering the importance of link and current situation of both the areas namely Katerniaghat WLS — Corridor- Bardia WLS. A finding of earlier survey of this area is included as Annexure-I in the current report.

Project Objectives

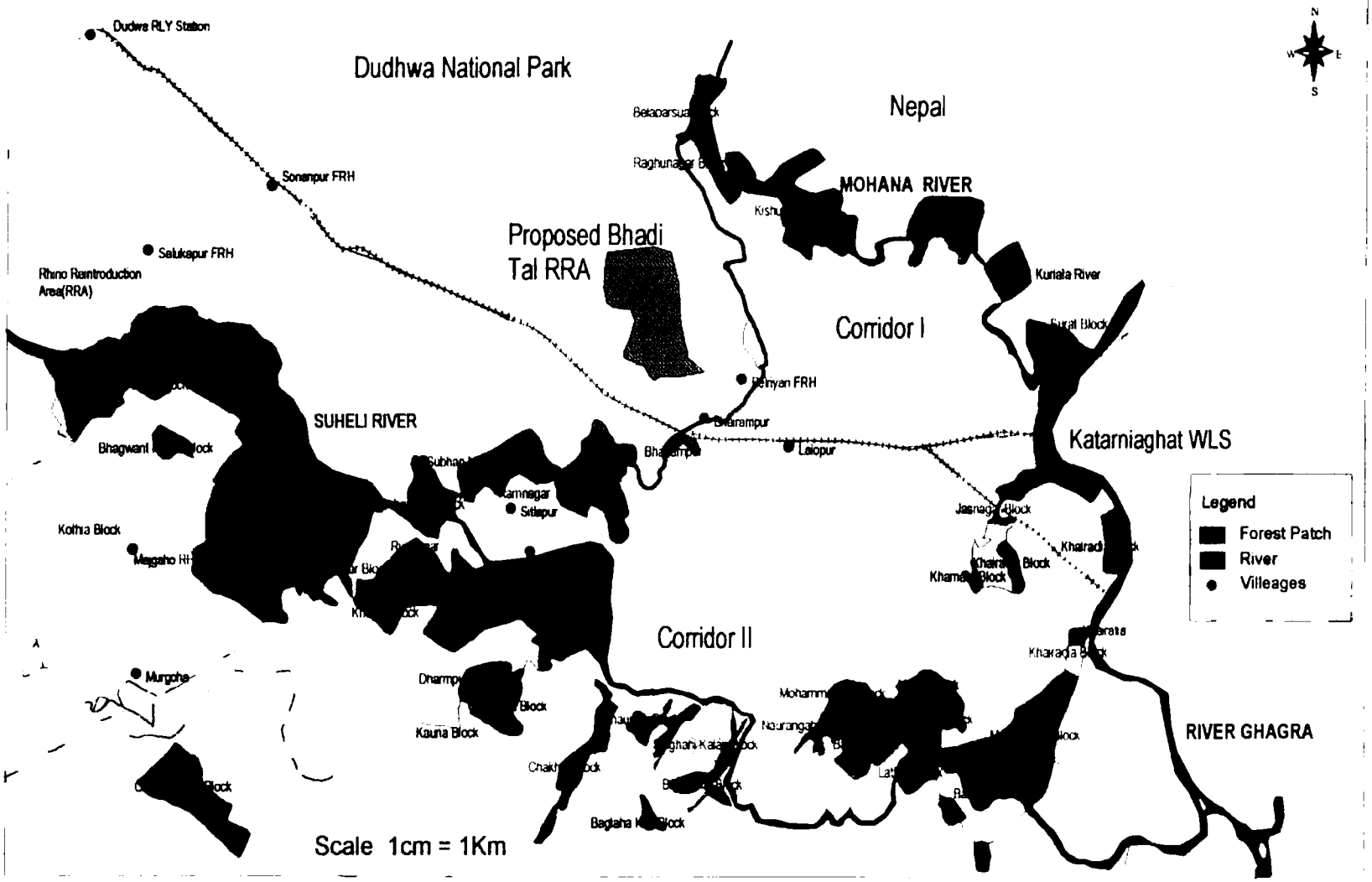
1. To assess the current status of the reintroduced rhino population and conduct a review of the Rhino Reintroduction Programme in Dudhwa National Park / Tiger Reserve.
2. To assess the current state of faunal and floral diversity in the corridor habitats between DNP — Katerniaghat.WLS.
3. To assess the extent of the wild animal movement in the corridor.
4. To study the socio-economic status of people living in and around the corridor areas and their dependency on the resources of the areas.
5. Using the information demarcate the possible corridor link between Dudhwa National Park - Katerniaghat Wildlife Sanctuary and to prepare a plan for habitat restoration that includes cost analysis and other management inputs needed.

Project Sites

The forest patches in possible corridors between Dudhwa National park and Katerniaghat Wildlife Sanctuary are a part of North Kheri forest division, which lies between 27^0 42 to 28^0 46 N and 80^0 12 to 81^0 16 E. North Kheri Forest Division was created in the year 1916 with vide G.O.No 313/xiv-31, dated April 8,1916 with the forests in Trans-Sarda areas. In 1977, the division was reorganized after the creation of Dudhwa National Park. Most of the old reserve forests of the division were transferred to the Dudhwa National Park, which forms the buffer. Forests of North forest division are fragmented and in small patches which are situated on the banks of rivers Mohana and Suheli. The Northern boundary of the forest division forms international border between India and Nepal extending from Pillar No. 98 to 139 and 195 to 211. There are six forest ranges in the North Kheri forest division namely, Sampurnanagar, Palia, Manjhghae, North Nighasan, South Nighasan and Dharohara. The forest patches of two possible corridors falls mainly under North Nighasan, South Nighasan and Manjhghae ranges. The corridor No.1 links the North Eastern corner of Dudhwa NP to North Western part of Katerniaghat WLS and corridor No.2, the South Eastern portion of Dudhwa NP to North Western part of Katerniaghat WLS below the first corridor.



Proposed Corridor and Forest Patches between Dudhwa National Park and Katerniaghat WLS

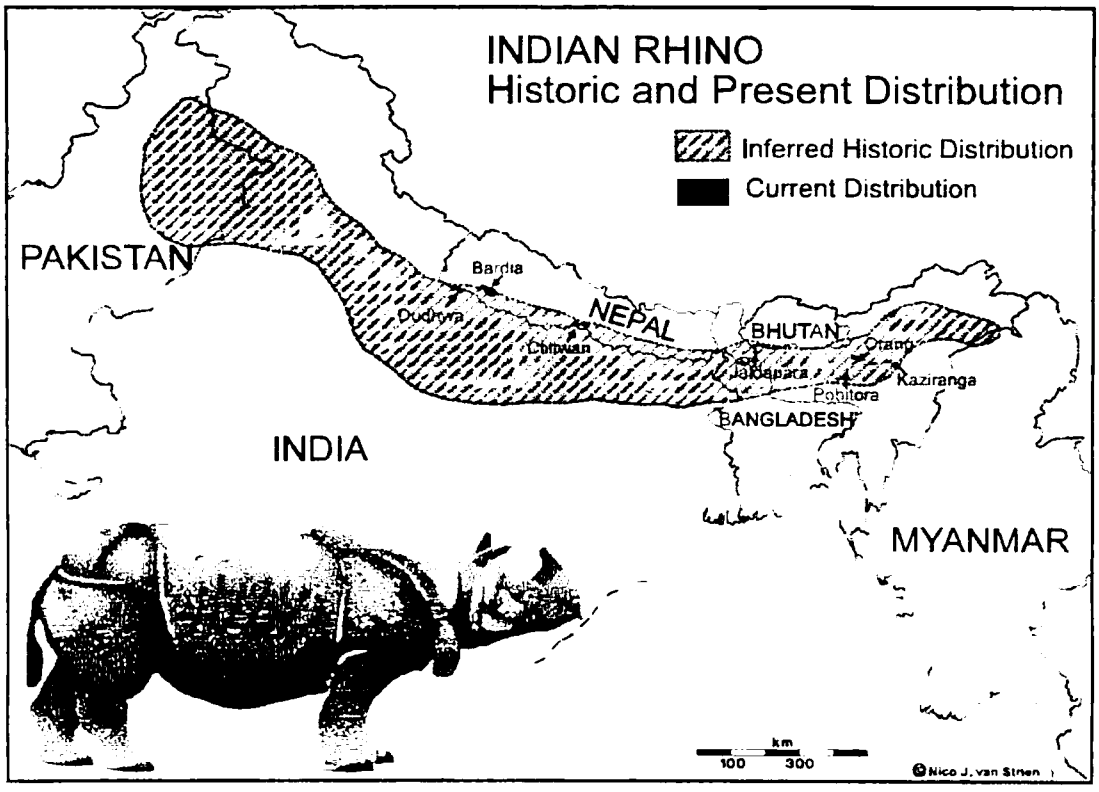


CHAPTER 1

Status of the reintroduced rhino population

1.1 Historical perspective

The Great Indian One — Horned Rhinoceros roamed all along the foothills of Himalayas. Its distribution range formed a northern border fringe of the erstwhile-undivided Hindustan. It extended from Afghanistan to include Bangladesh and up to Arunachal Pradesh. Babar mentions its presence up to Peshawar. This magnificent mega-herbivore was distributed in the valleys of Indus, the Ganges and Brahmaputra. Its southern limit seems somewhat uncertain but presumably, it did not extend into drier parts (Sale, J.B.). Hunting and poaching for sport, horn or hide as well large scale conversion of the terai grasslands to agriculture and tea plantations during last two hundred years or so has led to the persecution of this species from its past distribution range. This has converted the past continuous range from Peshawar to Assam into isolated pockets of grasslands.



By 1984, only 1500 individuals of the species were left all over the world (Singh and Rao, 1984) of which 1200 existed in India and another 300 in Nepal. In India, almost the entire population was found in Assam, Kaziranga National Park being the stronghold with about 1000 individuals. Rhino population in Nepal at that time was restricted to one location i.e. The Royal Chitwan National Park.

Being concerned with the alarming situation the world community led by the IUCN looked into the problem at great length. The Asian Rhino Specialist Group of the IUCN s Species Survival Commission studied the causes of decline in the population of the species and concluded that some of the rhinos from Assam may be trans located to a place within its past distributional range. Current threats and criteria for translocation, referred to as re-introduction hereafter, were hammered out. A Sub-Committee of the Indian Board of Wild Life was constituted to select and recommend a site for Re-introduction Programme. The sub-Committee visited seven sites in India and sought the services of the Botanical Survey of India to assess the habitat suitability of different alternative sites. A team led by Dr.Hazra, Botanical Survey of India studied the vegetation of Kaziranga and Dudhwa, concluded that Dudhwa National Park had 45 common floral components similar to that of Kaziranga NP, Assam. Later on, based on expert committee report, it was decided to translocate 30 rhinos from Assam to Dudhwa as it was thought that it would help assure survival of the species in case of any stochastic eventuality of local extinction. A team led by Dr Sale, FAO Expert, recommended techniques for capture, transport and conducted training to the forest personnel and veterinarian. Later on the same team led the capture and transport operations.

In March 1984, six animals were captured from Pabitara Wildlife Sanctuary, Assam out of which one large male escaped from stockade during night. Remaining five was transported via air and road to Dudhwa National Park. At Dudhwa, these animals were initially kept in stockades for intensive care. One female from the group died after 11 days. Of the remaining four, three animals were released on the 20th April 1984 and the large male was released on the 9th May 1984.

During 1985, with an object of establishing a vigorous founder population of Rhinos, four young adult female Rhinos were obtained from Royal Chitwan National Park, Nepal in Exchange for 16 domesticated Indian elephants. It was thought that by selecting only females, the reproductive potential in Dudhwa would be more than doubled and eventual mating of these animals with the totally unrelated Assam males would ensure genetic vigor (Sale. and Singh, 1986).

There were several setbacks faced by the Re- introduced rhino population. The single major cause was intra-specific fight among male and between male and females. There was one individual dominant male from Assam, named Bankey that has dominated the entire re-introduced population. During 1988, one of the males was died leaving behind only male in the population. Realizing the threats of in breeding, one male was brought from Kanpur Zoo, but it was seriously injured by Bankey, and was sent back.

Eighteen years after the re-introduction, rhino population has increased to 20 but recently lost two rhino calves killed by the tiger. Total existing rhino population in Dudhwa NP reached to 18 rhino. It shows by a number of birth took place in Rhino Re-Introduction Area (RRA) in Dudhwa NP/Tiger Reserve which is quite encouraging and a successful reintroduction Programme and has well adapted in its former range.

1.2 Objectives of the Study

1. To assess the measures adopted for managing re-introduced population of rhinoceros at Dudhwa Tiger Reserve
2. To analyze the problems realized in managing the population
3. To develop strategy for sustained success of the Programme
4. To examine the possibilities of enlarging the habitats for the re-introduced rhinos
5. To identify the potential rhino habitats for enlarging the habitats
6. To identify the strengths and weaknesses in managing these areas

1.3 Study Area

Approximately 90 sq. km of grassland area under Dudhwa Tiger reserve is located on its south — west portion along river Suheli. It is a 15 km long tract, which is suitable as rhino habitat. About 50 percent of this area is subject to seasonal flooding and an area of about 560 ha is permanently swampy and water logged. The Rhino Sub-Committee of the Wildlife Status Evaluation Committee of the IBWL felt that the area was highly suitable. Energized fencing called as Rhino Re-introduction Area (RRA) was selected for re-introducing rhinos enclosed a small area of about 27 sq. km. This comprised the entire Kakraha Block and a part of Chhota Palia Block falling under the jurisdiction of South Sonaripur Range. The RRA has a total of eleven water-bodies (Taals) namely Kakraha Taal, Bara Puraina, Chhota Puraina, Bhandar, Bar Godha, Chhedia, Chaitua, Amha, Bela, Kurmunia and Kaimahia. First seven are permanent whereas the last four get dried during summers and water is augmented by pumping water from wells. The chain of water bodies lie along the Damar Sal and grassland ecotone.

The lakes and streams, Andhra and Chabakwa represent remnant flows of the old courses of river Suheli. During monsoon, major portion of the grassland inside RRA remains flooded and water currents can be seen in the two streams and across the chain of swamps while the other areas have up to four feet of standing water. The area of 27 sq. km comprises Damar Sal forest — 20 percent and grasslands - 80 percent with fringe forest. Initially entire area was enclosed with a three strand energized fence. A 9 km stretch of the RRA forming park boundary along river Suheli was additionally protected against accidental escapes by construction of an elephant proof trench (3.0mX 2.0mX 1.5m) equally effective for rhinos.

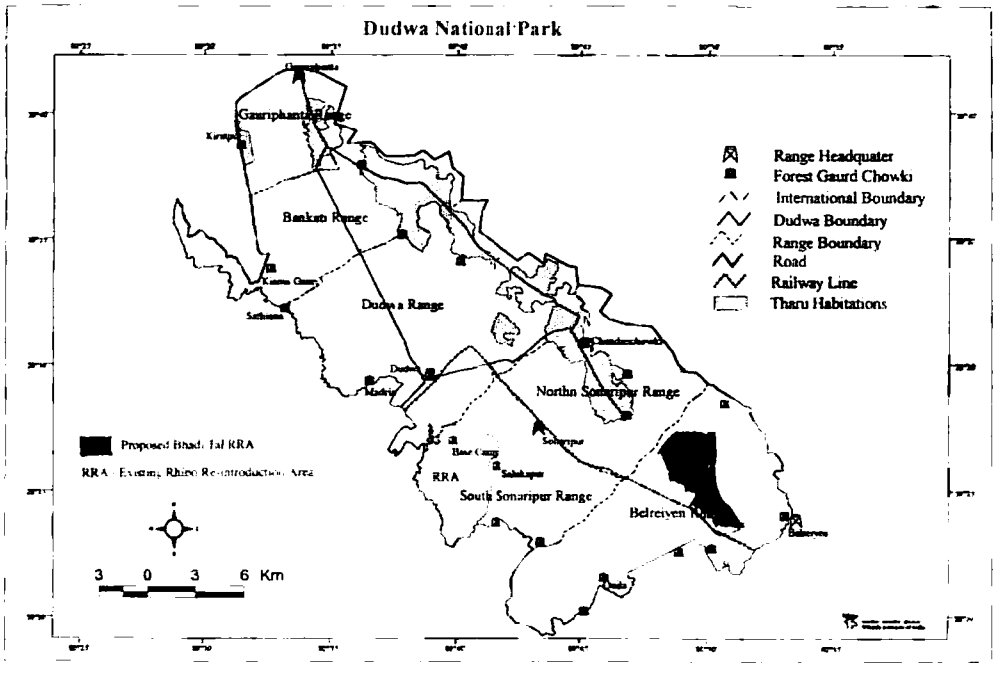
The RRA habitat is a mix of tall grassland, short grassland, marshy grassland and woodland. The extent of each type is presented in the following **Table 1.1**.

Table 1.1: Habitat Types

Sl. No.	Vegetation Type	Area (in ha)
1	Tall grassland	343
2	Short grassland	807
3	Marshy grassland	563
4	Water-bodies (Aquatic vegetation)	107
5	Fringe and Riparian	107
6	Woodland	584

The floral diversity in this area and in the park is immense. Current documentation indicates presence of 75 species of trees, 21 species of shrubs, 17 species of climbers, 77 species of grasses and 179 species of aquatic plants. There are at least 24 species of plants of conservation importance.

Fig. 1.1: Dudhwa Tiger Reserve



The main tree species are Sal (Shorea robusta), Asna (Terminalia tomentosa), Shisham (Delbergia sissoo), Bahera (Terminalia belerica), Teak (Tectona grandis), Eucalyptus spp, Khair (Accacia catechu), Jamun (Syzygium cumini), Kydia calicyna, Mitrangyna parviflora, Emblica officinalis, Phyllanthus reticulates,

Aegle marmelos, Kusum (Schleichera oleosa), Ficus spp, Semul (Bombex cieba) ect. The main grass species occurring in this area are Ulla (Bothrichloa intermedia), Meyari (Imperata cylindrica), Kaans (Saccharum spontaneum), Munja (Saccharum munja), Retwa (Sclerostachya fusca), Cymbopogon flexuosus, Desmostachya bippinata, Themeda spp, Vetiveria zizanioides, Narenga porphyrocoma ect. Reed grasses such as Arundo donax and Narkul (Phragmites karka) are distributed around water bodies and swamps.

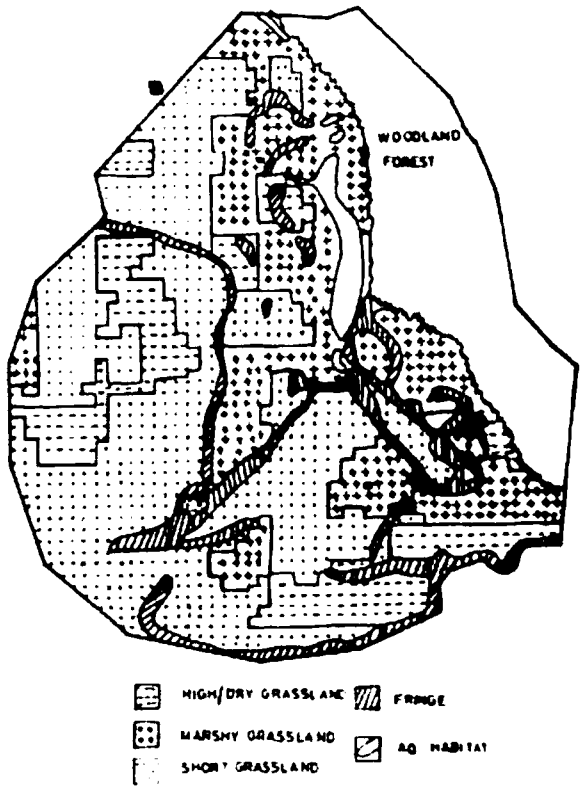
Some of the aquatic plants like Hydrilla verticillata, Vallisneria spirolis, Hygroryza aristata, Nymph spp, Water lily spp and Potamogeton spp are commonly found in the water bodies.

The RRA has a network of roads and can be approached from outside from 3 sides, namely Base Camp, Chhota Palia and Salukapur where gates have been provided in the power fence. There are two main roads inside the fence-while one travels straight from Salukapur to Base Camp, the other run along the Southern perimeter fence joining the main road at either end. As these roads remain unserviceable for long period during and after monsoon, an additional road from Salukapur to Kakraha was made in 1997-98. A feeder road links the central main road and the peripheral road. At Salukapur the staff is housed in conventional quarters. At Base Camp log huts have been built on top of high piles for housing the staff. This is a special requirement as the area remains under water for prolonged periods during monsoon. There are four watchtowers inside the RRA. While three are located around Kakraha swamp, one is at Kaimahia. All are wooden structures. These serve as animal observation posts and fire watchtowers. After opening up of the area for tourism, these towers are being used by tourists. But the condition of these towers is very bad and need immediate repair. The RRA provides a good habitat for a range of animals like Tiger, Leopard, Elephant, Swamp Deer, Sambar, Spotted Deer, Hog Deer, Barking Deer, Hispid Hare, Bengal Florican, and Swamp Partridge. During field visits hispid hare pellets and tiger pugmarks were observed. A pair of Bengal Florican was also sighted during this visit inside the RRA and in other grassland areas in Dudhwa.

The area identified for creation of a satellite population falls in the Bhadi- Churaila sector of the Reserve, which fulfils all habitat requirements for the Rhino rehabilitation. The area has already been surveyed for its habitat suitability and found fit for rehabilitation of Rhinos. The extent of area to be fenced in the Bhadi-Churaila sector has been decided on the basis of estimated number of animals in the population to be built in due course of time and habitat requirement of Rhinos for different purposes. This area comprises of Sal forest (336 ha), Grassland (608.23 ha) and Wetland/ Swamp (129.00 ha), which fulfil the need of rhino, and is one the prime rhino area in Dudhwa.NP.

FIG 1.2: RHINO REINTRODUCTION AREA

(Figure shows different habitat types inside RRA)



Habitat types inside Rhino Reintroduction Area

1.4 Methodology

Methods used for the study included primary and secondary studies. Whereas primary study consisted site visits, observation made on the rhinos in the field, management inputs provided, problems dealing with maintenance of electric fence, interaction with PA management authorities, local staff and local villagers in the southern boundary of RRA. Secondary study included study of a series of observations and assessments made by several scientists in the past years.

Methods applied for the study included:

i) Literature Survey,
ii) Interaction with PA management,
iii) Field observations and
iv) Village Survey

1.4.1 Review of literature

Literature available at the WII library was studied to develop a firsthand concept of the area and activities. It also gave the details of planning, operation. Data on births and mortality in the re-introduced population collected from past publications and from Range Forest Office Sonaripur, Dudhwa Tiger Reserve. PA management including Range Officer, Section Officers, Forest Guards, Mahouts and Fence watchers were interviewed for collecting information on different aspects of management and related problems. Records maintained at camp level, Range level and at Division level were studied to analyze monitoring mechanism. Detailed field visits were conducted for assessing monitoring efforts, status and maintenance of the fence and studying the habitat. Three Villages near the RRA were visited to assess the extent of straying out problem of rhinos.

1.4.2 Reconnaissance

A survey was conducted in the Dudhwa Tiger Reserve to collect information on present distribution of rhinos (outside the fenced area), identification of potential habitats for enlarging the rhino habitat in the near future, land use pattern, ground verification of vegetation and major threats.

- Interaction with the various levels of forest staff with a view to collect information related to current situation in RRA, problems and issues, threats etc. in potential rhino habitat were carried out.
- Various secondary information related to rhinos were collected from literature and forest records.

1.5 Scope of the Study

A comparison of the objectives of the Programme viz a viz achievements indicates success and setbacks of the Programme. Such comparison necessitates evaluation on the following aspects :

- Planning and execution,
- Breeding success,
- Management and monitoring on a daily basis, and
- Ecological aspects,

As far as planning for the re-introduction Programme is considered, it was done elaborately and this process involved experts from the Indian Board of Wild Life, Asian Rhino Specialist Group and officials from the Department of Environment and Forests at Union and State levels. An expert group led operations of capture and transport. As the success of the Programme at Dudhwa is closely related with the success of the capture and release Programme, it is felt necessary to analyze the performance of these operations too. Breeding success or otherwise and management and monitoring on a daily basis needs detailed analysis and an effort has been made. A very important component of the evaluation of the Programme would be to look into ecological implications. It would have been interesting to study the impact of the presence of the species in the Eco-system after a gap of about 100 years in Dudhwa grasslands on:

- Composition and maintenance of grasslands,
- Facilitation by the re-introduced population for other herbivores,
- Any change taking place after the Re-Introduction.

Since the current study was for a very limited period it was not possible to look into such details. However, mentioned topic needs a long term ecological monitoring and a detailed research on individual topics.

1.6 Evaluation of Measures of Success

As there were different phases of this programme's implementation, its performance has to be evaluated for these different phases separately. For this exercise, the rhino re-introduction Programme has to be analyzed for the following phases:

1. Planning Phase
2. Preparatory Phase
3. Operational Phase, and
4. Establishment Phase & Monitoring of Animals

Large-scale hunting as sports, later poaching and habitat destruction leading to fast dwindling population of this magnificent mega-herbivore attracted the attention of conservationists round the globe during mid 70 s. This followed studies, surveys and discussions on international forums like International Union for Conservation of Nature and Natural Resources (IUCN). It was during late 70 s that the Asian Rhino Specialist Group and Indian Board for Wild Life considered re-introducing the Great Indian One-Horned Rhinoceros at suitable sites within its past distributional range from where it had disappeared or was disappearing. This would, in their opinion, reduce the chances of the species becoming extinct. This Programme started with planning during late 70 s, followed by capture and release of rhinos from Assam during 1984, from Nepal in 1985 and translocation of a male rhino from Kanpur Zoo during 1992. The current rhino population has increased to seventeen by May 2002.

1.6.1 Planning Phase

For the present exercise analysis of planning phase is not required as it is out of purview of the study, subsequent phases are analyzed in the following paragraphs.

1.6.2 Preparatory Phase

After having decided to re-introduce rhinos from Assam to Dudhwa, the most challenging job was to capture them from the wild without causing injury to the animals, transport them safely and release them in a smooth manner. All these operations needed in-depth knowledge of biology and behaviour of animal and suitable technique. There was no experience of capturing Great Indian One-Horned Rhinoceros by chemical immobilization at that time, so, the noted specialist in wildlife management with specialization in drug immobilization of large animals Dr.. Sale was vested with the responsibility of suggesting technique for capture, handling and transportation, training to field staff and leading the entire operation.

Dr. Sale and Dr. Wood ford (consultant wildlife veterinarian) conducted capture trials in Assam between 7th January and 12th February 1980. The team captured five animals (all males) out of which four were transported to holding sites specially set up for this purpose. Capture and transport techniques were developed by the team and training was imparted to field personnel and veterinarians. A full report on this trial operation was published on the 5th March 1980. The report gave detailed procedures recommended for the capture and release operation. The report gave details of five successful immobilizations but did not mention any attempt of immobilization that might have failed or of any casualty. Moreover, all the five animals captured were males. Had a few females also been captured, a better know-how in special cares to be taken while capturing female rhinos might have been developed.

1.6.3 Operational Phase (Capture and Transport and release operation)

The Wildlife Status Evaluation Committee of the IBWL suggested that a minimum number of ten rhinos might be translocate to Dudhwa National Park on an experimental basis. A capture team led by Dr. J.B. Sale conducted the capture operation between 15th and 21st March 1984 in Pobitara Wildlife Sanctuary, Assam. All were captured by darting, using doses of between 1.0 to 2.0 ml Immobilon (etorphine and acepromazine mixture, Reckettes, U.K.) that was reversed by Revivon (diprenorphine). Three of the rhinos were walked directly into

crates placed immediately in front of them, by administering small doses of Revivon and guiding them forwards with ropes as resultant recovery from immobilization took place. The other two had to be transported about 1.5 km from capture site to crates on sledges. They were revived after the sledge bearing them had been inserted into the crates. All animals except one female quickly settled in the stockades and were eating well after a few days. During this capture operation, six animals were captured of which one died at Guwahati Zoo (Sinha, Sawarkar and Tiwari; Singh & Rao, 1986). Remaining five animals comprise of one adult male, one sub-adult male, two adult females and one sub-adult female were kept in the stockades.

These five animals were transported to Dudhwa having been airlifted from Guwahati to Delhi and then onwards carted by trucks. Three of the animals were given pre-flight sedation (between 10 and 20 ml azaperon) and all behaved well during the 150-minute flight to Delhi. After food and water at Delhi s Palam airport, the crated animals embarked on an 18-hour truck journey to Dudhwa National Park. Immediately on arrival, they were released into individual stockades. Rhinos were monitored round the clock basis under the supervision of Dr.R.L.Singh, Director, Dudhwa NP. All the animals were kept in holding stockades for a minimum of about three weeks to recover from the shock of tranquillization and get an experience of energized fence. One female died following a stressful abortion after eleven days at Dudhwa (Singh and Rao, 1986). Three of the remaining four was released on the 20th April 1984 and the remaining one, which was a dominant male, was released in the main fenced area after radio collaring on the 9th May 1984.

Another translocation of rhino to Dudhwa was taken up from Nepal during March-April 1985. Four females estimated to be between 5 and 7 years were captured by immobilizing from Royal Chitwan National Park. These animals were sledged into crates in which they were revived. They were driven 720 km to Dudhwa and all withstood the 24 hr journey well and with the exception of the first arrival, which broke out during the first night, quickly settled in the wild after a week.

In the two operations a total of ten animals were captured (six from Assam and four from Nepal) by drug immobilization. Out of six animals captured from Assam in 1984, two died within a fortnight after being captured. One of the animals died at Guwahati Zoo and the other at Dudhwa. Both these animals were the elder ones of the group; the female that died at Dudhwa was presumably in advanced stage of pregnancy. Another adult female was in good condition when released on 20th April 1984, but developed a limp shortly after and also had a troublesome open sore on her back. In order to investigate and treat both ailments, the rhino was immobilized on the 7th May 1984. On rising after revival her right forelimb was seen paralyzed, apparently due to nerve damage while recumbent (Sale. and Singh, 1986). In spite of intensive veterinary care the animal finally died on the 31st May 1984.

These three deaths out of a total of six animals captured were due to failure of the capture team and hence the capture and training operation was a definite failure. On the other hand it also justified that this type of incidence happens due to long distance to cover for release site and especially when large bodied animals are transported.

Capture operation of 1985 handled by the Nepalese forest authority, on the other hand was much better in various ways. First, only sub-adult animals were captured, thus minimizing the possibility of any pregnant animal being captured as had happened in the case of Assam capture. Secondly, there was no casualty after the translocation operation and all animals settled well in Dudhwa. But in 1991,one adult female of this group died because of the internal infection and abortion after fought with the dominating male to save her male calf.

1.6.4 Establishment Phase

A total of 10 rhinos were translocate to Dudhwa from 1984 to 1992. However, the last arrival to Dudhwa, a male from Kanpur Zoo returned back and it could not contribute in breeding. Out of the remaining 9 animals, one could not even be released in the wild and died in the holding stockade, two females died in 1984, one more male died in 1988 of injuries inflicted during its fight with another male

and adult female died in 1991 and lost her male calf in 1992 killed by the dominating male. So, the founder population for the Programme is five. This founder population of five has only one male and four females, which has increased to a total of 17 rhinos, which includes the founder individual (5 Rhino) by May 2002.

One wild female rhino had found her way into the RRA. She definitely must have belonged to the population in the Royal Bardia National Park in Nepal. She died when attacked by Bankey.

Before the breeding of the re-introduced population could start off several setbacks were faced. By the end of 1984, the year of translocation of rhinos, Dudhwa had only three individuals (two males and one female). After receiving four females from Nepal in March-April 1984, Dudhwa population had two males and five females. But, at this point of time started a serious fighting, particularly between the two males for dominance. The larger male named Raju asserted its dominance in the beginning. The other male named Bankey , with the passage of time became more and more aggressive that resulted in frequent fighting between the two. During mid 1988, in one fight Raju broke his horn and thereafter Bankey became the dominant male. Raju was chased out of the fence time and again. A fence was created to separate them but the fights continued and in a final fight Raju sustained fatal injuries and died on 11.12.1988. As a consequence of death of Raju, Bankey remained the only breeding male of the population.

The females re-introduced at early ages of about 5 years (in case of the animals from Nepal) adopted better in the RRA. There had been no casualty during or after capture and release operations. Performance with respect to breeding success has been better in case of animals re-introduced in sub-adult stage.

Re-introduction from Assam as compared to that from Nepal had a basic difference of distance of the destination from the origin. Nepal being nearer to the re-introduction site involved ease and economy in operation. This may also be a

reason of the re-introduction from Nepal being more successful as compared to that from Assam.

Out of the three females brought from Assam, the two elder ones died within three months and consequently the Dudhwa population had only one 4 year old female and two males (one 7 year old and another 25 year old). In 1985, four females, all below 6 years of age were brought. The period from 1984 to 1989 may be considered as pre breeding establishment phase, as all five females were sub-adult. With the death of old male in 1988, the entire population was of uniform age structure with high breeding potential. In 1989 four of the five females successfully calved. The experiment very clearly indicates that success in case of sub-adult individuals and failure in case of old aged individuals. There has been no casualty in case of sub adult females, whereas the adult females died. Furthermore, these sub adult females only have contributed to breeding.

Table 1.2: Causes of Adult Mortality in Dudhwa from April 1984 to February 2002

Cause of death	Number
Internal Infection and hemorrhagic septicemia	1
Injured by male attack and abortion	2
Injured due to accident and paralyzed	1
Stressful abortion and infection	1
TOTAL	5

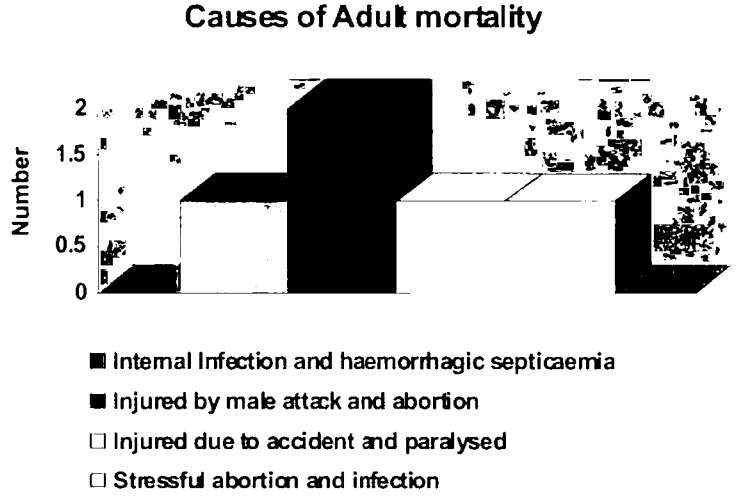
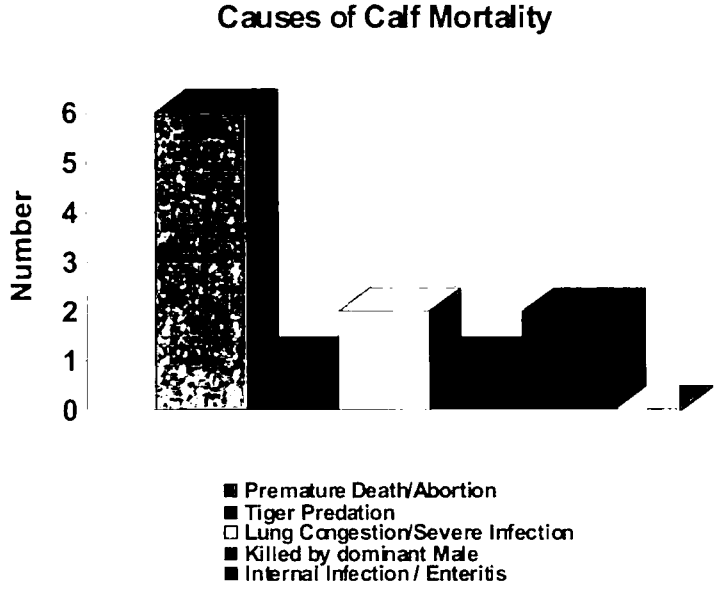


Table 1.3: Causes of Calf Mortality in Dudhwa from April 1984 to December 2002

Cause of death	Number
Premature Death/Abortion	6
Tiger Predation	3
Lung Congestion/Severe Infection	2
Killed by dominant Male	1
Internal Infection / Enteritis	2



1.7 Breeding & Population Dynamics

The first evidence of breeding in the re-introduced population was detected in the form of remains of a newly born calf in a patch of tall grasses in August 1987. There was no sign of predation indicating a possibility of premature birth or any such natural circumstances. The first successful calving occurred in early 1989 on the Park Day (2nd February 1989). Three more calving in the same year followed this.

Table 1.4: Year-Wise Calving Pattern in RRA

Year	Calving	Total No.	Abortion	No. of abortion
1984	Nil	0	Sa-1	1
1985	Nil	0		0
1986	Nil	0		0
1987	Nil	0	N-1	1
1988	Nil	0		0
1989	• R-1 (19.05.89, Died on 11.12.93), • H-1 (02.02.89,Surviving), • N-2 (01.06.89,Surviving), • S-1 (12.10.89,died)	4		0
1990	Nil	0		0
1991	• 1. S-2 (10.08.91,Surviving) • 2. P-1 (4.08.91 Died on 12.01.2000)	2	R-2 (1991)	1
1992	• 1. N-3, (31.07.92, Surviving), • 2. H-2 (0508.92,Surviving	2		0
1993	Nil	0		0
1994	• 1. N • 1-1(11.01.94,Died on 17.10.94), • 2. S-3 (07.10.94Surviving)	2		0
1995	• 1 P-2 (2109.95,died on 21.01.96)	1	H-1-1 (1995)	0
1996	Nil	0		0
1997	• 1. P-3 (02.10.97,Surviving), • 2. H-3 (19.10.97,Surviving), • 3. N-1-2 (17.09.97,Surviving)	3		0
1998	• 1. S-4 (06.08.98,Surviving)	1		0
1999	• 1. H-1-2 (02.10.99,Died on 28.10.99), • 2. H-2-1 (12.06.99,Died on 25.02.2000)	3		0
2000	Nil	0		0
2001	• 1. H-1-3 • 2. N-4 (29.10.2001)	2		0
2002 Dec	• Sw-2-1 killed by tiger in Dec 2002	1		
TOTAL	**Total Surviving Rhinos in RRA, Dudhwa NP**	18		4

(Source: Office of the Deputy Director, Dudhwa.NP, Forest Department, Uttar Pradesh)
Abbreviations: P-Pabitri, Sa-Saheli, S-Swayambara, H-Himrani, R-Rapti, H-1: 1st progeny of Himrani, H-1-1-1stcalf of first progeny of Himrani.

Table 1.5: Population dynamics of Reintroduced rhino population in Dudhwa

Year	Introduced	Withdrawn	Abortion	Born	Calves died	Adult died	Mortality	Recruitment	Population
1984	5	0	1	0	0	2	2	-2	3
1985	4	0	0	0	0	0	0	0	7
1986	0	0	0	0	0	0	0	0	7
1987	0	0	1	0	0	0	0	0	7
1988	0	0	0	0	0	1	1	-1	6
1989	0	0	0	4	0	0	1	3	9
1990	0	0	0	0	1	0	0	0	9
1991	0	0	1	2	0	1	1	1	10
1992	1	1	0	2	0	0	0	2	12
1993	0	0	0	0	1	0	1	-1	11
1994	0	0	0	2	1	0	1	1	12
1995	0	0	1	1	0	0	0	1	13
1996	0	0	0	0	1	0	1	-1	12
1997	0	0	0	3	0	0	0	3	15
1998	0	0	0	1	0	0	0	1	16
1999	0	0	0	3	1	0	1	2	17
2000	0	0	0	0	3	0	2	-2	15
2001	0	0	0	2	0	0	0	2	17
2002	0	0	0	0	0	0	0	0	17
	10	**1**	**4**	**20**	**8**	**4**	**12**	**12**	

Figure 1.3: Population Growth Trend

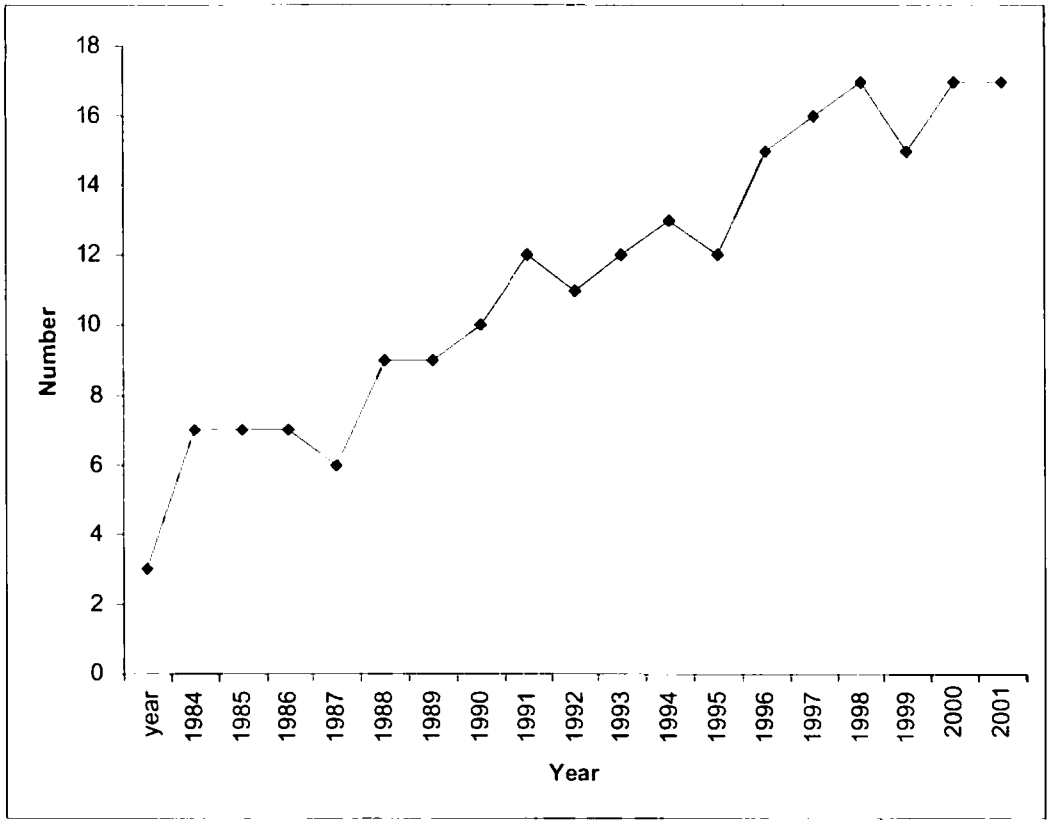


Table 1.6: Calving by different females

Name of the mother	Origin	Total (Calving+Abortion)	Surviving
Saheli	Assam	0+1	0
Narayani	Nepal	4+1	3
Swayamvara	Nepal	4+0	3
Pabitri	Assam	3+0	1
Himrani	Nepal	3+0	3
Rapti	Nepal	1+1	0
H-1	First calf of Himrani	2+1	1
N-1	First calf of Narayani	2+0	1
H-2	Second calf of Himrani	1+0	0
	Total	**20+4**	**12**

After the death of Raju in 1988 and a failed attempt to introduce a male from Kanpur Zoo, Dudhwa has not got any other adult male from outside even after a lapse of about 14 years. As a consequence, only one male is mating with all the females of the population and single male sires all the calves born in RRA in Dudhwa TR. This has resulted into:

- Slow rate of population build up due to availability of single breeding male. Since female rhino initiate male for mating and is a time consuming process in which male rhino exhaust.
- Severe inbreeding and in future possibilities of imbalance in Sex Ratio.

Had there been few more males capable of participating in breeding, birth rate in the population might have been much higher. At the same time there might have been a genetically healthy population. As the same male sires all the calves, and that male continues to dominate, the females of the progeny are mating with their sire. The population as of now is heavily inbred and this trend should not be allowed to continue. This can reflects how small populations face various setbacks. Nobody knew that out of two males, one is going to be totally ineffective for the breeding programme and only one will participate in all breeding. An attempt to tide over this problem was made by bringing one male Lohit from Kanpur Zoo in 1992, but Bankey did not allow Lohit even to settle down at Dudhwa. Lohit was seriously injured by Bankey and was sent back to Kanpur Zoo after treatment. Now, we are faced with a situation in which even if Dudhwa born males establish them, they will be mating with close relatives only, which is genetically totally undesired proposition and in future of possibilities of imbalance in the sex ratio.

1.8 Management Related Issues

1.8.1 Fence Maintenance

The re-introduced rhino population is enclosed within an area of 28.11 sq.km fenced by a four strand energized fence. Two energizers power this fence, one each at Salukapur and Base Camp. There is facility of solar power run chargers for charging the batteries. This system is effective and useful in open weather but

during rainy season arrangements are made to get them charged from Dudhwa or Palia.

Visitors watching Rhino inside RRA

Fence around Rhino reintroduction Area (RRA)

Proper maintenance of this fence is very important for the success of the rhino re-introduction programme. If the fence goes ineffective and rhinos start straying out in all directions, it will not be within managing proportion for the park authorities. That is precisely why the management lays due emphasis on maintenance of the fence. A total of eight fence watchers are engaged on daily basis for maintenance of this fence. Apart from fence watchers, other departmental personnel are given

responsibility for the maintenance of the fence. There is well laid out system for the purpose. Duties assigned for each of functionary are as follows:

- ***Fence Watcher:*** is supposed to walk along the entire length of the fence under his jurisdiction from 9.00 A.M. to 5.00 P.M. While walking, he is supposed to check the fence and clean all vegetation, tighten strands, insulator and poles if needed. In case of any breakage, the fence watcher is supposed to report to the Beat Officer.
- ***Beat Officer/Fence Supervisor:*** to ensure proper duties of all the fence watchers within his jurisdiction and act immediately on reports of fence watchers. Five fence supervisors are deputed for maintenance of the entire length of the fence. Five different fence sectors have been identified and five fence supervisors are made responsible for the entire length.
- ***Section Officer (Forester):***
  - Surprise checking of the duties of fence watchers and Beat officer
  - If any rhino is not seen for a long period, scan the entire area and locate it
  - To check voltage of fencing
  - Walk on foot and check fence at least twice a week
  - Maintain store for fence upkeep
- ***Range Officer:*** is supposed to ensure proper duties of Fence Watchers, Fence Supervisors and Section Officers and proper maintenance of the fence and ration provided to elephants. He is required to walk and check full fence twice a month.
- ***Wildlife warden, Belrayan***: is supposed to co-ordinate fence monitoring by surprised inspection of batteries, energizers and other fence materials. He is supposed to check the entire length of fence once a month.

In the given circumstances, it is very much obvious that the management is trying its every bit for better management of the fence and it is satisfactory. But there are problems in arranging fund for proper upkeep of the fence that will be discussed later on.

1.8.2 Monitoring

Due emphasis is laid on regular and thorough monitoring of rhino population at Dudhwa. This monitoring in based on scanning the area by riding elephants, from watchtowers and on foot and on motorbike. There are four elephants deployed for this purpose. Two elephants are camped at Salukapur and an equal number at Base Camp. Four teams monitor different area within the RRA. They try to locate rhinos, identify them and observe their activity. Each of the adult rhinos is well identified by all of the monitoring staff. Daily observation of sighting location, activity while sighted and any unusual behaviour are recorded in registers maintained at the two camps. A consolidated monitoring report is taken by the Range Officer and submitted to the Deputy Director every fortnight. This fortnightly rhino monitoring report is forwarded to the Director, Dudhwa Tiger Reserve and upto the Chief Wild Life Warden, U.P. This is a very effective monitoring system and any problem arising at any point of time is likely to be detected at an early stage. It is sad on the part of the park and a set back for the monitoring effort that one of the monitoring elephants has died recently. At present, monitoring is done using three elephants. Right now, the grasses are short and problem may not be readily realized, but once the monsoon sets in, it will be very difficult to ensure effective scanning if additional elephants are not deployed.

Every day, rhinos located are thoroughly scrutinized for wounds or scars. If any fresh wounds are noticed, usually prescribed medicines are sprayed with the help of pumps. Dung samples are collected in all seasons to estimate parasitic load. The parasitic load, however, has never been a problem. Professional veterinarians at Chandan Chowki and Palia are consulted as and when necessary. Veterinary scientist from IVRI Izatnagar, Bareilly help in post mortem and monitoring of health of elephants from time to time and whenever required not on regular basis.

Identification of individual rhinos by their prominent physical features and deformities

Horn Shape & Size

Tail Length & Folding Pattern

Shape of Ear Pinna and Tubercle

Wound Mark

Shape and Size of White Pigmentation Patch Between Horn and Upper Lip

1.8.3 Captive Elephant Management

As monitoring depends to a great extent on number and proper management of captive elephants, it becomes essential for the present exercise to get a stock of the manner in which elephants are being managed and kept at Dudhwa Tiger Reserve.

The observations made during the study are as follows:

General health of most of the animals is poor. Hygiene at the elephant camps to be improved. Proper control over quality and quantity of ration and fodder fed is lacking. Ration Register, Medical Register and Service Book should accompany each elephant wherever it is deployed. But, unfortunately these essential documents are not available at the camps. Ration Register for one elephant was found at South Sonaripur Range Office. There is no utility if the register if it is not kept at the elephant camp.

Weight of Gaddi — is a very important consideration in captive elephant use. Whereas in other parts of the country this weight is well below 100 kg, that in Dudhwa is 200 kg. This is supposed to have a deleterious bearing on the health of the animals. Whereas in Jaldapara, there is a different lightweight gaddi for patrolling purpose suited for long duty periods, in Dudhwa the same one is being used for both purposes. A fair load for an average elephant is about 1000 lbs as per Evans (as sighted by A.J.W. Milroy s Management of Elephants in Captivity, Edited by Bist S.S. 2002).

Duty hours — With the opening up of the RRA for tourism, animals are used for long a period that is deleterious for elephant s health. Elephants should not be worked for more than 5 hours and during mid days as prescribed in the Management Plan for Jaldapara Wild Life Sanctuary for the period 1997-98 to 2006-07.

1.8.4 Tourism Inside the RRA

From December 2001, this area has been opened for tourism. After the formation of Uttaranchal, U.P. is left with only one National Park, that is Dudhwa and tourism pressure has increased. Another fact that Dudhwa is the site of first ever reintroduction Programme of the country, makes tourists even more curious to see rhinos at Dudhwa. Amount of tourist pressure on PA authorities to open up the RRA is understandable. But, it is very important to assess the infrastructure facilities.

Allowing tourism inside the RRA may have some other impacts due to overcrowding in a small area of 28.11 sq.km that will need detailed study. This is the prime area of the park that apparently has very high concentration several species other than rhino. A rapid survey could reveal that highly endangered species like Swap Deer, Bengal Florican and Hispid Hare use this area regularly. A very high concentration of hispid hare pellets was found in the area where tourists are being allowed. Leaving apart ecological considerations that would need a detailed study, from management point of view it was necessary first to procure additional elephants and manpower and only then tourism should have been allowed inside the RRA. Although with individual visitor group guide is provided but it has been observed that out of curiosity visitor get down from the vehicle to take photographs and make noise, which forced the animals to flee from the scene and get disturb. There are chances when unnoticed rhino in tall grassland area specially dominating male can charge which can prove fatal. Before leaving for the field trip all the visitors should be brief properly by the accompanying guide.

1.8.5 Habitat Management

Grassland management strategy adopted in the RRA is the same as followed in the other parts of the park. Management interventions here can be categorized into two broad categories:

Cool season burning, and harrowing followed by burning is done once immediately before onset of monsoon and once after monsoon

Whereas the first one is one time intervention, the second one is done twice each year. The park management considers monsoon as the pinch period from fodder availability point of view. In order to provide more of palatable grasses for the herbivores during rainy season, portions of grasslands are first harrowed and then burnt immediately before monsoon and also after monsoon. This certainly gives new shoot cherished by all herbivores. But, it seems important to study the effects of this practice on the overall health of the grassland eco-system. One thing is for sure that if this practice is continued in area adjacent to water-bodies, their siltation is bound to accelerate.

As far as cool season burning is considered, the entire grassland is burnt every year in mosaic pattern. On the areas used by Bengal Florican, grass is cut first prior to burning in patches in a mosaic manner to provide a mosaic of tall and short grasslands. The areas used by hispid hare are supposed to be protected from fire. Whereas burning as a tool seems to be a British legacy as it has been used for more than 100 years to check fire in woodlands, its long term impact on grassland eco-systems need to be studied in detail.

Daytime Burning

Cool burning in late evening hours

Water augmentation during summer months

1.9 Problems

1.9.1 Man Management of Rhino Monitoring Staff

Currently rhino monitoring unit is located in Salukapur and rhino monitoring is done from two locations. Living conditions by considering the housing facilities is not at all hygienic. Since entire area is a malaria zone and comes under high rain falls. All the occupied buildings at Salukapur and range head quarter based in Sonaripur are currently in a very bad shape needs proper maintenance including the Salukapur FRH. Since most of the staff is not only involved in the regular monitoring of rhinos but are also in regular patrolling of their respective beats. Southern boundary of the Rhino fence is quite close to the notorious villages involved in number of illegal activities and staffs have to look after these problems. Considering the period when entire staff gets cut off during the rainy months. Provision of extra allowance should be made which is applicable in other Tiger Reserves.

1.9.2 In-breeding

As discussed earlier, all individuals of single male rhino sires the Dudhwa bred population. There is no other unrelated male currently and all the mating of Dudhwa bred population is taking place between close relatives. This is certainly a very discouraging reality.

Table 1.7: Details of potential breeding population

Sex	Name	Origin/Born on	Age in March 2002
Male	Bankey	From Assam	25 years
	N-3	31.07.92	9 year 8 months
	S-2	10.08.91	10 year 7 months
	P-3	02.10.97	4 year 5 months
Female	Pabitri	From Assam	22 years
	Swayamvara	From Nepal	22 years
	Narayani	From Nepal	22 years
	Himrani	From Nepal	21 years
	H-1	02.02.89	13 years
	N-2	01.06.89	13 years
	H-2	05.08.92	9 year 7 months
	S-3	07.10.94	7 year 5 months

The original target was aimed at releasing 30 rhinos, but due to financial and administrative constraints only 10 could be released including a captive male from Kanpur Zoo between 1984 to 1992.Four out of these ten have died and another one from the Kanpur Zoo had been sent back to its origin. So, breeding started with one male and five females. During about 18 years of breeding, a total of 19 calves were born out of which 12 are surviving. There had been 4-recorded cases of abortions. The population size as of now stands at 17 (February, 2002).

The problems of in-breeding as well as desired response to the stochastic eventuality need be addressed. These are rooted in genetic variability as well as in numbers. These need to be overcome with further restocking from large populations. The original number of 30, though not a magic number needs to be considered. These could be from Nepal or Assam and all need to be from the wild, that are not nuisance animals habituated to crop raiding.

Table 1.8: Demographic Status of existing Rhinoceros in RRA (2002)

	SEX		
	Male	**Female**	**Calf**
AGE	1. 25 years 2. 11 years 3. 10 years 4. 4 years	1. 23 years 2. 22 years 3. 21 years 4. 19 years 5. 13 years 6. 13 years 7. 10 years 8. 8 years 9. 5 years 10. 5 years 11. 3 years	1. 1 year 2. 1 year
TOTAL	**4**	**11**	**2**

In future Inbreeding can cause sex-ratio imbalance that is preferably 1: 3 ratio between male and female. If inbreeding continues than there are chances of imbalance in sex ratio and possibilities of more number males or females in the rhino population.

From the beginning, there has been a serious intra-specific fight between males as well as between male and female. As a consequence of such fights, one of the two males of the first group got killed. Another male from Kanpur Zoo was seriously injured by the dominant male from Assam and finally had to send back. Owing perhaps to this very reason, Narayani a female from Nepal is presently staying outside the fenced area. Narayani even gave birth to her last calf in a sugarcane field in Bela Kalan village about 4 km from the RRA.

As suggested by experts, it is necessary to enhance the fenced area to include more of swamps, wallowing grounds, grasslands and upland forest habitats to prevent intra-specific fights. It was suggested to extend the area to include Gupti Phanta area including Road No 60 leading towards Belraiyan. They have further suggested creation of artificial wallows to cause more extensive utilization of the habitat and also to help reduce intra-specific competition.

1.9.3 Straying Out of Rhinos

From last two years, some rhinos, especially Narayani have started straying out of the park. A rapid survey in the villages Bela Kalan, Bela Tapar and Gulra Tanda and an interaction with forest staff of Gulra Chowki indicated that there have been 11 recorded cases of straying out of rhinos. There had been crop damage but no other damage has been reported. It is quite interesting and disturbing too that Narayani , that lives outside the fenced area gave birth to a calf during October 2001 in a sugarcane field in Bela Kalan village about 4 km away from the RRA.

Although, the problem now is not of very serious dimension from depredation point of view, trend is not very good for the rhino re-introduction Programme. Since in most cases, only one individual is straying out, that too during her pregnancy, chances are that it is a part of her strategy to avoid Bankey. But it has to be seen as the calf grows.

Whatever may be the reason, the fact that the PA management is not in a position to maintain the 9 km elephant proof trench is disheartening. The trench has to be maintained at all costs if the Programme has to be a success.

Alternative site at Bhadi Tal in Belraiyen range has been selected and fencing work is on progress. This new site may prove helpful in providing home to such animals.

1.9.4 Resource Crunch

The park management faces a lot of difficulties in procuring money for taking up the following activities on a regular manner:

- Fence maintenance
- Wages to fence watchers
- Maintaining elephants for rhino monitoring and recent need for tourism.

Apart from ongoing activities, large sums are needed to create and maintain a 9 km long elephant proof trench as prescribed by the Rhino Sub Committee at the beginning of the project. Such a trench is extremely important to check straying out of rhinos that may even lead to poaching. Additional money would be required to procure elephants for monitoring and for tourism purposes. This again is a vicious circle, as it would require recurring expenditure on maintenance of elephants. Such recurring expenditure is to be anticipated in advance and sources ensured. Another important of this programme is maintenance of fence, which need at regular intervals replacement of rusted wires, energizers and regular monitoring of fence and removal of under growth of plants touching wires. Currently only two energizers are used to flow current in the entire 27 long perimeter length and according to prescription and effectiveness of the capacity of a energizer is 7 kms. Considering the total perimeter length of RRA of 27 kms it needs four energizer. One more factor that it has been a regular problem in getting funds to cover the payment of daily wages labourers involve in the maintenance of fence. There is immediate need of one generator at Salukapur that will be used in recharging the batteries used in the rhino fence. Currently

batteries are brought to Dudhwa or Palia for recharging and it takes days, which depend on the power availability. During monsoon months of six months when road are not accessible elephant is only means to reach Dudhwa FRH. During this one monitoring elephant along with a staff will have to accompany batteries. This leads to loss of at least three to four days in this exercise hamper the regular monitoring and patrolling of the area when other illegal activities like timber theft, poaching, fishing and removal of fence wire used in animal traps by the notorious groups operates from neighbouring villages of southern boundary of the RRA.

1.9.5 Tourism inside RRA

Park authorities have opened the RRA for tourism from December 2001. Earlier this area was supposed to be a restricted zone and no body was allowed to enter the RRA. When the RRA was opened for tourism, there were four elephants engaged for monitoring duties. Unfortunately, because of bad health one female elephant died in February 2002 and another is too weak to stand. These monitoring elephants are kept on long duty hours in locating rhinos. The same elephants are used to make number of trips for the tourist in rhino shows. This practice should be discontinued or reduced to three days per week. There is also a need of regular checking of amount of prescribed food provided to individual elephants and health care measures by the veterinary officer and other officer concern.

1.9.6 Poaching

At present the park management in very much alert, patrolling duty is being done religiously and rhinos stray out in rare cases only, so rhino poaching does not seem to be a problem. But, its possibility remains as other animals are being poached. Currently due to affective measures like regular patrolling and arrest of notorious elements by Mr. Ashish Tewari, Deputy Director Dudhwa Tiger Reserve and his staff has made possible to check such illegal activities. Despite of the different pressures from local politicians and influential people patrolling staff have high moral and support to tackle with any odd situation and protecting the wildlife of Dudhwa Tiger Reserve.

1.9.7 Biotic Pressure

Villages like Bela Kalan, Bela Tapar, Gulra Tanda etc. are located near Southern fringe of the power fence. People from these villages, at times, venture into the RRA for collection of thatch grass, fodder and at times fuel wood and for fishing in the swamps. The addition of the southern buffer has helped in reducing the problem to some extent. It has been observed that in the past the theft of fence wire was directed at preparing snares by local poachers to snare deer found in the RRA. Daily monitoring of entire length of fence and monitoring rhinos with the help of riding elephants has contained to a low level but it remains a constant threat.

1.9.8 Veterinary and Research Officer

There are sanctioned post of one veterinarian and one Research officer in Dudhwa Tiger Reserve, but no one has joined on permanent basis. Veterinary doctors are called from Chandan Chowki or sometimes from Palia as and when required. From time to time-Veterinary officer and Veterinary scientist from Lucknow Zoo and Indian Veterinary Institute, Izatnagar, Bareilly visits this area. Due to these reasons it is difficult to get timely medication. On many occasions doctors are not available or are not well versed with the wild animal in providing the correct doses. It is very difficult to ensure appropriate health care of the camp elephants and rhinos without having proper veterinary care facilities in the existing conditions. Similarly there is also need for a research officer to look after the monitoring of rhino and habitat management aspect as a whole on full time basis.

1.10 Need of Enlarging Rhino Area and Establish a Separate Rhino Population inside Dudhwa NP

1.10.1 Genetic Variability and check Inbreeding

The original objective was aimed at releasing 30 rhinos in Dudhwa National Park. The Precise reason why this was not carried out after release of two batches is both financial and administrative. However, due to breeding the number has increased from seven to seventeen. Out of the seven seed population, only two were male named Raju and Bankey. Initially, Raju had asserted his dominance but with passage of time Bankey became dominate and killed Raju in one of their regular fights in October 1988. During 1991 an attempt was made to counter the

anticipated problem of inbreeding by introducing a male, named Rohit, in captivity from Kanpur Zoo. He was repeatedly attacked by Bankey and severely injured. This animal had to be taken out, treated and returned to the zoo after it had recovered. The existing rhino population in RRA has two more adult males but they are unable to asset themselves in front of the dominant male Bankey. Bankey continues to be the dominant male even today. All the calves born till today are progeny of this dominant male — Bankey. Because all these calves surviving now are born after 1989, there is little chance of mating with Raju who died in 1988. In absence of any other male even the sexually mature daughters are mating with their father. The two adult males, though unable to assert are also the progenies of same rhino Bankey and if in the future they will mate with the females, same type of genes will be transmitted to the next generation. If this situation prevails for few successive generations, it may cause inbreeding depression, which is a threat for genetic viability. So, there is an urgent need to introduce some other male with different genetic base. And keeping in view the past experiences with Bankey s behaviour newly translocate male rhinos should be kept in separate enclosure to avoid the chance fighting among them. And hence, there is an urgent need of enlarging rhino habitat (***Sinha, 1991 and 1999***).

(i) To Reduce conflict amongst males in existing RRA

Bankey has driven one of the two adult males in existing population out from the main fence on several occasions. Therefore, separate contiguous mini fence has been created to provide safe heaven to one of these animals. The two males are often seen parading on their respective sides of the common section of the fence. The operation failures of the fence and even functional fence also are unable to restrict the rhinos from fighting. Thus, there is an urgent need to create another rhino habitat (***Sinha, 1999***).

(ii) Increasing Population in the existing RRA

Increasing population of rhino in the existing area is also a major problem. In this case, either new area can be selected for rhino translocation in Dudhwa Tiger Reserve or the enclosure will be removed. In case of the removal of the enclosures, there are chances of crop depredation by rhinos in the adjoining areas, which is very close to the southern boundary of the

Rhino Re-introduction Area (RRA). Recently four rhinos went outside he RRA and regularly raiding the croplands. The rhinos also killed two local villagers. In response to these situation, it is better to keep the rhino under enclosure for few more years, at least till the people accept them as their neighbours. And hence, there is a need to select some new area inside the Dudhwa National Park. In the light of above facts, long back in 1991, strongly recommended for the urgency of creating another viable breeding population of rhino in Dudhwa Tiger Reserve and proposed Bhadi-Churaila area in Belrayan Range of Dudhwa Tiger Reserve.

1.10.2 The area selected for enlarging Rhino habitat

In 2002, the work is in progress and proposed area is to be enclosed in power fence for the creation of another viable population of rhino inside the Dudhwa Tiger Reserve. The area falls in Bhadi-Churaila sector of Belrayan Range. This area provides water for drinking and wallowing, shade and an adequate variety of plants known to be eaten by rhino elsewhere. One of the essential prerequisite for rhino re-introduction is vast grassland with water for drinking and wallowing. This Bhadi-Churaila sector has two permanent water bodies known as Bhadi Tal and Churaila Tal respectively. Apart from these two permanent and large water bodies, there are various other smaller water bodies, which are permanent as well as, seasonal. The Rhino Subcommittee of Indian Board for Wildlife (IBWL) has identified this Bhadi-Churaila sector in Belrayan Range as one of the possible sites for re-introduction of rhino in their original recommendation. Feasibility study with regard to the habitat availability for the re-introduction of rhino in Dudhwa by the Botanical Survey of India led by Dr.Hajra carried out a detailed survey of the vegetation of Dudhwa in relation to the rhino feeding ecology. The detailed study clearly established a number of floral elements common to Dudhwa National Park (U.P.) and Kaziranga (Assam), both of which are excellent rhino habitats.

The advantage of the area selected is that it is in the central location of Belrayan Range. There is no danger of rhino wandering in the human occupation and cultivation in case of operation failure of power fence. While in case of existing rhino re-introduced area, it is adjacent to the southern boundary of the park, which

lacks a buffer zone and outside of which is an area of dense human occupation and cultivation. Bhadi-Churaila sector is centrally located and sufficient buffer is available.

This Bhadi-Churaila sector comprises an area of 10.74 sq.km and the 17 kms long fencing work has already been started and target was to complete the fencing operation by the end of this financial year. The work was in progress when the study was carried out.

Table 1.9: The Bhadi-Churaila Habitat

Range	Block/Compartment	Sal Forest (ha.)	Grassland (ha.)	Wetland/ Swamps (ha.)
Belrayan Range	Bhadi-2	180.09	-	-
	Bhadi-3a (Part)	-	30.00	105.00
	Bhadi-3C	18.21	354.88	105.00
	Bhadi-6a	88.63	-	-
	Bhadi-6b	-	106.43	-
	Laudaria-2 (Part)	35.39	-	-
	Laudaria — 3B	4.04	96.62	24.00
	Laudaria — 4 (Part)	9.72	20.30	-

(Source: Proposed Plan for Bhadhital Rhino Area, Tewari.A. 2002)
Total Area = 1,073.31 ha = 10.733 sq. km
Total length of the fence = 17 km

1.10.3 Other Possible Sites

There are excellent phantas (grassland) and water bodies in other ranges as well. These areas are blessed with vast expanse of grasslands with number of viable swamps. These areas can also be rehabilitated with rhinos in due course of time when the rhino population increases. Although due to road network and railway lines direct connectivity by means of construction of enclosure between the existing rhino area no more exist with different grasslands. In due course of time with the increase in rhino population and the fenced areas be extended in the southern boundaries of the park to check the rhino movement in the cultivation.

1.11 PROPOSED ACTION PLAN

1.11.1 Fencing the newly identified RRA

As per the plans, the fencing of newly identified RRA i.e. Bhadi-Churaila sector of RRA will be completed by the end of the financial year 2001-2002 i.e. by end of March 2002. Work is in progress when the study was carried out. The erection of fencing posts were in progress and about 3000 posts were required for this purpose. The three-strand power fence will cover entire proposed area of 17 km long stretch of perimeter before releasing the rhinos.

1.11.2 Releasing rhinos in the newly created RRA from the existing RRA

After the completion of power fencing, three females and one male from the existing RRA will be released in this newly created Bhadi-Churaila sector of RRA. This will provide immediate relief to the conflict situation in the existing RRA and enhance breeding in the newly created RRA.

1.11.3 Releasing fresh batch of rhinos to augment the genetic variability

Since all the rhinos born in the existing re-introduction area are progenies of single bull Bankey, the problem of inbreeding depression needs to be addressed timely. In order to overcome this problem, there is a proposal to introduce fresh batch of rhinos — one male and three females, either from Royal Bardia NP in Nepal or Assam to broaden the genetic base.

1.11.4 Monitoring

Presently four elephants are engaged in the monitoring work. Mahouts and staff scan the area and send the report to the headquarter and office of the Deputy Director. Monitoring is an important activity to see their health condition, movement pattern and other behavioural aspects. With the creation of new RRA, more number of elephants and Mahouts as well as monitoring staff is required.

1.11.5 Infrastructure support

- A road will be built along the inner side of the entire fence to familiarize patrolling and fire management
- The monitoring parties are provided with walkie-talkie sets so that they are always in contact while conducting monitoring.

1.11.6 Habitat Management

This is one of most important aspect of the proposed action plan. It has several components:-

(I) **Grassland Management:** For the management of grassland, annual burning is one of the most important exercise. This discourages the invasion of woodland and facilitates new shoots there by increasing nutritional value. But the annual burning is to be made in consideration of the other endangered species like Bengal Florican, Hispid Hare, prey species of tiger and sensitivity to breeding requirements of species that are obligate of the grasslands. For example, the grasslands utilized by Bengal Florican, the grass is cut first prior to burning. Burning is done in patches while the areas used by the hispid hare are protected from the fire (Sinha, Sawarkar and Tiwari, 2001). Controlled and cool burning plays an important role in management of grasslands especially relating to timing and pattern of prescribed burning.

(II) **Wetland management:** Water is the lifeline of rhino thought here are permanent swamps in the newly created RRA, creation of additional wallowing grounds and waterholes as well as supplementing in the existing taals (water bodies), new borings and pumping sets are required.

(III) **Weed Removal:** Removal of weeds from the phantas (grasslands) and water bodies also is an important aspect of habitat management.

(IV) **Woodland manipulation:** The newly created RRA contains predominantly of Sal trees and other species as well. Though felling and removal of tree from PA is totally banned, the problem needs to be addressed to check the invasion of trees into grasslands. The removal of trees is required from the point of view of extension of rhino habitat.

1.11.7 Research Work

With the passage of time, more and more research is required in relation to its habitat, food availability intraspecific behaviour and health aspects.

1.11.8 Veterinary Care

In Dudhwa NP, at present there are working elephants for monitoring purpose as well as for tourists. These working elephants need proper care and upkeep. Veterinary care also needed from time to time for rhinos. So, establishment of veterinary units is required.

1.11.9 Local Awareness

Villages located at the fringes are already facing the problem of elephants and other herbivores straying into their agricultural field. Re-introduction of rhino is another added burden to their problem. Due to proper power fencing and constant monitoring, rhinos generally do no stray into agricultural fields and there is no such report till date from the existing RRA. But with the creation of new RRA, these rhino population is bound to increase. Therefore, to make the conservation programme more successful, participation of fringe villagers is of utmost importance, so that they may compromise with the situation, at least their hostility can be reduced.

1.11.10 Ecotourism

The last rhino disappeared in this area was around 1878. Re-introduction of rhinos in this area has fascinated the tourists. Now every tourist who visits the National Park wants to have a glimpse of this mighty animal. More elephants and mahouts are required for this purpose.

1.11.11 Eco-development

The fringe villagers are the worst sufferers in the process of building up the PAs. They are deprived of the forest produces required by them for their day-to-day livelihood. In addition, they become the victim of wildlife depredations including loss of life. Thus, the people have to face severe economic hardships. To

ameliorate the economic hardships of these people, economic support in the form of eco-development programme has become very essential.

1.11.12 Anti-poaching measure

Protection is the *sine qua non* for any PA. Some conservationists give importance to the protection to the extent that PA doesn t require any input except protection. This is true to the great extent. The success story of increased rhino population in Kaziranga National Park, Assam, Royal Chitwan.NP, Nepal and other rhino bearing PAs is primarily due to effective anti-poaching network built up in these areas. Dudhwa Tiger Reserve shares 56 kms of international boundary with Nepal. With the re-introduction of rhinos, the determined poachers may be attracted in their venture as the rhino horns fetch good revenue in the international market. Moreover, Tharu villages located in the Northern fringe of the park have relation in Nepal. For them, it can be new and wonderful avenue for getting fast and handsome revenue. The facilities provided presently are not at all adequate. Sophisticated arms and training of anti-poaching personnel is of utmost importance to make the Rhino Re-introduction Programme successful.

1.11.13 Setting up of Field Station in the New RRA

There is a requirement of setting up of head quarter, possibly in Chhanga Nala FRH after its renovation for better monitoring of newly re-introduced rhinos. But will require appropriate funding. At Salukapur FRH already Rhino Monitoring Station exist and is operational for RRA. But Salukapur FRH needs total renovation, major repairing and proper maintenance.

1.11.14 Construction and Maintenance of watchtowers / Machan

Watch towers need to construct in this new area for monitoring activities. Currently all the watch tower need proper repair and maintenance inside the RRA and outside as well in Bhadhi Tal area.

1.11.15 Requirement of more elephants

More elephants are required for monitoring the rhinos in the newly re-introduced rhino area for monitoring purpose as well as for the tourists. At present the

elephants are less in number and to fulfil the requirement s of tourists and monitoring activities they are put in to overworking which badly affects their health.

1.11.16 Budget

All the above mentioned points in Proposed Action Plan will be light of the day only if adequate financial provision is available. Initially, the Government of India has provided financial support for the translocation and conservation of the rhino in newly reintroduced area. But with the passage of time, no funding is available from the Central Government for the conservation of rhino in Dudhwa. At present, the entire effort for conservation of rhino in Dudhwa is being born by the State Government as a part of the Forestry budget. Thus, the financial input is obviously very small. With the increase of rhino population in this protected are i.e. Dudhwa National Park and gradual change of management strategies, the requirement of financial support is very essential

1.12 Expected Results

1.12.1 The creation of the Bhadi-Churaila sector of RRA will reduce the prevailing conflict situation among the males in the existing population. Fresh batch of rhinos either from Nepal or Wild captive rhinos will also be reintroduced in this area to broaden the genetic base.

1.12.2 The intensive management efforts to be applied for Rhinos are bound to benefit the existing take off population of the highly endangered swamp deer in the area. These expectations are based on the observations recorded in the existing RRA. The existing RRA is located on the south Sonaripur Range and this Range has recorded the highest number of all the five deer s found including swamp deer and hog deer amongst the nine ranges of Dudhwa Tiger Reserve. (UP Forest Department, 2001)

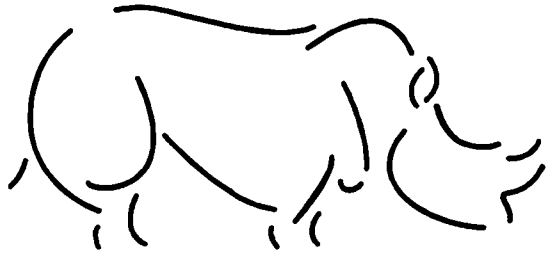
1.12.3 There exists a viable connectivity between the existing and newly created RRAs through the grasslands of Bankey Tal area. Thus two populations can also be joined in due course of time when the Rhino population increases by extending the fenced areas.

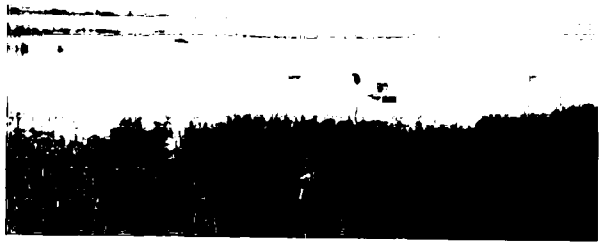
1.12.4 Last but not the least, the conservationists ultimate objective of creating as many separated viable islands as possible to reduce the risk of extinction will be fulfilled when the re-introduced rhinos of Dudhwa once again haunts the entire Terai area.

1.13 Conclusions

- Procure a few (in the ratio 1 male to 3 females) males and females from the wild or wild captive rhinos.
- In all future re-introductions, only sub-adult individuals in the same age group should be brought, as there are lesser chances of casualty and they adopt better in new conditions. Moreover, by having males of same age group there may be lesser possibility of over dominance by one individual.
- Develop alternative rhino area within Dudhwa N.P.
- Maintain Rhino Proof Trench on the Southern side of the RRA.
- Restricted Rhino watch to 4 days per week within the RRA until necessary infrastructure facilities are properly developed.
- Procure additional riding elephants (4 for daily monitoring and 2 elephants for tourists).
- Long-term studies on Grassland Management, habitat use by different large and small mammals and regular monitoring of population of highly endangered species like Tiger, Swamp deer, Bengal Florican and Hispid hare. This is only possible by creating a permanent research and monitoring station at Salukapur funded by National and International Funding as an independent body. This will attract not only Indian Scientist and from abroad to work in this area. Such long-term studies and monitoring will not only help in the future management of rhinos but in the habitat management as a whole.
- State Forest Department must allow the revenue generated from tourism activities should be recycle in the developmental activities and maintenance of infrastructures of the park and welfare of the forest staff. This will also help in generating more revenue.
- Since getting funds is one of the major concerns, Park authority with the consent of State Forest Department can create a registered Wildlife

Welfare Society or Foundation to be looked after by Deputy Director of the Park. This society/foundation should be allowed to accept donation and funds from different funding individuals and agencies for different conservation activities and welfare of the staff of the Tiger Reserve. Currently Gir Welfare Society in Gir National Park, Gujarat and Tiger foundation Society in Madhya Pradesh are running successfully.





Fencing around Bhadhi Tal area & Habitat - A Prime area for Rhinos

THE TIMES OF INDIA, NEW DELHI

A new home for rhinos at Dudhwa sanctuary

By Mohit Dubey
Times News Network

LUCKNOW: Hostility between two male rhinos and fear of vendetta from a calf on an elder — the lone reproducing male rhino at the Dudhwa national park — has jolted the state forest department into action.

The outcome: A sprawling new 20-square km home, dotted by swamps and grasslands, for the 17 Indian Rhinoceros housed here.

Confirming that the second phase of the 'Rhino rehabilitation project' had begun after it was undertaken in 1984, chief wildlife warden R L Singh said on Monday that electric fencing of the new area had begun.

Back from a two-day visit of Dudhwa, Singh said that they had decided to "get going" after reports that the hostility among male members was posing a major safety hazard for the regionally extinct race of Indian rhinos. The new area being carved out in the thickets of Dudhwa involves two swamp areas of Bhadi and Churaila Taal. The second phase entails an expenditure of Rs 15 lakh that involves the setting up of a field headquarters in the area, some watch towers and the construction of the electric fencing.

The department has cleared renovation of a dilapidated and abandoned rest house at *Changa Nala* which would serve as the field headquarters. Dudhwa houses 17 rhinos which is the largest concentration in India except for the Brahmaputra valley in North-East.

The second phase of the "Rhino rehabilitation" project has also been hurried through since the incidence of tiger preying have increased manifold in the area. Fears of inbreeding have also forced foresters hands. Six animals have fallen to the wild cat in the last two decades.

CHAPTER 2

Floral Diversity in the Corridor Areas

2.1 Introduction

Tropical grassland and savanna occupy an important place in the biomes of the world and acoount for about 1.05 X 10.10 tones of organic matter production (Leith, 1975) and cover about 20 % of the earth s surface. The terai grassland of South Asia has relativiely high densities of animals and this is due to their large primary production (Roger, 1988). They are one of the richest ecosystems in India and harbour some of the most endangered and localized floral and faunal elements.

Forests are mosaics driven by disturbance and biotic processes. Forest structure, composition, and ecological processes change over a vast range of spatial and temporal scales. Therefore, the condition of vegetation in a stand, landscape, or region is product of the inertplay of forces of disturbance and biotic development on a stage set by pattern and dynamics of climate, soil and landforms (Hunter, 1999). Vegetation is universally recognized as a component of major importance in site evalution and classification; it integrates the effect of many interacting factors, and key species may indicate specific site conditions (Barrnes et al, 1998) Vegetation is strongly controlled by macro and micro climate, floristically complex, dynamic and varies in occurence, abundance, coverage, biomass and vertical layering. These attributes to vegetation are of major significance in animal ecology and wildlife management.

2.2 Methodology

The present existing forest cover between Dudhwa NP and Kateniaghat WLS is highly fragmented and scattered. Most of the forest patches and grassland were found small in size and interspersed with the human settlement and agriculture fields. Line transect sampling (Burnham *et al.,* 1990) for vegetation quantification was found infeasible due to small size of patches, hence sampling was done covering many random points in each patch of corridors. Sampling for trees was

done in circular plot of 20 m radius at various points, picked randomly in each existing forest cover in the both identified corridor. Optimum size of vegetation sampling plot was followed as described by Sharma *et al.* (1983). From the same sampling point, data were also collected for shrub and herb using circular plot of 5 and 1 m respectively. Woody species exceeding 20 cm GBH (Girth sizes) were considered as trees whereas less than 20 cm in GBH were counted as shrub.

At each sampling plot, plant species and their number, GBH, tree height, terrain, vegetation type and canopy cover was measured. Importance Value Index generated to assess the ecological value of a species with respect to the community structure (Muller Dombois and Ellenberg, 1974 and Roy *et al.*, 1993). The purpose of measuring community diversity was to judge its relationship with either to community properties or to the environmental conditions to which the community was exposed. Krebs (1989) has illustrated the importance and measurement of vegetation diversity indices. Canopy cover was measured with the help of GRS densiometer. Both twinspan i.e. two-way indicator species analysis (Hill, 1979) or cluster analysis (Norussis, 1994) are used to classify the vegetation community of study area of North Kheri forest division. Numbers of other techniques are in practice for the quantification of vegetation especially for the measurement for diversity indices in the various part of the world. (Pielou, 1975., Pielou, 1988., McIntosh, 1967., Magurran, 1988., Hill, 1973 and Inouye, 1998). Vegetational analysis of woody species was done for Chakrata Himalayas by Singhal *et al.*, (1986). Plant species diversity and tree population structure of a humid tropical forest in Tamil Nadu, India was studied by Swamy *et al.* (2000).

Similarly for shrubs quantification, shrubs numbers, height and cover were recorded. Since grasses are highly significant for rhino, hence grasses were quantified using a cross of 5 m length from the centre. Grass species and their height were recorded at distance of 20 cm interval of the 5 m rope of cross in all four directions. In total 100 points were taken in a quadrate for grass abundance.

2.3 Results

2.3.1 Abundance of grasses, shrubs and trees in the corridor area

***Herb and Grass Abundace*:** Altogether 14 species of grasses and 2 species of herbs were recorded in the corridor patches of forest and grassland. *Fimbristylis falcata* was most abundant followed by *Desmostachya bipinnata*, *Cyperus niveus*, *Pennisetum cenchroides*, and *Cynodon dactylon* **Table 2.1**. As far height profile of the herb and grasses is concerned, Typha latifolia were tallest followed by *Saccharum spontaneum*, *Saccharum bengalense*, *Vetiveria zizanioides*, *Cyperus niveus* and *Cyperus nutans*.

The range of height of herb and grasses varies between 1-300 cm but it was not at culmination because grasses were still growing and at some places facing tremendous grazing pressure which eventually kept constant height of grasses **Table 2.2**. Recorded mean heights of herb/grasses was 16.87– .5 (SE) cm. More than 98.9% plants were recorded between 1-100 cm, which indicate the growth of herb, and grasses facing large extent of biotic pressure **Table 2.3.**

Shrub abundance: 64 species of shrubs were recorded in the corridor area of North Kheri. Most abundant species was *Cassia obtusifolia* followed by *Clerodendron viscosum*, *Glycosmis pentaphylla*, *Piper nepalense*, *Lantana camara* and *Ziziphus nummularia*. Density of shrubs per hectare was highest for Glycosmis *pentaphylla* (1181.71), followed by *Clerodendron viscosum* (793.33), *Ziziphus nummularia* (455.7), Lantana camera (447.41) and *Syzygium cumini* (440.16) **Table 2.4**. Mean and sum density of shrubs per hectare was 94.55–3.78 and 5861.97–209.54 respectively.

2.3.2 Diversity indices for vegetation

62 species of shrubs and 54 tree species were recorded in the corridor area. Hill s diversity H1, Shanon H log base 10, Shanon J , and Simpson diversity indices (1/D) was eastimated highest for shrub compared to trees **Table 2.5.**

2.3.3 Clustering of tree vegetation using Twinspan

Altogether 11 cluster communities of tree vegetation were formed using Twinspan analysis. Tree vegetation was found to be heterogeneous because eigenvaluse of 5th division during analysis was found higher than the parent cluster. In other words, division of plots did not get constant decrease of eigenvalues **Figure 2.1.** Unscaled dendrogram of cluster of tree communities were illustrated as made by Forbes (1994) and Kala (1998).

Cluster 1. *Dillenia pentagyna*, *Terminalia alata*, *Parocalyx scariosus*, *Asparagus racemosus*, *Cissampelos pareira*, *Ficus rumphii*, *Bridellia verrucosa*, *Millusa velutina*, *Bauhinia* sp. *Litsea* sp., *Accacia concinna*, Murraya *koenigii*

Cluster 2. *Cassia fistula*, *Litsea monopetala*, *Butea monosperma*, *Millusa tomentosa*, *Schleichera oleosa*, *Spondias pinnata*, *Bauhinia recemosa*, *Mallotus phillipensis*.

Cluster 3. *Litsea chinensis*, *Albizia procera*, *Putranjiva roxburgii*, *Grewia asiatica*, *Ficus religiosa*

Cluster 4. *Hymenodictyon excelsum*, *Mitragyna parvifolia*, *Casearia elliptica*

Cluster 5. *Dodonaea viscose*, Trewia *nudiflora*, *Pongammia pinnata*, *Morus alba*.

Cluster 6. *Lannea coromandelica*, *Terminalia bellirica*, *Grewia tilaefolia*, *Randia uliginosa*, *Holoptela integrifolia*.

Cluster 7. *Cordia dichotoma*, *Xeromphis spinosa*

Cluster 8. *Ficus hispida*, *Ficus racemosa*, *Bridellia squamosa*, *Bombax ceiba*, *Syzygium cumini*.

Cluster 9. *Ziziphus mauritiana*, *Aegle marmelos*, *Acacia catechu*

Cluster 10. *Terminalia arjuna*, *Eucalyptus sp.*, *Carrisa congesta*, *Dalbergia sissso*, *Ficus bengalensis*.

Cluster 11. *Albizia lebbek*, *Tectona grandis*.

Cluster 1, 2, 3, 4, 5, 6 and 7 truly represented the communities of mix forests whereas cluster 8, 9, 10, and 11 represented the plant species of silviculture use. In the corridors it was observed that many of the forests patches were afforested

under silvivulture practice and most of the forest patches were dominated by single species.

Cluster analysis using ward method also showed distinction of plant communities use in silviculture practice i.e. *Bridellia squamosa*, *Trewia nudiflora*, *Mallotus philipensis*, *Syzygium cumini*, *Tectona grandis*, *Acacia catechu* and *Dalbergia sisso* **Figure 2.2.**

2.3.4 Clustering of shrub vegetation using Twinspan

Altogether 11 clusters were formed to show association to each other, using Twinspan analysis. Similar to tree vegetation, shrub vegetation was found to be heterogeneous and eigenvalue at 10^{th} division that is higher than parents plots **Figure 2.3.**

Cluster 1. *Mallotus philipensis*, *Dillenia pentagyna*, *Cassia fistula*, *Psidium guajawa*, *Terminalia arjuna*, *Aegle marmelos*, Cannabis sativa, *Calicarpa microphylla*, *Ficus hispida*, *Ficus hirta*, *Pongamia pinnata*, *Millusa tomentosa*, *Bridelia squamosa*, *Schleichera oleosa*, Cordia dichotoma, *Viscum nepalense*, *Albizia lebbek*, *Grewia asiatica*, *Grewia tilaefolia*, *Tiliacora acuminata*, *Justica adhotoda*, *Holopetala integrifolia*, *Albizia lebbek*, and *Putranjiva roxburgii.*

Cluster 2. *Vallaris solanacea*, *Murraya koenigii*

Cluster 3. *Nyctanthes arbortristis*, Adina *cordifolia*, *Derris indica*, *Piper nepalense*, Inga dulicis, *Glycosmis pentaphylla*, *Ltsea monopetala*, *Grewia sapida*, *Tamarix dioica*, *Trewia nudiflora*, *Casearia elliptica*, and *Cissampelos parviflora.*

Cluster 4. *Mitragyna parvifolia*, *Syzygium cumini*, and *Millettia auriculata.*

Cluster 5. *Clerodendron viscosum*, and *Accacia concinna*

Cluster 6.*Butea monosperma*, *Pogostemon benghalense*, and *Xeromphis spinosa.*

Cluster 7. *Dodonaea viscose* and *Ficus recemosa.*

Cluster 8. *Ziziphus nummularia*, *Cassia obtusifolia* and *Dalbergia sisso.*

Cluster 9. *Calotropis procera*, *Eucalyptus* sp. *Carrisa congesta*, and Amnitis *indica*

Cluster 10. *Lannea coromandelica, Kydia calycina, Lantana camara, Bombax ceiba, Tectona grandis* and *Acacia catechu*

Cluster 11. *Ipomea carnea.*

Cluster 1, 2, 4, 5, 6 and 7 showed the communities of plant occur mainly in mix forest whereas cluster 8, 9, and 10 showed the occurrence and association of plant communities, which generally used for planting purpose and silviculture activities. Cluster 5, 6 and 7 showed truly shrub species occurrence and association.

2.3.5 Importance value index (IVI) for tree vegetation

Most abundant tree species of the corridor area was *Tectona grandis* (17.2), followed by *Dalbergia sisso* (10.9), whereas most frequently occurred species were *Acacia catechu* (80), *Syzygium cumini* (47), *Mallotus philipensis* (40) and *Trewia nudiflora* (21). As far as density of tree/ha is concerned *Acacia catechu* (56.57) was found with greatest density followed by *Dalbergia sisso* (45.31), *Syzygium cumini* (16.89) and *Tectona grandis* (14.5). Similarly Acacia catechu estimated with greatest Importance Value Index (IVI) i.e. 44.25 followed by *Dalbergia sisso* (31.89), *Ficus benghalensis* (22.71), and *Ficus rumphii* (19.56). Ab/F ratio generally indicated the species, which are rare and found in cluster. *Cissampelos pareira* and *Terminalia alata* (6.0) were found to be with highest

Ab/F ratio followed by *Millusa velutina* and *Parocalyx scariosus* with 5 and 5 respectively **Table 2 6.**

2.3.6 Abundance of vegetation in Katerniaghat WLS.

Tree: In Katerniaghat WLS, Katernigaht forest range was most abundant by *Dalbergia sisso* (8.8) tree species, followed by *Tectona grandis* (8.14), *Mallotus philipensis* (5.8), *Trewia nudiflora* (5.26) and *Syzygium cumini* (3.7) tree species. Whereas density of tree per hectare was estimated greatest for *Mallotus philipensis* (24.14), *Dalbergia sisso* (22.6), *Trewia nudiflora* (20.28) and Tectona *grandis* (14.6) **Table 2.7.**

Clustering of tree using Ward method, *Acacia catechu*, *Syzygium cumini*, *Tectona grandis*, *Trewia nudiflora*, *Dalbergia sisso*, and *Mallotus philipensis* species were distinctly separate from other species **Figure 2.4.**

Shrub: Most abundant shrub species was found to be *Kydia calycina* (28.64), followed by *Clerodendron viscosum* (27.93), *Vallaris solonacea* (19.33), *Lantana camara* (14.5) and Kydia *calycina* (12.67). Shrub density per hectare was estimated greatest for *Clerodendron viscosum* (1721.80) followed by *Mitragyna parvifolia* (1294.43), *Murraya koenigii* (571.19), *Vallaris solonacea* (476.68) and Glycosmis *pentaphylla* (271.21). However, mean shrub density per hectare was estimated 362.84– 12.25 (SD) **Table 2.8.**

Herb/grass: Most abundant species of herb/grass in Katerniaghat WLS was *Ageratum conizoides*, (77.33) followed by *Cissampelos pareira* (45.5), *Malva coromandelica* (42.6), *Trifolium indicum* (24), *Brachiaria prostrata* (23.88), *Cyperus niveus* and *Saccharum bengalense* (22.5). Density per hectare was highest for *Brachysema lanceolata* (41709), followed by *Ageratum conizoides* (23833.98), *Desmostachya bipinnata* (20135.61), *Capillipedium assimile* (13149.78) and *Saccharum bengalense* (12122.46). The mean herb density per hectare was 8853.14–25.30 **Table 2.9.**

Height profile of herb species, varies between 5 — 200 cm. Mean height of herb was 29.9 cm. Mean height was highest for *Capillipedium assimile* (116.6), followed by *Desmostachya bipinnata* (89), *Imperata cylindrica* (69.3) and *Achyranthus aspera* (35).

2.3.7 Quantification of vegetation of proposed Rhino area (Bhadital Area)

Tree: Clustering of tree using Ward method revealed that *Shorea robusta*, *Tectona grandis*, *Mallotus philipensis*, *Tectona grandis*, *Bombax ceiba* and *Buchanania lanzan* showed close association to each other **Figure 2.5**

Most abundant tree species in proposed rhino area was *Tectona grandis* (26) followed by *Shorea robusta* (14.4), *Bombax ceiba* (8) and *Mallotus philipensis*

(5.36). Whereas density of tree per hectare was estimated highest for *Shorea robusta* (95.54) followed by *Mallotus philipensis* (33.17), *Tectona grandis* (23.0), *Millusa tomentosa* (15.92) **Table 2.11.**

Shrub: Most abundant species of shrub, Clerodendron *viscosum*, estimated with 5357.81 plants per hectare. Species with high density were Glycosmis *pentaphylla, Tamarix dioica* and *Shorea robusta* with 547.02, 224.8 , 1483.7 per hectare and *Tiliacora acuminata (a climber)* , 5245.41 per hactare respectively **Table 2.12** . Tiliacora has encroached most of the woodland areas and becomes a weed in the forest and a very strong physical barrier in the free movement of wild animals.

Herb/grasses: Altogether 11 species of grasses were recorded from proposed area of Dudhwa NP. Most abundant species was *Desmostachya bipinnata* (18.8%), followed by *Themeda arundinacea* (15.1%), *Saccharum bengalense* (12.9), and *Saccharum fuscum* (12.2%). About 13.3 percent land was bare without any herb or grasses **Table 2.13.**

Height profile of grasses varies between 3-620 cm. Grass speices like Saccharum *bengalense* have the maximum height (280.29 cm) followed by *Themeda arundinacea* (254.54), *Saccharum fuscum* (252.9) and *Saccharum spontaneum* (197.7). Reason behind the great height was that grasses were at the maturation and flowering stage where grasses already achieved it maximum growth as height is concerned. Mean height of grass was 184.6–91.04 cm (SD) (Table 14). One of the major reasons in gaining the maximum height of grasses is because of the location of the area and restricted to any type of removal as well as any type of anthrogenic pressure like regular grazing by large number of livestock and irregular burning of grassland.

Only 6 species of herb/grass were recorded in the woodland of proposed area. *Imperata cylindrica* was most abundant followed by *Desmostachya bipinnta*, *Ageratum conizoides* and *Cappillipedian assimile* grass species **Table 2.15.**

The mean height of herb/grass ranges between 5-150 cm. *Bothriochloa intermedia* with a maximum mean height (95 cm) followed by *Desmostachya bipinnta* (90), *Imperata cylindrica* (80 cm), and *Capillipedian assimile* (80) **Table 2.16**. Mean height of grass was 55.8 – 47.11 cm. Common name of important Flora is given in **Appendix 1.**

2.4 Discussion

The important grasses of the corridor area between Dudhwa NP and Katerniaghat WLS were *Saccharum spontaneum*, *Vetiveria zizanioides* and *Cynodon dactylon*. Due to high intensity of grazing pressure, grasses did not attain their natural height and this fact was supported by dung density in terms of grazing. Fairly good species richness and diversity of shrub was found in the corridor area. Important species of shrubs recorded in the area were *Clerodendron viscosum*, *Glycosmis pentaphylla*, *Lantana camera*, and *Ziziphus nummularia*. Due to heterogeneity of vegetation and patchiness of forest species diversity were greater for shrubs than the tree vegetation. Vegetation quantification using Twinspan and Ward methods revealed that forest community is highly heterogeneous and nature of vegetation varies from one forest patch to other. Clustering of tree and shrubs were found to reveal clear distinction between the clusters. Importance Value Index (IVI) shows dominance of the species on others in the same community. Plant species such as *Tectona grandis*, *Dalbergia sisso, Acacia catechu*, *Syzygium cumini* and *Trewia nudiflora* estimated with high value of IVI. Since these plant species are used by Forest deparment for their silviculture practice.

Similarly in Katerniaghat range of Katerniaghat WLS plant communities of *Acacia catechu, Syzygium cumini, Trewia nudiflora*, and Dalbergia sisso had shown clear distinction from other communities. *Clerodendron viscosum*, *Vallaris solonacea* and *Murraya koenigii* were important shrub species, which were frequently found in the area of Katerniaghat range. Grassland of Katerniaghat was mainly abundant with *Imperata cylindrica*, *Desmostachya bipinnata*, *Saccharum bengalense* and *Themeda arundinacea* with *Ageratum conizoides* and *Capillipedium assimile* herb species. Grass species of Katerniaghat range

attained comparatively better height than the grass of corridor area, probably due to less grazing pressure and better protection.

Woody vegetation in and around proposed area was mainly dominated by Sal forest. *Tectona grandis* and eucalyptus species planted in patches. *Tiliacora acuminata* and *Glycosmis pentaphylla* were important shrub species found in the Sal forest. *Themeda arundinacea*, *Saccharum fuscum* and *Saccharum spontaneum* were important grass species found in the grassland area. Since the area falls under protected category hence all grasses achieved their natural heights and better habitat for rhino.

Some forest patches of northern corridor were found under the silviculture practice and dominated by single species. Forest patches of Belaparsua Ragunagar, Kishunnagar, Deepnagar, and Ganganagar of northern corridor were basically mixed in nature. At few places at Ganganagar there was afforestation of *Tectona grandis* and *Dalbergia sisso*. At many places of Belaparsua and Raghunagar plantation of *Acacia catechu* was also done but it was found in virgin condition. Because of grazing shrub species of whole corridor area affected as far as density and diversity is concerned. Grazing did not seem to have its impact on tree vegetation. As far as tree abundance and occurrence in northern corridor forest patches were found in small size, interspersed with agriculture field and human settlement and moderately dense due to thick plantation and protection by the forest department. It is a part of Dudhwa forest belt extended from Dudhwa to Nepal. Hardly there was any grassland in the forest patches of northern corridor. Such patches are turned into cultivation and serve as man made corridors that equally serve the purpose of migration of large herbivore and carnivores. This is an adaptation in the current situation and development in landuse pattern around Protected Areas and between two protected areas.

Southern corridor comparatively covers large area than northern corridor and is possessed with a wide variety of habitats. Forest patches of Mohammadpur, Naurangabad, Bathua, Murthiha, Baria, Lathua, and Majhra east truly represent the mixed type of vegetation and at some places afforested by *Acacia catechu*.

Forest patches of Dharmapur, Bilora, Ladhouri, Chakra, Singhai, Banglaha, and Takiya mainly managed and afforested by *Acacia catechu*, *Dalbergia sisso* and *Tectona grandis*. Forest patches of Nunia were mainly afforested by three species i.e. *Syzygium cumini*, *Tectona grandis* and *Dalbergia sisso*. There are some good patches of grasslands in Nunia, Chakra and Majhra forest that seems to be ideal habitat of rhino with short grassland. Shrub abundance and diversity in the southern corridor is found comparatively less than the northern corridor, may be due to location which is far from either Dudhwa NP and Katerniaghat and secondly, forest patches were under the management practice which also affect the abundance and distribution of shrub species. Sissaya is adjacent to Kila range of Dudhwa forest and separated from Nunia by Suheli River and forested by *Acacia catechu* and *Dlabergia sisso*. Due to inundation caused by Suheli River, afforestation activities could not get success as other areas of North Kheri forest division. In other words, it may be useful for the restoration of rhino habitat, which is fully supported by Suheli River in terms of inundation of the area. Recently one of the male rhino escaped from RRA has reached Naurangabad Area of southern corridor and this rhino had killed a local labourer in the sugar cane field.

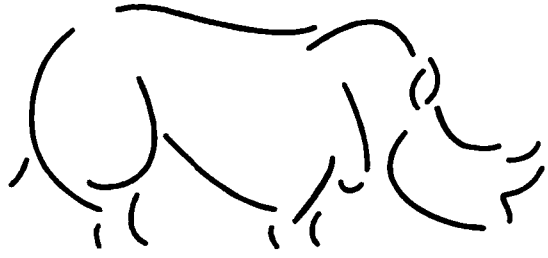


Table 2.1: Height profile of herb/grasses in the corridors area of North Kheri

Species	Frequency of occurrence	Minimum height (cm)	Maximum height (cm)	Mean height (cm)	SD
Bare land	148	0	0	0	0
Cyperus sp.	14	5	110	28.57	26.56
Hemarthria altissima	18	5	40	16.11	12.07
Carex cruciata	67	5	110	34.78	23.39
Cynodon dactylon	106	2	80	10.14	10.69
Pennisetum cenchroides	34	5	60	20.74	18.79
Eragrostis tenella	45	4	30	12.16	5.97
Dichanthium annulatum	30	5	5	5	0
Saccharum bengalense	40	1	150	27.78	35.73
Saccharum spontaneum	3	40	250	113.33	118.46
Vetiveria zizanioides	467	1	110	26.8	23.63
Desmostachya bipinata	3	10	40	28.33	16.07
Imperata cylindrica	1303	2	100	12.13	13.55
Fimbristylis falcata	5	5	10	8	2.74
Saccharum munja	45	10	110	29.22	24.84
Imperata arundinacea	4	30	30	30	0
Trifolium indicum	54	2	10	4.09	1.64
Typha latifolia	14	150	300	246.43	57.06
Total	2400	0	300	16.87	26.3

Table 2.2: Abundance of grass species in the corridors area of North Kheri

Species	Frequency	Percent	Cumulative Percent
Cyperus sp.	148	6.17	6.17
Hemarthria altissima	14	0.58	6.75
Carex cruciata	18	0.75	7.50
Cynodon dactylon	67	2.79	10.29
Pennisetum cenchroides	106	4.42	14.71
Eragrostis tenella	34	1.42	16.13
Dichanthium annulatum	45	1.88	18.00
Saccharum bengalense	30	1.25	19.25
Saccharum spontaneum	40	1.67	20.92
Vetiveria zizanioides	3	0.13	21.04
Desmostachya bipinata	467	19.46	40.50
Imperata cylindrica	3	0.13	40.63
Fimbristylis falcata	1303	54.29	94.92
Saccharum munja	5	0.21	95.13
Imperata arundinacea	45	1.88	97.00
Trifolium indicum	4	0.17	97.17
Typha latifolia	54	2.25	99.42
Total	14	0.58	100.00

Table 2.3: Frequency occurrence of heights of grasses of corridors area of North Kheri

*Heights occurrence (cm)	Frequency	Percent occurrence	Cumulative Percent
0	148	6.17	6.17
1	2	0.08	6.25
2	46	1.92	8.17
3	1	0.04	8.21
4	1	0.04	8.25
5	850	35.42	43.67
6	3	0.13	43.79
7	2	0.08	43.88
8	6	0.25	44.13
9	1	0.04	44.17
10	543	22.63	66.79
11	1	0.04	66.83
13	1	0.04	66.88
15	174	7.25	74.13
18	3	0.13	74.25
20	188	7.83	82.08
25	29	1.21	83.29
30	83	3.46	86.75
35	27	1.13	87.88
36	1	0.04	87.92
40	78	3.25	91.17
45	4	0.17	91.33
50	56	2.33	93.67
55	3	0.13	93.79
60	44	1.83	95.63
65	12	0.50	96.13
70	25	1.04	97.17
75	4	0.17	97.33
78	2	0.08	97.42
80	20	0.83	98.25
90	5	0.21	98.46
100	12	0.50	98.96
105	2	0.08	99.04
110	6	0.25	99.29
120	1	0.04	99.33
150	2	0.08	99.42
200	6	0.25	99.67
250	1	0.04	99.71
300	7	0.29	100.00
Total	2400	100	*

Table 2.4: Shrub density in the corridors area of North Kheri

Species	F.No.Of occurrence	No. of plant	Abundance	Density /ha	Std. Deviation	Relative density
Dillenia pentagyna	1	2	2	2.07	.	0.04
Limonia acidissima	1	1	1	1.04	.	0.02
Cassia fistula	1	2	2	2.07	.	0.04
Psidium guajawa	1	1	1	1.04	.	0.02
Terminalia arjuna	1	2	2	2.07	.	0.04
Glycosmis pentaphylla	58	1141	19.67	1181.71	28.55	20.16
Litsea monopetala	3	3	1.00	3.11	0.00	0.05
Aegle marmelos	10	55	5.50	56.96	8.05	0.97
Grewia sapida	3	10	3.33	10.36	1.15	0.18
Ziziphus nummularia	32	440	13.75	455.70	15.62	7.77
Ipomea carnea	1	2	2.00	2.07	.	0.04
Cannabis sativa	1	8	8.00	8.29	.	0.14
Clerodendron viscosum	36	766	21.28	793.33	25.95	13.53
Calicarpa microphylla	2	5	2.50	5.18	0.71	0.09
Calotropis procera	3	8	2.67	8.29	2.08	0.14
Mitragyna parvifoia	4	11	2.75	11.39	3.50	0.19
Nyctanthes arbortristis	2	10	5.00	10.36	0.00	0.18
Casearia elliptica	5	7	1.40	7.25	0.55	0.12
Dodonaea viscose	16	44	2.75	45.57	1.53	0.78
Ficus hispida	2	4	2.00	4.14	1.41	0.07
Butea monosperma	4	5	1.25	5.18	0.50	0.09
Cissampelos pareira	14	81	5.79	83.89	5.56	1.43
Eucalyptus sp	1	2	2.00	2.07	.	0.04
Vallaris solanacea	31	400	12.90	414.27	11.33	7.07
Tamarix dioica	3	5	1.67	5.18	1.15	0.09
Ficus racemosa	5	8	1.60	8.29	0.89	0.14
Trewia nudiflora	2	2	1.00	2.07	0.00	0.04
Adina cordifolia	8	18	2.25	18.64	1.28	0.32
Syzygium cumini	55	425	7.73	440.16	12.44	7.51
Lannea coromandelica	1	2	2.00	2.07		0.04
Inga dulicis	2	2	1.00	2.07	0.00	0.04
Kydia calycina	5	34	6.80	35.21	6.72	0.60
Pogostemon bengalense	23	180	7.83	186.42	5.54	3.18
Derris indica	2	5	2.50	5.18	0.71	0.09
Pongamia pinnata	1	1	1.00	1.04	.	0.02
Millusa tomentosa	12	72	6.00	74.57	5.59	1.27

Species	F.No.Of occurrence	No. of plant	Abundance	Density /ha	Std. Deviation	Relative density
Murraya koenigii	44	358	8.14	370.77	14.73	6.33
Carrissa congesta	16	102	6.38	105.64	8.29	1.80
Solanum indicum	1	1	1.00	1.04	.	0.02
Acacia catechu	11	36	3.27	37.28	2.15	0.64
Bridelia squamosa	5	6	1.20	6.21	0.45	0.11
Amnitis indica	7	30	4.29	31.07	2.36	0.53
Schleichera oleosa	7	9	1.29	9.32	0.49	0.16
Lantana camara	31	432	13.94	447.41	8.55	7.63
Cordia dichotoma	1	1	1.00	1.04	.	0.02
Xeromphis spinosa	18	52	2.89	53.86	1.75	0.92
Viscum nepalense	1	1	1.00	1.04	.	0.02
Albizia procera	3	8	2.67	8.29	0.58	0.14
Putranjive roxburgii	15	60	4.00	62.14	5.35	1.06
Cassia obtusifolia	14	410	29.29	424.63	20.09	7.24
Grewia asiatica	3	5	1.67	5.18	0.58	0.09
Piper nepalense	3	44	14.67	45.57	13.50	0.78
Tiliacora acuminata	23	120	5.22	124.28	6.32	2.12
Mallotus philipensis	31	137	4.42	141.89	5.48	2.42
Justica adhotoda	1	4	4.00	4.14	.	0.07
Bombax ceiba	1	4	4.00	4.14	.	0.07
Acacia catechu	16	47	2.94	48.68	2.95	0.83
Dalbergia sisso	2	2	1.00	2.07	0.00	0.04
Holoptela integrifolia	1	1	1.00	1.04	.	0.02
Albizia lebbek	2	2	1.00	2.07	0.00	0.04
Tectona grandis	4	10	2.50	10.36	1.91	0.18
Millettia auriculata	7	14	2.00	14.50	0.82	0.25
Total	620	5660	9.13	5861.94	15.15	100

Table2.5: Diversity index for vegetation of corridors area of North Kheri

Index	Shrubs	Tree
Hill's Number H0	62	54
Hill's Number H1	79.414	52.456
Shannon H' Log Base 10.	1.207	1.082
Shannon J'	0.673	0.624
Simpsons Diversity (1/D)	10.648	6.348

Figure 2.1: Clustering Of Tree Vegetation Using Twinspan

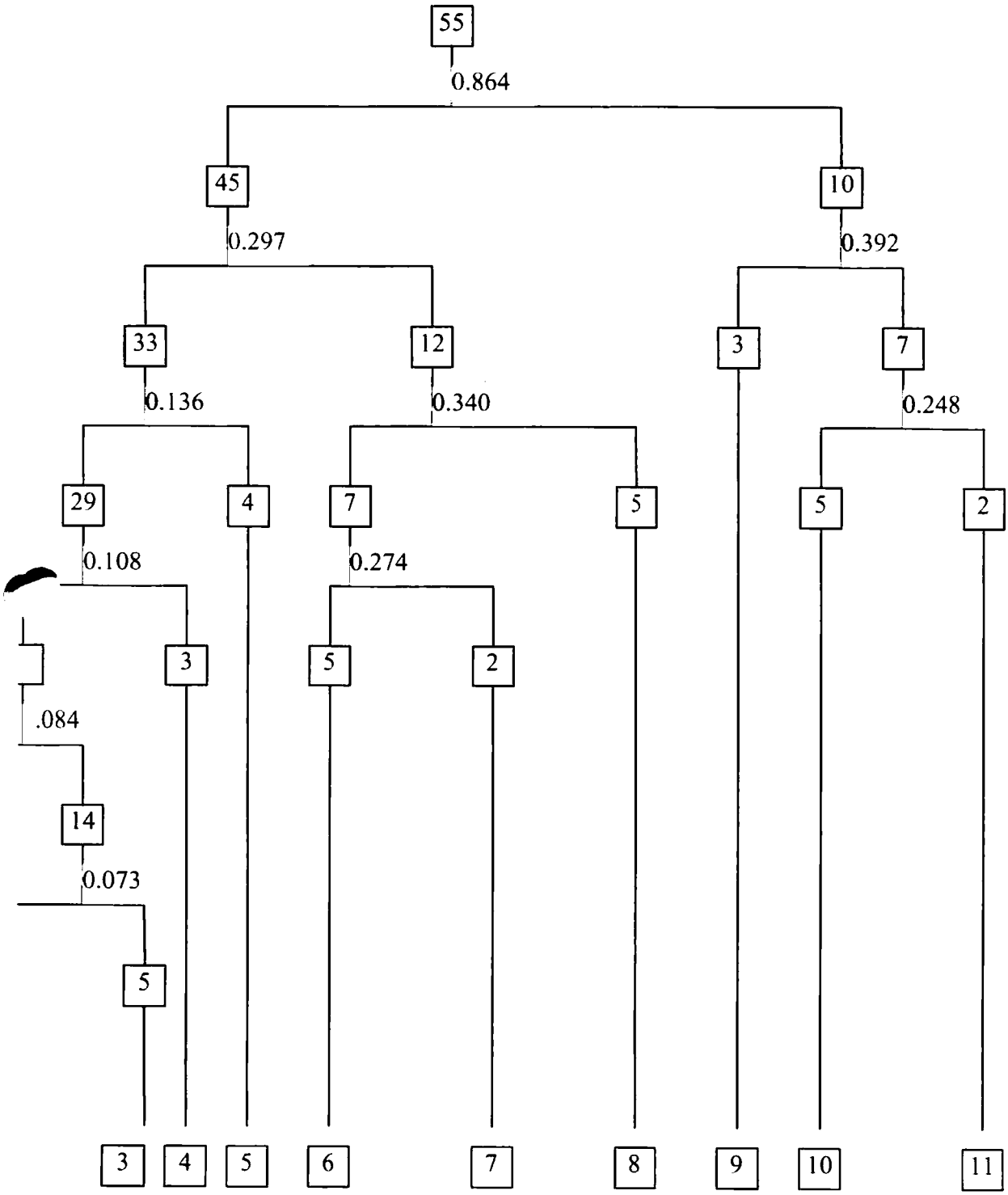


Figure 2.2: Clustering of Shrub Vegetation using Twinspan

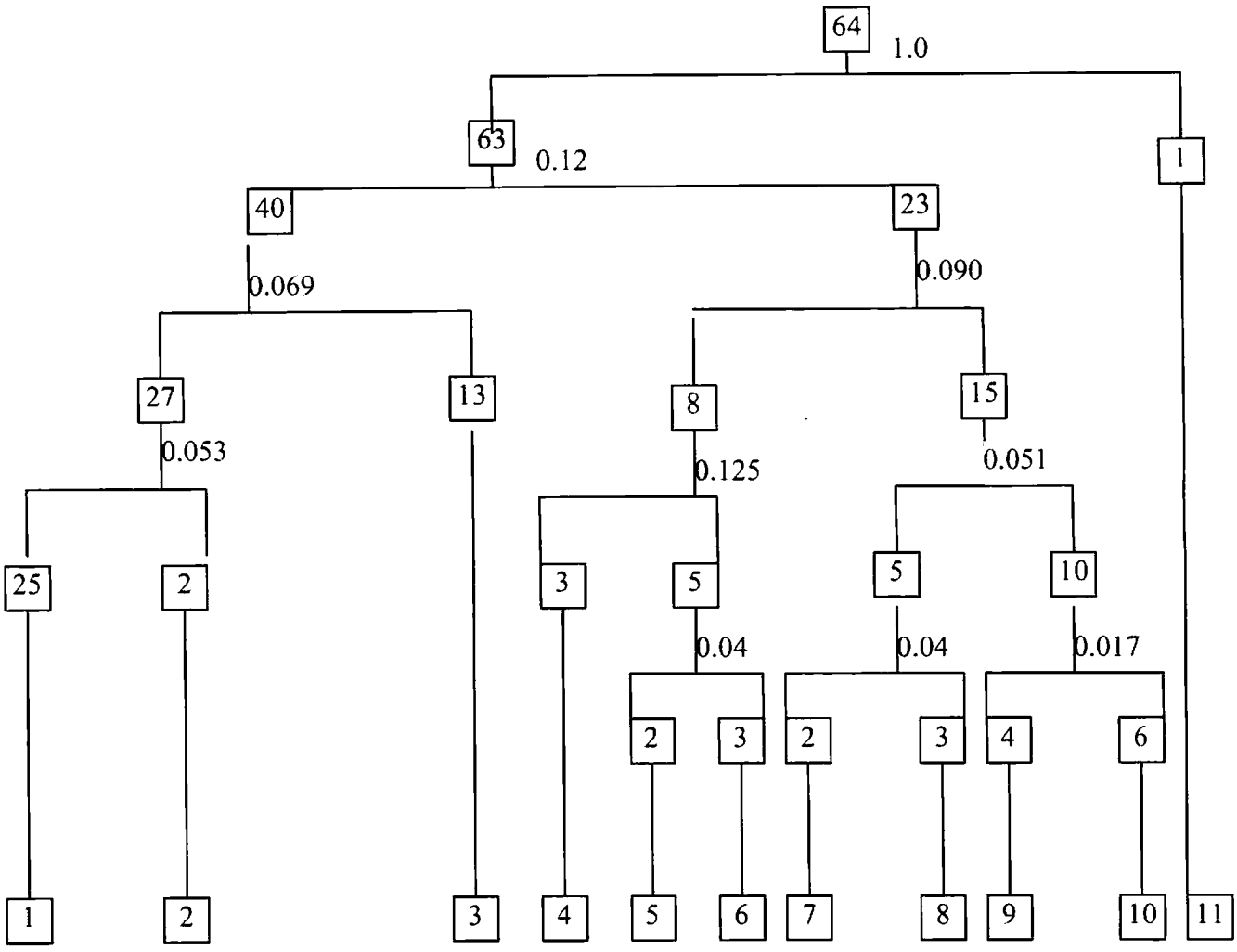


Figure 2.3: Hierachical cluster analysis for tree vegetation of corridors of North Kheri

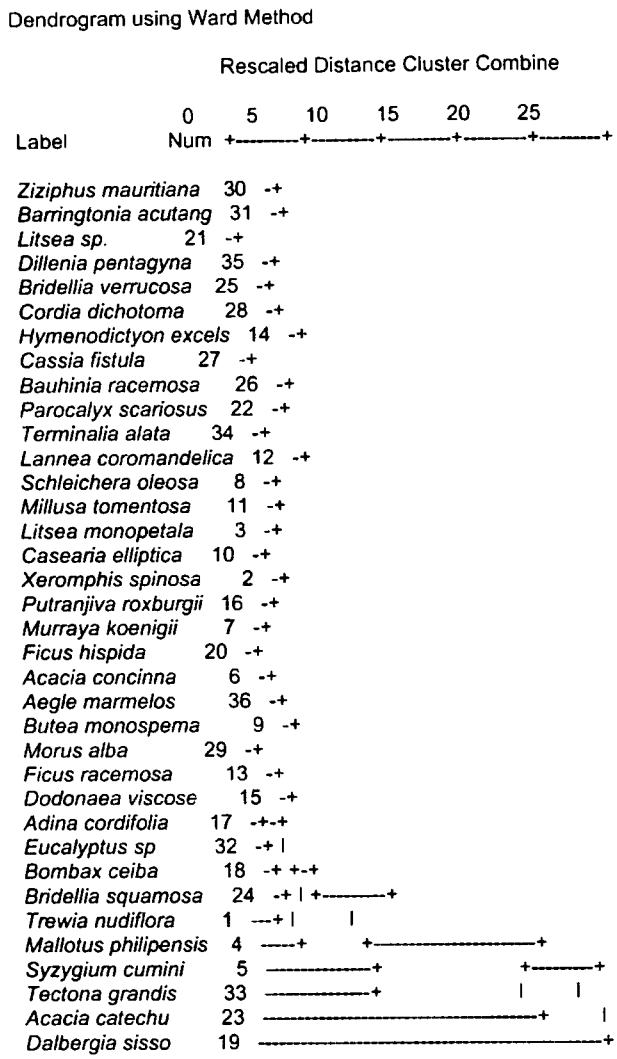


Figure 2.4: Hierarchical cluster analysis of tree vegetation of proposed area of rhino translocation in Dudhwa NP

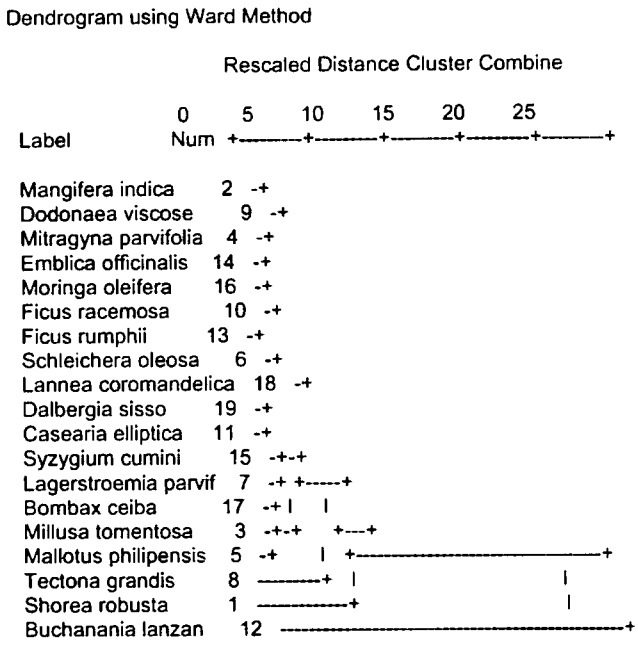


Figure 2.5: Clustering of tree vegetation of Katerniaghat WLS

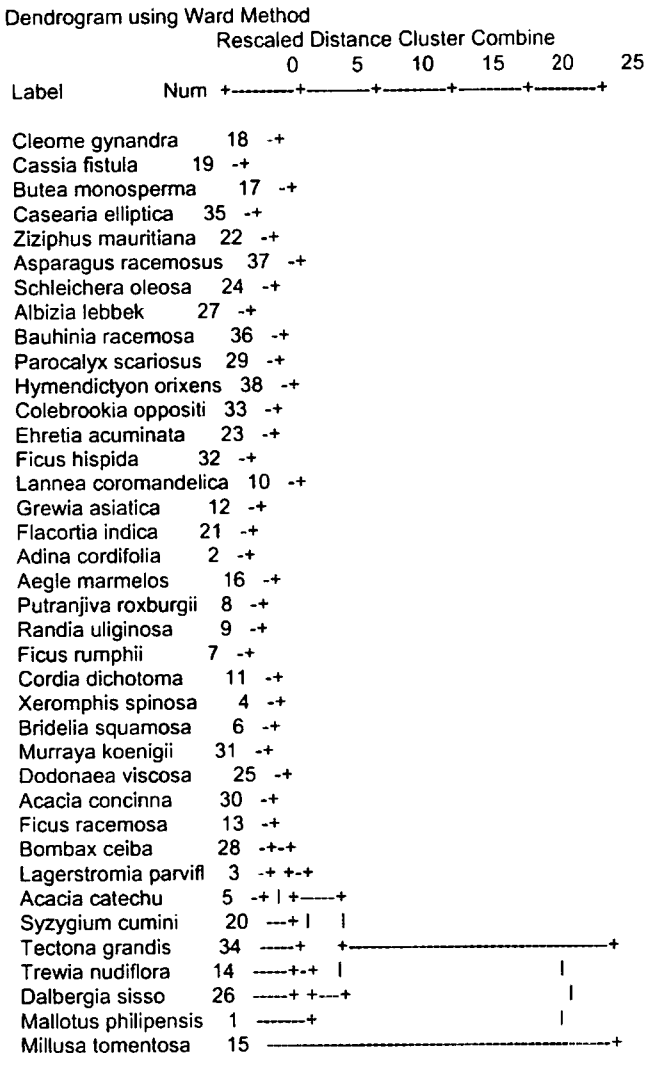


Table 2.6: Importance value index (IVI) of the vegetation of corridors

ɔecies	F. Of occurrence	N. of plant	Abundance	Avg. GBH (cm)	Basal area/ha	Frequency %	Density/ ha	Relative Frequency	Relative density	Relative Basal Area	IVI	Ab/f
illenia pentagyna	1	1	1.00	25	0.000	0.81	0.06	0.18	0.03	0.08	0.30	1.00
assia fistula	5	6	1.20	56	0.002	4.07	0.39	0.90	0.20	0.43	1.53	0.24
ɜrminalia arjuna	3	33	11.00	36.69	0.001	2.44	2.14	0.54	1.10	0.18	1.82	3.67
ɜrminalia alata	1	6	6.00	175	0.016	0.81	0.39	0.18	0.20	4.16	4.54	6.00
ɜrminalia bellirica	4	11	2.75	98.04	0.005	3.25	0.71	0.72	0.37	1.31	2.39	0.69
'ziphus mauritiana	7	8	1.14	75	0.003	5.69	0.52	1.26	0.27	0.76	2.29	0.16
'cus bengalensis	1	1	1.00	450	0.104	0.81	0.06	0.18	0.03	27.52	27.74	1.00
tsea monopetala	12	16	1.33	64.17	0.002	9.76	1.04	2.17	0.53	0.56	3.26	0.11
ıegle marmelos	12	27	2.25	76.58	0.003	9.76	1.75	2.17	0.90	0.80	3.86	0.19
ɜrocalyx scariosus	1	5	5.00	33	0.001	0.81	0.32	0.18	0.17	0.15	0.50	5.00
ymenodictyon ‹celsum	3	5	1.67	150	0.012	2.44	0.32	0.54	0.17	3.06	3.77	0.56
ɜromphis spinosa	7	18	2.57	60.18	0.002	5.69	1.17	1.26	0.60	0.49	2.36	0.37
hretia acuminata	2	2	1.00	130	0.009	1.63	0.13	0.36	0.07	2.30	2.72	0.50
sparagus 'cemosus	1	1	1.00	20	0.000	0.81	0.06	0.18	0.03	0.05	0.27	1.00
asearia elliptica	8	12	1.50	64.06	0.002	6.50	0.78	1.44	0.40	0.56	2.40	0.19
odonaea viscose	22	66	3.00	66.77	0.002	17.89	4.27	3.97	2.20	0.61	6.78	0.14
'cus hispida	13	26	2.00	55.31	0.002	10.57	1.68	2.35	0.87	0.42	3.63	0.15
utea monosperma	17	42	2.47	122.41	0.008	13.82	2.72	3.07	1.40	2.04	6.50	0.15
Cissampelos pareira	1	6	6.00	70.83	0.003	0.81	0.39	0.18	0.20	0.68	1.06	6.00
ucalyptus sp.	5	26	5.20	62.38	0.002	4.07	1.68	0.90	0.87	0.53	2.30	1.04
rewia asiatica	5	7	1.40	84	0.004	4.07	0.45	0.90	0.23	0.96	2.09	0.28
'cus rumphii	3	3	1.00	377.5	0.073	2.44	0.19	0.54	0.10	19.37	20.01	0.33
ridellia verrucosa	1	1	1.00	25	0.000	0.81	0.06	0.18	0.03	0.08	0.30	1.00
'illusa velutina	1	5	5.00	152	0.012	0.81	0.32	0.18	0.17	3.14	3.49	5.00
'cus racemosa	17	40	2.35	153.06	0.012	13.82	2.59	3.07	1.33	3.18	7.59	0.14

andia uliginosa	1	1	1.00	30	0.000	0.81	0.06	0.18	0.03	0.12	0.34	1.00
ewia nudiflora	21	87	4.14	64.53	0.002	17.07	5.63	3.79	2.90	0.57	7.26	0.20
dina cordifolia	25	61	2.44	80.23	0.003	20.33	3.95	4.51	2.03	0.87	7.42	0.10
yzygium cumini	47	261	5.55	71.51	0.003	38.21	16.89	8.48	8.70	0.70	17.88	0.12
annea romandelica	12	18	1.50	80.76	0.003	9.76	1.17	2.17	0.60	0.89	3.65	0.13
urraya koenigii	5	12	2.40	80.67	0.003	4.07	0.78	0.90	0.40	0.88	2.19	0.48
illusa tomentosa	12	20	1.67	44.03	0.001	9.76	1.29	2.17	0.67	0.26	3.10	0.14
arrisa congesta	3	3	1.00	23.33	0.000	2.44	0.19	0.54	0.10	0.07	0.72	0.33
cacia catechu	80	874	10.93	78.63	0.003	65.04	56.57	14.44	29.12	0.84	44.40	0.14
ridelia squamosa	11	36	3.27	58.73	0.002	8.94	2.33	1.99	1.20	0.47	3.65	0.30
chleichera oleosa	9	12	1.33	162.5	0.014	7.32	0.78	1.62	0.40	3.59	5.61	0.15
cus palmata	2	2	1.00	32.5	0.001	1.63	0.13	0.36	0.07	0.14	0.57	0.50
auhinia recemosa	1	1	1.00	40	0.001	0.81	0.06	0.18	0.03	0.22	0.43	1.00
ordia dichotoma	3	3	1.00	35	0.001	2.44	0.19	0.54	0.10	0.17	0.81	0.33
eromphis spinosa	12	20	1.67	40.28	0.001	9.76	1.29	2.17	0.67	0.22	3.05	0.14
tsea sp	1	1	1.00	20	0.000	0.81	0.06	0.18	0.03	0.05	0.27	1.00
auhinia sp.	6	7	1.17	48.92	0.001	4.88	0.45	1.08	0.23	0.33	1.64	0.19
lbizia procera	2	4	2.00	50.83	0.001	1.63	0.26	0.36	0.13	0.35	0.85	1.00
ongamia pinnata	4	7	1.75	131.95	0.009	3.25	0.45	0.72	0.23	2.37	3.32	0.44
utranjiva roxburgii	10	26	2.60	72.93	0.003	8.13	1.68	1.81	0.87	0.72	3.39	0.26
cus religiosa	3	3	1.00	225	0.026	2.44	0.19	0.54	0.10	6.88	7.52	0.33
allotus philipensis	40	150	3.75	44.44	0.001	32.52	9.71	7.22	5.00	0.27	12.49	0.09
ombax ceiba	19	52	2.74	116.98	0.007	15.45	3.37	3.43	1.73	1.86	7.02	0.14
orus alba	2	14	7.00	35.94	0.001	1.63	0.91	0.36	0.47	0.18	1.00	3.50
cacia concina	11	23	2.09	31.88	0.001	8.94	1.49	1.99	0.77	0.14	2.89	0.19
albergia sisso	43	700	16.28	85.2	0.004	34.96	45.31	7.76	23.33	0.99	32.07	0.38
olopetala integrifolia	1	1	1.00	30	0.000	0.81	0.06	0.18	0.03	0.12	0.34	1.00
lbizia lebbek	2	4	2.00	110.83	0.006	1.63	0.26	0.36	0.13	1.67	2.16	1.00
ectona grandis	13	224	17.23	68.96	0.002	10.57	14.50	2.35	7.46	0.65	10.46	1.33
	554	3001	.	.	0.37	450.40	194.25	100.00	100.00	100.00	.	.

Table 2.7: Tree density in Katernigaht range of Katerniaghat WLS

Species	Frequency	No. of plant	Abundance	Density/ ha	Minimum occurrence	Maximum occurrence	Std. Deviation
Acacia catechu	12	40	3.33	10.27	1	10	2.81
Acacia concinna	5	8	1.6	2.05	1	3	0.89
Acacia pinnata	1	2	2	0.51	2	2	.
Adina cordifolia	4	5	1.25	1.28	1	2	0.5
Aegle marmelos	3	4	1.33	1.03	1	2	0.58
Albizia lebbek	1	1	1	0.26	1	1	.
Asparagus racemosus	1	1	1	0.26	1	1	.
Bauhinia racemosa	2	2	1	0.51	1	1	0
Bombax ceiba	9	27	3	6.93	1	6	1.58
Bridellia squamosa	7	13	1.86	3.34	1	4	1.07
Butea monosperma	2	2	1	0.51	1	1	0
Casearia elliptica	1	1	1	0.26	1	1	.
Cassia fistula	1	1	1	0.26	1	1	.
Ehretia acuminata	3	4	1.33	1.03	1	2	0.58
Colebrookia oppositifoli	1	1	1	0.26	1	1	.
Cordia dichotoma	4	7	1.75	1.8	1	3	0.96
Dalbergia sisso	10	88	8.8	22.6	3	18	5.61
Dodonaea viscosa	6	8	1.33	2.05	1	2	0.52
Ficus hispida	5	6	1.2	1.54	1	2	0.45
Ficus racemosa	8	14	1.75	3.6	1	3	0.71
Ficus rumphii	1	2	2	0.51	2	2	.
Grewia tilaefolia	4	5	1.25	1.28	1	2	0.5
Hymenodictyon sp.	1	2	2	0.51	2	2	.
Kydia sp	3	4	1.33	1.03	1	2	0.58
Lagerstromia parviflora	5	21	4.2	5.39	1	6	1.92
Lannea coromandelica	4	5	1.25	1.28	1	2	0.5
Mallotus philipensis	16	94	5.88	24.14	1	18	4.94
Millusa tomentosa	5	5	1	1.28	1	1	0
Murraya koenigii	5	11	2.2	2.83	1	5	1.64
Parocalyx scariosus	2	2	1	0.51	1	1	0
Putranjiva roxburgii	1	1	1	0.26	1	1	.
Randia uliginosa	1	1	1	0.26	1	1	.
Schleichera oleosa	1	1	1	0.26	1	1	.
Syzygium cumini	9	34	3.78	8.73	1	15	5.33
Tectona grandis	7	57	8.14	14.64	3	16	5.3
Trewia nudiflora	15	79	5.27	20.29	1	17	5.44
Vallaris solanacea	4	4	1	1.03	1	1	0
Xeromphis spinosa	5	7	1.4	1.8	1	2	0.55
Ziziphus mauritiana	1	1	1	0.26	1	1	.

Table 2.8: Shrub density at Katerniaghat WLS

Species	Frequency	No of plant	Abundance	Density/ha	Minimum	Maximum	Std. Deviation
Acacia pinnata	3	7	2.33	28.77	1	4	1.53
Glycosmis pentaphylla	8	66	8.25	271.2	2	24	7.76
Ziziphus mauritiana	3	32	10.67	131.59	4	17	6.51
Ziziphus mauritiana	1	1	1.00	4.2	1	1	.
Clerodendron viscosum	15	419	27.93	1721.80	1	98	30.54
Pogostemon benghalensis	4	11	2.75	45.20	2	4	0.96
Argemone maxicana	3	5	1.67	20.55	1	2	0.58
Calicarpa microphylla	7	31	4.43	127.39	2	7	1.90
Desmodium pulchellum	1	2	2.00	8.22	2	2	.
Casearia elliptica	1	1	1.00	4.11	1	1	.
Dodonaea viscose	3	3	1.00	12.33	1	1	0.00
Ficus hispida	1	1	1.00	4.12	1	1	.
Vallaris solonacea	6	116	19.33	476.68	2	42	16.93
Ficus racemosa	1	1	1.00	4.11	1	1	.
Trewia nudiflora	1	2	2.00	8.22	2	2	.
Adina cordifolia	1	2	2.00	8.22	2	2	.
Syzygium cumini	6	56	9.33	230.12	1	42	16.05
Kydia calycina	11	315	28.64	1294.43	1	175	52.30
Mitragyna parvifolia	1	6	6.00	24.66	6	6	.
Millusa tomentosa	5	19	3.80	78.07	1	6	1.92
Murraya koenigii	13	139	10.69	571.19	1	44	14.04
Acacia catechu	1	2	2.00	8.22	2	2	.
Bridelia squamosa	1	1	1.00	4.11	1	1	.
Lantana camera	2	29	14.50	119.17	4	25	14.85
Achyranthes aspera	2	15	7.50	61.64	5	10	3.54
Xeromphis spinosa	5	8	1.60	32.87	1	3	0.89
Flacortia indica	3	38	12.67	156.15	2	22	10.07
Putranjiva roxburgii	4	18	4.50	73.96	1	8	3.51
Grewia tilaefolia	1	2	2.00	8.22	2	2	.
Tiliocora acuminata	6	38	6.33	156.15	2	14	4.63
Mallotus philipensis	4	17	4.25	69.86	2	6	1.71
Acacia concina	2	5	2.50	20.55	2	3	0.71
Tectona grandis	2	7	3.50	28.76	3	4	0.71
Millettia auriculata	1	1	1.00	4.11	1	1	.
Total	138	1416	10.26	5818.78	0	175	20.89

Table 2.9: Herb density at Katerniaghat range of Katerniaghat WLS

Species	Frequency	No. of plant	Abundance	Density/ha	Minimum	Maximum	SD
Costus speciosus	1	1	1.00	102.73	1.00	1.00	.
Capillipedium	7	118	16.86	12122.46	3.00	64.00	21.83
Cyperus niveus	2	45	22.50	4622.97	2.00	43.00	28.99
Alternanthera sessilis	2	36	18.00	3698.38	13.00	23.00	7.07
Cynodon dactylon	1	24	24.00	2465.58	24.00	24.00	.
Phyla nodiflora	1	3	3.00	308.20	3.00	3.00	.
Ageratum conyzoides	3	232	77.33	23833.98	3.00	180.00	91.84
Malva coromandelica	3	128	42.67	13149.78	8.00	65.00	30.44
Equisetum sp.	1	3	3.00	308.20	3.00	3.00	.
Desmostachya bipinnata	10	196	19.60	20135.61	1.00	78.00	24.86
Achyranthus aspra	3	35	11.67	3595.64	3.00	24.00	10.97
Imperata cylindrica	3	96	32.00	9862.34	26.00	42.00	8.72
Aiserna scadia	5	27	5.40	2773.78	1.00	8.00	2.97
Cissampelos pareira	2	91	45.50	9348.67	18.00	73.00	38.89
Brachiaria prostrata	17	406	23.88	41709.47	2.00	149.00	37.14
Trifolium indicum	1	24	24.00	2465.58	24.00	24.00	.
Total	72	1465	20.35	150503.39	0.00	180.00	31.79
		SD		11049.09			

Table2.10: Height profile of grass/herb of Katerniaghat range of Katerniaghat WLS

Species	Frequency	Minimum height	Maximum height	Mean height	Std. Deviation
Costus speciosus	1	20	20	20.00	.
Capillipedium	7	10	40	18.57	10.29
Cyperus niveus	2	5	30	17.50	17.68
Alternanthera sessilis	2	5	10	7.50	3.54
Cynodon dactylon	1	20	20	20.00	.
Phyla nodiflora	1	5	5	5.00	.
Ageratum conyzoides	3	10	20	13.33	5.77
Malva coromandelica	3	100	150	116.67	28.87
Equisetum sp.	1	20	20	20.00	.
Desmostachya bipinnata	10	10	200	89.00	51.52
Achyranthus aspra	3	15	70	35.00	30.41
Imperata cylindrica	3	8	120	69.33	56.76
Aiserna scadia	5	5	10	8.00	2.74
Cissampelos pareira	2	10	20	15.00	7.07
Brachiaria prostrata	17	5	30	14.41	6.34
Trifolium indicum	1	2	2	2.00	.
Total	72	0	200	29.93	40.84

Table 2.11: Tree density in the proposed Rhino area in Dudhwa NP

Species	Frequency	No. Of plant	Abundance	Mean	SD	Density /ha
Shorea robusta	15	216	14.40	12.71	8.32	95.54
Mangifera indica	1	1	1.00	0.06	0.24	0.44
Millusa tomentosa	7	36	5.14	2.12	5.11	15.92
Mitragyna parvifolia	1	2	2.00	0.12	0.49	0.88
Mallotus philipensis	14	75	5.36	4.41	3.48	33.17
Schleichera oleosa	5	7	1.40	0.41	0.80	3.10
Lagerstroemia parviflora	7	14	2.00	0.82	1.33	6.19
Tectona grandis	2	52	26.00	3.06	12.36	23.00
Dodonaea viscose	1	1	1.00	0.06	0.24	0.44
Ficus racemosa	1	1	1.00	0.06	0.24	0.44
Casearia elliptica	3	4	1.33	0.24	0.56	1.77
Buchanania lanzan	5	17	3.40	1.00	2.89	7.52
Ficus rumphii	1	1	1.00	0.06	0.24	0.44
Emblica officinalis	1	1	1.00	0.06	0.24	0.44
Syzygium cumini	2	6	3.00	0.35	1.06	2.65
Moringa oleifera	1	1	1.00	0.06	0.24	0.44
Bombax ceiba	1	8	8.00	0.47	1.94	3.54
Lannea coromandelica	1	2	2.00	0.12	0.49	0.88
Dalbergia sisso	1	3	3.00	0.18	0.73	1.33

Table 2.12: Shrub density in the proposed Rhino area in Dudhwa NP

Species	Frequency	No of plant	Abundance	Density/ha	Std. Deviation
Lagerstroemia parviflora	8	16	2.00	119.90	1.93
Aegle marmelos	1	7	7.00	52.45	.
Glycosmis pentaphylla	8	73	9.13	547.02	5.44
Grewia sp.	1	8	8.00	59.95	.
Clerodendron viscosum	16	715	44.69	5357.81	52.03
Nyctanthes arbortristis	1	3	3.00	22.48	.
Casearia elliptica	9	27	3.00	202.32	1.58
Desmodiumppulchellum	2	7	3.50	52.45	2.12
Bridelia verrucosa	3	30	10.00	224.80	3.61
Sygygium cumini	3	8	2.67	59.95	1.53
Millusa tomentosa	5	26	5.20	194.83	3.70
Schleichera oleosa	1	1	1.00	7.49	.
Mangifera indica	1	18	18.00	134.88	.
Litsea sp.	1	2	2.00	14.99	.
Murraya koenigii	1	3	3.00	22.48	.
Flacourtia indica	1	2	2.00	14.99	.
Tiliacora acuminata	15	700	46.67	5245.41	31.87
Mallotus philipensis	5	30	6.00	224.80	1.87
Shorea robusta	13	198	15.23	1483.70	15.22
Rauvolfia serpentina	1	1	1.00	7.49	.
Total	96	1875	19.53	14050.21	30.93

Table 2.13: Herb density in the proposed Rhino area in Dudhwa NP

SPECIES	Frequenc y	No. of plants	Abundanc e	Density /ha	Mini	Maxi	SD
Capillipedian assimile	1	4	4	749.34	4	4	.
Ageratum conizoides	1	14	14	2622.71	14	14	.
Desmostachya bipinata	7	152	21.714	28475.08	5	48	18. 00
Imperata cylindrical	6	270	45	50580.74	5	88	35. 09
Aiserna scadia	1	1	1	187.34	1	1	.
Bothriochloa intermedia	2	6	3	1124.02	2	4	1.4 1
Total	25	447	17.88	83739.23	1	88	25. 65

Table 2.14: Height profile in the proposed Rhino area in Dudhwa NP

SPECIES	Frequency	No. of plants	Mean height (cm)	Minimum height (cm)	Maximum height (cm)	SD
Capillipedian assimile	1	80	80	80	80	.
Ageratum conizoides	1	5	5	5	5	.
Desmostachya bipinata	7	630	90	50	150	33.66
Imperata cylindrica	6	480	80	30	110	30.33
Aiserna scadia	1	10	10	10	10	.
Bothriochloa intermedia	2	190	95	90	100	7.071
Total	25	1395	55.8	5	150	47.11

Table 2.15: Grass abundance in the proposed Rhino area in Dudhwa NP

Species	Frequency	Percent	Cumulative Percent
Bare land	106	13.3	13.3
Vicia sativa	2	.3	13.6
Cyperus sp.	1	.1	13.7
Capillipedianassimile	68	8.5	22.2
Saccharum spontaneum	53	6.6	28.9
Vetiveria zizanioides	47	5.9	34.8
Desmostachya bipinnata	150	18.8	53.6
Imperata cylindrica	24	3.0	56.6
Saccharum fuscum	97	12.2	68.8
Bothriochloa intermedia	21	2.6	71.4
Saccharum bengalense	103	12.9	84.3
Trifolium indicum	5	.6	84.9
Themeda arundininacea	120	15.1	100.0
Total	797	100.0	

Table 2.16: Height profile of grasses proposed Rhino area in Dudhwa NP

Species	Frequency	Mean height (cm)	Minimum height (cm)	Maximum height (cm)	SD
Bare land	106	0	0	0	0
Vicia sativa	2	67.5	65	70	3.54
Cyperus sp.	1	190	190	190	.
Capillipedianassimile	68	164.04	40	320	71.2
Saccharum spontaneum	53	197.74	100	320	52.61
Vetiveria zizanioides	47	166.6	75	320	58.03
Desmostachya bipinnata	150	181.27	0	320	47.59
Imperata cylindrica	24	83.75	20	240	56.78
Saccharum fuscum	97	252.99	120	410	57.06
Bothriochloa intermedia	21	198.57	140	270	36.92
Saccharum bengalense	103	280.29	40	620	125.99
Trifolium indicum	5	4.2	3	5	1.1
Themeda arundininacea	120	254.54	110	610	102.7
Total	797	184.61	0	620	114.05

Appendix 1. A List of Common Plant Found in the Corridor Area

Common tree species

Common name	°Scientific name	Common name	°Scientific name
Ambari	*Hymendictyon orixense*	Asna	*Terminlaia alata*
Chatawar	*Alstonia scholaris*	Asidha	*Lagerstroemia parvuflora*
Chajan	*Miletia auriculata*	Maholi	*Bauhinia racemosa*
Char	*Buchanania lanzan*	Anjeer	*Ficus palmata*
Pata	*Kydia calyare*	Anwala	*Emblica officinalis*
Kanji	*Pongamia pinnata*	Mango	*Mangifera indica*
Batua	*Litsea glutinosa*	Imli	*Tamarindus indica*
Chilla	*Miliusa tomentosa*	Drasta	*Wrightia arborea*
kaimi	*Mitragyna parvifolia*	Udal	*sterculia vilosa*
Khaja	*Bridelia retusa*	kakai	*Grewia disperma*
Maholi	*Bauhinia racemosa*		*Abutilon bidentatum*
Rohini	*Mallotus philipensis*	Kataiya	*Flacourtia indica*
Bathua	*Cordia myxa*	Dhamin	*Holoptelia integrifolia*
Patpata	*Ardiasias solanara*	Kankachampa	*Pterospermum acerifolium*
Bathua	*Cordia dichotoma*	Kumbhi	*Cariya arborea*
Maholi	*Bauhinia racemosa*	Kahmhar	*Gmelina arborea*
Patzia	*Putranjiva roxburgii*	Katneem	*Millingtenia hottensis*
Gulri	*Ficus sp*	Gajhad	*Ficus rumphii*
Meida	*Bridelia squamosa*	Chandana	*Litsea cninensis*
Akhnoor	*Antidesma bunius*	Ghurdhiya	*Gardenia turgida*
	Barassomtia parviflora	Chilla	*Casearia elliptica*
Chilla	*Caesearia tomentosa*	Chironhi	*Buchanania lanzan*
Pakri	*Ficus glomerata*	Chitwan	*Alstonia schoclaris*
Khaja	*Lagerstroemia speciosa*	Jamun	*Syzygium cumini*
Katgular	*Ficus hispida*	Jigna	*Lannea coromandelica*
Gurdhia	*Randia dumetorum*	Homsal	*Milusa velutina*
°Gutel	*Trewia nudiflora*	Dhak	*Butea monosperma*
°Mana	*Cordia dichotoma*°	Tilka	*Wenlandia heynei*
°Pati	*Cleome gynanadra*°	Tendu	*diospyros melanoxylon*
°Adhora	*Colebrookia oppositifolia*°	Dhakhi	*Antidesma acidum*
°Chandi	*Ehretia acuminata*°	Dudhi	*Holarrhena*

			antidysentric
˚Akhor	*Limonia˚acidissima*	Pharsa	*Grewia tiliaefolia*
˚Siris	*Albizia procera*	Dhola	*Erythrina suberosa*
pandal	*stereospermum cheensis*	Neura	*Barringtonia acutangula*
Pula	*Kydia calycins*	Patjia	*Putranjiva roxburgii*
Pindara	*catunaregam ulicinosa*	Paniyala	*Flacoutia jancemas*
paper mulberi	*Broussonetia papyrifera*	Pakriya	*Ficcus lacer*
Phalsa	*Grewia asiatica*	Maharukh	*Ailanthus excelsa*
Pharsa	*Grewia tilaefolia*	Bahera	*Terminlaia bellirica*
Lasod	*cordia dichotoma*	Dho	*Anogeissus latifolia*
ban kakai	*Celtis tetrandra*	Ber	*Ziziphus mauritiana*
Vijay sal	*Pterospermum marsupium*	Bel	*Aegle marmelos*
Bilaytee Babool	*Prosopis juliflora*	Bhurkul	*Hymenodictyon ecelsum*
Safed siris	*Albizia procera*	Bhoru	*Salix tetrasperma*
Sandan	*ougeinia ojeinensis*	Bhelwa	*Semecarpus anacardium*
Sagon	*Tectona grandis*	Mahua	*Maduca indica*
sal	*Shorea robusta*	Maida	*Litsea chinensis*
Sinhor	*streblus asper*	Mainphal	*Catunarecam nutans*
Suhaga	*Aphanzoixis poystachya*	Nilgir	*Eucalyptus hybrid*
Samel	*Bombax ceiba*	Rohini	*Mallotus phillipensis*
Sahjan	*Moringa oleifera*	Haldu	*Heldina cordifolia*
Sahtut	*Morus alba*	Choriya	*Dodonaea viscose*
Shishum	*Dalbergia sissoo*	Shikakai	*Acacia concinna*
Patjia	*Putranjiva roxburgii*		

Common shrub species

Common name	**˚Scientific name**	**Common name**	**˚Scientific name**
Banbera	*Moghania sp*	Arusa	*Justica adhatoda*
Rangoi	*Tiliacora acumulata*	Aak	*Calotropis procera*
Gulabi phul wala shrub	*Garuga pinnata*	Karonda	*Carissa congesta*
Safed Bhat	*Colebrooke oppositifolia*	kataiya	*Flacoutia indica*
Agaia	*Dillenia indica*	Katrot	*Mochania chappar*
˚	*Momordica dioica*	Khajur	*Phoenix acualis*
kasonji	*Cassia occidentalis*	Gur sakri	*Grewia helicterifolia*
Thanedar	*Baliospermum tritanum*	Gutur	*Glycosmis arborea*

Ban nimbu	*Glycosmis pentaphylla*	katneem or Karipatta	*Murraya koenighii*
Chauranga	*Desmodium pulchellum*	Chameli	*Jasmenium arborevcen*
Ghont	*Ziziphus xylophyrus*	Satavar or chitawar	*Asparagus adscendens*
kandoori jaisa lal	*Trichosanthes cucumerine*	Choti Van tulsi	*Ageratum conyzoides*
Dhudia	*Ipomoea aquatica*	Jal kemba	*Cephalenthus tetrandra*
°	*Clerodendron infortunatum*	Juhi	*Jasminum arndiflorum*
	Premna barbeta	Ber	*Ziziphus mauritiana*
°	*Leea asiatica*	Dhawri	*Woodfordia fruiticosa*
	Premna mucronata	Dhatura	*Detura motel*
Aaila	*Acacia torta*	Panwar	*cassia obtusirolie*
Dudhiya	*Frecypron fruticyon*	Singi	*Emblica tsjerium*
°	*Jasminum multiflorum*	Bhakmal	*Ardisia solonacea*
°	*Apocynum frutescens*	Bhang	*Cannabis sativa*
Bendu	*Grewia sapida*	Bhant	*Clerodendron viscosum*
Gumma	*Leucas nudiflora*	Bhat kataiya	*Solanum indicum*
Tihuna Bel	*Ichnocarpus fruitescens*	Maror phal	*Helictres isora*
galgal	*Vallaris solanacea*	Makoi	*Ziziphus oneoplia*
Ban tulsi	*Pocostemon benchalensis*	Ratanjot	*Clausena pentaphylla*
Ban Tarai	*Crotalaric junosa*	Ram bans	*Agave cantula*
Kakhhai	*Kydia calycina*	Kuri	*Lantana camara*
Bhat	*Clerodendron infortunatum*	*Neeli Kateya*	*Solanum surattense*
Kober	*Amnitis indica*	*Phalsa*	*Grewia asiatica*
Kali Bhat	*Pogostemon benghalensis*	*Berri*	*Sida acuta*
Silkit	*Clerodendron odoratum*	Ban haldi	*Curcuma longa*
Badi Duhi	*Wrightia tomentosa*	*Gundhi*	*Typha latifolia*
Peele phul wali kateli	*Solanum indicum*	*Badi Duhi*	*Wrightia tinctoria*
Safed Bhat	*Callicarpa macrophylla*	*Peele kateli*	*Argemone maxicana*

Climbers

Common name	**°Scientific name**	**Common name**	**°Scientific name**

Al	***Caesalpinia decapetela***	Paniyala	*Flacoutia jancomes*
Aila	*Acacia torta*	Parwal	*Trichosanthes dioica*
Rohini	*Tiliacora acuminata*	walai kand	*Pueraria tuberosa*
Kundru	*Coccinia indica*	Banth	*Calamus tenuis*
Kanja	*Caesalpinia crista*	BAUSAM	*Paracalyx scariosus*
Kancha	*Caesalpinia crista*	Maulina	*Bauhinia vahlii*
Kancha	*Mucuna prueins*	Molkani	*Celastrus paniculatus*
Garara	*Butea parviflora*	bhondh	*Butea superba*
Gurch	*Tinospora sinensis*	Ram datun	*Smilax perfoliata*
Gonjh	*Millettia extensa*	Ram pan	*Smilax ovalifolia*
Giloh	*Tinospora cordifolia*	Ratti	*Abrus precatorius*
Chameli	*Jasminum multiflorum*	Dudhi	*Cryptolepis buchanani*
Taorr	*Dioscorea belophylla*	safed bel	*Porana paniculata*
Tuki	*Ichnocarpus fruitescens*	Harjor	*Cissampelos pareira*
Pani bel	*Cissus adnata*	Amar bel	*Cuscuta reflexa*
Piper	*Piper sp.*	Banda	*Dendrophthoe falcata*

Common herbs

Common name	**˚Scientific name**	**Common name**	**˚Scientific name**
˚	*Youngia japonica*	˚Jor tor	*Equisetum diffusum*
˚Piperi	*Cissampelos pareira*	˚Jhak	*Malva coromandelica*
Panchunia	*Aiserna scadia*	Osimum baccilans	*Osimum baccilans*
˚	*Cayratia auriculata*	Polygonum barbatum	*Polygonum barbatum*
˚	*Phyla nodiflora*	Panchunia	*Alternanthera sessilis*
˚	*Sonchus coightianus*	Tihuna	*Dioscorea pentaphylla*
Ghusiyari	*Diplocyclas palmatus*	Ban til	*Sesamum indicum*
Lily jaisa tuber	*Costus speciosus*	Sitaphal	*Gritolaria alba*
Pawar	*Cassia tora*	Rusa	*Justicia adhatoda*
Akra munmun	*Vicia sativa*	˚	*Eleocharis acutangula*

Common grasses

Common name	***˚Scientific name***	**Common name**	***˚Scientific name***

Khagar	*Saccharum spontaneum*	*Nal*	*Arundi donax*
Much mucha	*Fimbristylis falcata*	*Kumaria*	*Heteropogon contortus*
basi	*Apluda mutica*	*Kans*	*Saccharum spontaneum*
Kudrel	*Paspalum scrobiculatum*	*Gulra*	*Chrysopogon fulvus*
Janewa	*Ischaemum indicum*	*Bush*	*Demostachya bipinnata*
Kush	*Desmostachya bipinnata*	*Dub*	*Cynodon dactylon*
Pasai chawal	*Oriza rufipogon*	*Narkul*	*Phragmitis karka*
Ban saveri	*Ofrlusmem corftrusitis*	*Patera*	*Typha elphantina*
Tavar	*Saccharum ranium*	*Bab*	*Eulaliopsis binata*
Basi	*Capllpedian assimile*	*Munj*	*Brianthus munja*
Jrakush	*Cymbopogon martinii*	*Rusa*	*Cymbopogon martinii*
	Thameda triandra	*Ratwa*	*Sclarestachya fusca*
Ratwa	*Coix lacryna*	*sarjora*	*Themeda arundinacea*
Bakas	*Hemarthria altissima*	*Sindhur*	*Bothriochloa bladhii*
Jrakush	*Andropogon tristis*	*Naranga, Kanvar*	*Saccharum porphyrocoma*
Narkul	*Thysanolaema maxima*	*Oiya*	*Bitterochlra galuca*
Janewa	*Dichanthium annulatum*	*Bhada*	*Cypreus niveus*
Badhai	*Cyperus sp.*	*Khus*	*Vetiveria zizanoides*
Florwa	*Eragrostis tenella*	*Bhada*	*Cypreus nutans*
Badhai	*Fimbristylis sp*	*Saveri*	*Brachiaria prostrata*
Chodi patti	*Chloris boivinii*	*Mayari*	*Imperata cylindrica*

CHAPTER 3

Faunal Diversity and Movement of Wild Animals

3.1 Introduction

Dudhwa Tiger Reserve and its surroundings in the Northern State of Uttar Pradesh, represents one of the few remaining examples of a highly diverse and productive terai ecosystem. It supports a complex landscape, harbors rich and diverse wildlife habitats. The alluvial action of the many streams and rivers, gorging monsoon rainwater from the Himalayan and Shiwalik hill track creates in the Gangetic plains a complex landscape of Sal dominated moist deciduous forests with interspersed tall grasslands and swamps. The original large herbivore community alone equaled the diversity and biomass of some better-known East African grassland-herbivore ecosystem (Lehmkhul, 1989). Elephant (*Elephas maximus*), wild buffalo (*Bubalus bubalis*), One horned rhinoceros (*Rhinoceros unicornis*), five species of deer namely Sambar (*Cervus unicolor*), Swamp deer (*C. duvauceli duvauceli*) Hog deer (*Axis porcinus*), Chital or spotted deer (*Axis axis*) and Barking deer (*Muntiacus muntjak*), Hispid hare and wild pig (*Sus scorfa*) were abundant, and supported a host of large and small carnivores such as Tiger (Panthera tigris tigris), Leopard (*Panthera pardus*), Wild dog (*Cuon alpinus*), Wolf (*Canis lupus*), Jackal (*Canis aureua*) and Stripped hyaens (*Hyaena hyaena*).This area also support Sloth bear population. The numerous rivers and swamps supported exceptionally abundant and rich avi-fauna like Bengal florican to Swamp partridge, rich in variety of Water bird assemblages both resident and migratory, and equally rich amphibian, reptiles, and fish communities. Both wetland and upland habitats are home for Crocodiles, Gharials to Dolphins to over 450 species of resident and migratory birds.

According to a study conducted under WII-USDA Forest Service Collaborative Project (1996 to 2002) on *Terai Conservation Area*. The *Terai Conservation Area* or TCA is critically linked in an informal network of Protected Areas that stretch across the terai through India and Nepal. Although the Terai landscape is fragmented, and increasingly with mounting population pressure, the TCA is the

potential link between Nepal s Sukhlaphanta Wildlife Reserve and Bardia National Park. Tiger, Elephant and Rhinoceros still manage on occasions to reach the TCA through tenuous corridors that cross the intervening human- dominating landscape. It is likely that tiger have been making the same movements. The TCA could be vital for the metapopulation viability of those large species as well as smaller species with sufficient dispersal capability.

The following section is to assess the Faunal Diversity and extent of the wild animal movement in the corridor areas between Dudhwa National Park and Katerniaghat Wildlife Sanctuary.

3.2 Methodology

The area between Dudhwa National Park and Katerniaghat Wildlife Sanctuary was interspersed with agriculture field and human settlement hence identification of the possible corridor for rhino was started to felicitate the rhino movement from Katerniaghat and Dudhwa and vice versa. Two potential corridors were identified for rhino movement on the basis of reconnaissance of the area, secondary information such as maps of Forest Survey of India, Survey of India toposheet, Satellite data, working plan maps of North Kheri Forest department, Dudhwa national park, and Katerniaghat wildlife sanctuary etc. Two criteria were adopted for the identification of corridor; first the route followed by wild rhino from Katerniaghat WLS to Dudhwa NP during 1996 should be included in the corridors and second, corridors should be feasible, forested and distance between the rhino inhabit area of Katerniaghat and Dudhwa National Park must be minimum.

The area between Dudhwa NP and Katerniaghat WLS come under the jurisdiction of North Nighasan, Mazgai and South Nighasan ranges of North Kheri forest division. Location of corridors between the Dudhwa National Park to Katerniaghat sanctuary is given hereunder:

Corridor-I (Northern Corridor). The area of this corridor lies along the river Mohna, which originates from Nepal and is a tributary of Sarju River. In the past, rhino of Katerniaghat crossed Kuryala Ghat and reached Belrayan range of Dudhwa

National Park via the crop fields of Banbirpur village. The villages and their forest cover which fall in Corridor-I are as below:

Belrayan range (DNP) - Bela Parsua - Kariya, Gulria Patharsha, Kishunnagar, Deepnagar - Banbirpur, Ganganagar, Rannagar - Suratnagar- Khairatya - Katerniaghat WLS.

Most of the land of this corridor is patchy forest and interspersed with crop fields and human settlement. Larger part of forestland of this corridor has been encroached by the local farmers.

Corridor -II (Southern corridor): This area has relatively high amount of forest than the northern corridor. This corridor is interspersed with forest patches and agriculture and human settlement. The Suheli River and its tributaries pass through it. The details of villages and their forest in the corridor- II are as follows: Kila range (DNP)- Sissaya — Nunia, Dharmapur, Kauria - Singhai Kalan, Banglaha, Chakra —Lathua, Bathua, Mohammadpur - Majhra East- Katerniaghat WLS

Forest patches of both the corridors were visited and information on animal movement recorded in circular plots of 10 m in terms of Indirect evidences such as scats, pellets and pugmark sign (Rodgers, 1988). Direct sighting of animal was also recorded whenever they were sighted. In addition, information was gathered from the villagers about the animal movement in the forest patches adjacent to the habitation of the identified corridors. Difference between the habitat variables present was tested using Kruskal-Wallis non-parametric test.

3.3 Results

3.3.1 Animal evidence and diversity in northern corridor

To collect the animal evidence altogether 146.11 hrs were spent in all the forest patches. 38.17 hrs and 108.01 hrs were spent in northern and southern corridor respectively. Animal evidence in northern corridor was estimated in terms of spending hours and evidence were density per hectare. Area covered by

Khairatya i.e. 456.71 hectare was found largest followed by Raghunagar 244.46 ha, Kishunnagar 208.66 ha, Deepnagar 187.63 ha, Belaparsua 136.78 ha and Ganganagar 27.75 ha respectively. Hours spend in Raghungar, Belaparsua, Deepnagar, Kishunagar, Ganganagar and Khairatya were 12.30 hrs, 10.10 hrs, 6.00 hrs, 4.45 hrs, 2.25 hrs and 2.20 hrs respectively. **Table 3.1.**

The northern corridor was inhabited by Elephant (*Elephas maximus*), Tiger (*Panthera tigris*), Hog deer, (*Axis porcinus*), Chital (*Cervus axis*), Nilgai (Boselaphus tragocamelus), Wild boar (*Sus scrofa*), Jackal and (*Canis aureus*). One tigress with one cub and another tigress with two cubs were seen frequently in the areas of Kishannagar, Deepnagar and Suratnagar. Suratnagar does not have any forest but villagers report the frequent use of these areas by tiger and our team has also seen the pugmark of tiger in the sugarcane field and near water bodies.

3.3.2 Animal evidence and diversity in southern corridor

Area covered by forest patches in Icchanagar, Sissaya, Nunia, Dharampur, Ladhuri, Singhai, Banglaha, Mohammadpur, Naurangabad, Bathua, Murthiha, Bairia, Lathua, Majhra East were 233.78 ha, 39.59 ha, 1641.96 ha, 89.0 ha, 231.14 ha, 45.92 ha, 349.26 ha, 178.05 ha, 223.98 ha, 542 ha, 166.14 ha, 453.98 ha, 251.56 ha and 775.38 ha respectively. However, maximum time was spent in Nunia (17.40 hrs), followed by Bairia (10.13), Bathua (9.10), Majhra East (9.04), Ladhuari (8.44), Dharampur (6.45), Lathua (6.40), Icchanagar (5.45), Naurangabad (5.10), Sissaya (4.5), Murthiha (4.40), Ladhuri (4.44), Takiya (4.25), Singahai (4.40), Banglaha (3.45) and Mohammadpur (2.30) respectively **Table 3.1.**

The wild animal evidences in this area are Tiger, Chital, Hog deer, Nilgai, Sloth bear (*Melursus ursinus*), Wild boar, Hare and Swamp deer (*Cervus duvacelii duvacelii*). Two tigers also inhabit this area. One sub-adult male tiger was killed during a fight. There was no evidence of elephant s presence.

3.3.3 Collection of animal evidence in autumn

During the autumn visit, scat density of Jackal and Wild boar was 0.83 ha and 0.42 respectively. Density of pugmark was highest for elephant, followed by Wild boar, Nilgai, Chital and Jackal. Pellet density was highest for Hare (5.20) followed by Chital (4.37), Nilgai (1.25) and Hog deer (0.21) respectively **Table 3.2**

3.3.4 Collection of animal evidence in summer

During the summer, scat density of Jackal, Wild boar, Tiger, Sloth bear was 0.62 ha, 0.21 ha, 0.21 ha, 0.21 ha respectively. Pugmark density was highest for Wild boar, Chital and Elephant respectively. Whereas, pellet density was highest for Hare i.e. 9.37/ha, followed by Chital 93.54), Nilgai (3.12) and Hog deer (2.08). Wild boar digging was 0.21/ha respectively **Table 3.3.**

3.3.5 Collection of animal evidence during winter

Density of scat of Jackal and Wild boar was 0.21/ha. Pugmark density of Nilgai and Tiger was 0.83 and 0.62 respectively. Whereas, pellet density for Swamp deer, Nilgai, Chital, and Hare was 0.42/ha, 2.08/ha, 2.50/ha, 1.87/ha, 2.91/ha respectively **Table 3.4**. Details of all types of evidence in each forest location are shown in **Table 3.6, 3.7 and 3.8.**

3.3.6 Differences between the habitat variables where animal evidences were present and absent

Habitat variables in animal utilized and unutilized sites were compared using Kruskal-Wallis test. Habitat and biotic pressure variable like number of cut trees, number of lopped trees, distance from existing road, distance from habitation, distance of water source, presence of dung, canopy cover, plant height were taken to compare these variables at utilized sites and unutilized sites. At <0.05 confidence level, only number of cut trees and number of dung s variables were found significantly different at utilized and unutilized sites. There was no significant difference for rest of the variable at utilized and unutilized sites **Table 3.5.**

3.4 Discussion

In the Northern Part adjacent to Indo - Nepal boundary and Mohana River in the proposed Corridor-I. Area of important forest patches are viz, Belaparsua, Ragunagar, Kishunnagar, Deepnagar, Ganganagar and Khairatya (Area wise 136.78, 244.46, 208.66, 187.63, 27.75 and 456.71 hectare respectively). The area available in all forest patches, Khairatya hold largest area but due to encroachment and swamp, sampling was carriedout in one point/plot. Large patches of forestland exist in Raghunagar and Kishunnagar respectively. Altogether 10:10 hrs, 12:30 hrs, 4.45hrs, 6.00 hrs, 2.25 hrs and 2.20 hrs spent in Belaparsua, Ragunagar, Kishunnagar Deepnagar, Ganganagar and Khairatya respectively to layout the plots and observations. Forest patches of northern corridor of North Nighasan forest range are very close to Dudhwa NP hence evidence of Elephant, Tiger, Chital, Wild boar, Nilgai, Hog deer were widely distributed in these areas. Animals do keep on moving from Dudhwa NP to these areas and vice versa. Since northern corridor lying along the Nepal border and on the Nepal side also have forest so large animal do keep on moving on either side. Although Deepnagar and Ganganagar are far from Dudhwa but found inhabited by Tiger, Chital, and Nilgai. Khairatya as it is just very close to Katerniaghat WLS and separated by Kuryala River and also connected to southern corridor via Majhra forest. In Khairataya area two tigers, chital, swamp deer and wild boar inhabit the area. Wetlands of Khairatya do receive migratory birds in winter. Since last one year, elephant are using this area for movement between Nepal to Dudhwa and North Kheri and vice versa. In the North Kheri forest division, elephants mainly raid the area of northern corridor of North Nighasan range.

As compared to northern corridor, southern corridor-II has large size of forest. From the side of Dudhwa NP to Sissaya & Nunia, viability of restoration of natural habitat is very much alive. Similarly from the Katerniaghat side to Majhra, Lathua, Bathua, Bairia patches, connectivity is with good forest. But middle part of the southern corridor is under immense biotic pressure; sizes of forest patches are very small and interspersed by agriculture field and people movement. People not only extract fuel wood and grasses but also poaching is common in these areas. Many times during the fieldwork there was encounter with the poachers. As far as

animal distribution is concerned, Sissaya and Nunia had the evidence of Wild boar, Chital, Hare, Nilgai and Jackal. In Dhrampur there was presence of wild boar, nilgai, and hare. Badhura, Ladhuri, Chakra, Singahi, Bangalaha Takiya were found highly disturbed due to its location.

Majhra east, lathua, Baria, Murthiha, Bathua, Naurangabad and Mohamadpur have comparatively dense and large forest and fairly high evidence of animal.

Evidence of three tiger, swamp deer, chital, hot deer, and wild boar was found in this area. The area is also under high degree of poaching and grazing pressure. Land has been encroached. If animals do try to go to Dudhwa via Nunia, perhaps it may get poached. Tiger of Majhra also move via Suratnagar and Deepnagar, Belaparsua and finally to Dudhwa