ASSESSMENT OF HUMAN – ELEPHANT CONFLICTS IN JALPAIGURI DISTRICT OF WEST BENGAL IN RELATION TO LAND-USE PATTERNS

Dissertation Submitted to

Saurashtra University, Rajkot

In partial fulfillment of

Master's Degree in Wildlife Science

JUNE 2003

By

ANIRBAN DATTA ROY

Under the supervision of

DR. S.P. GOYAL

DR. SATHYAKUMAR

भारतीय वन्यजीव संस्थान
Wildlife Institute of Indi

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

CERTIFICATE

This is to certify that **Mr. Anirban Datta Roy** of the Wildlife Institute of India has carried out original research titled " **ASSESSMENT OF HUMAN ELEPHANT CONFLICT IN JALPAIGURI DISTRICT OF WEST BENGAL IN RELATION TO LAND-USE PATTERNS** " for the partial fulfillment of the Master of Science (Wildlife Science) degree from Saurashtra University, Rajkot, India. These investigations were carried out under our supervision from November 2002 to June 2003. We also certify that this research has not been submitted for any other degree to any University.

Date: 27.06.03

Place: Dehradun

(S.P. Goyal)

Senior Reader

(S. Sathyakumar)

Reader

Post Box No.18, Chandrabani, Dehradun - 248001. India
EPABX: +91-135 640111 to 640115, 640990; **FAX:** 640117; **GRAM:** WILDLIFE
E-Mail: wii@wii.gov.in

CONTENTS

ACKNOWLEDGEMENTS

This study would never have happened if not for Wildlife Trust International and Asian Nature Conservation Foundation who provided me with the funds. I am immensely grateful to them. I am also extremely grateful to Prof. Raman Sukumar.

Prof. Savarkar, our Director at the time we started the study I sincerely thank for his support and encouragement.

Dr. Goyal and Dr. Sathyakumar my supervisors, were the best supervisors anybody could have asked for. They were great fun in the field and made light of even the most difficult and trying circumstance. Dr. Goyal and his storehouse of ideas is truly inexhaustible, and if he wanted could have helped me write a few more thesis! I am truly thankful to him for his guidance and extreme patience even in those mad, hectic times just before submission.

I am extremely thankful to the West Bengal Forest Department for their cooperation and support and for allowing me to work in North Bengal. I am especially grateful to Mr. NS Murali, (DFO Jalpaiguri Division), Mr Rajeev Kumar (DFO Wildlife Division II) and Mr. Mathew (Conservator). Mr Bidyut Das (RF Mal Wildlife Squad) and Mrs Anupama Nihar (RF Goyerkata) I would like to express my special thanks. Without their open and cooperative approach, I could not have completed the study. I thank the members of both the Mal and Binnaguri squads. I am also extremely grateful to

In the field, I would especially like to thank Bijoy da from the Mal squad, who was an invaluable help in the field and started by teaching me all about elephants and taught me much about life too in the process. Special thanks also goes out to Bishu da who single handedly did the work of four field assistants and was the best friend and field guide that anyone could ask for.

Back here at WII, I would like to thank the faculty for making our two years here worthwhile. It was a great time, a time which teaches much more than Wildlife Science. Especially unforgettable are classes by Dr. Johnsingh, Dr. Jhala, Dr. Ravi Chellam and Mr. Sanjay Shrivastav.

Our Course Director, Dr. Adhikari, I thank for his best efforts in managing us, inspite of our harassments. But on the cricket field he was a worthy adversary!

The computer and GIS cell staff were always helpful and I especially would like to thank Manoj and Pannalal for their help in preparation of my maps.

My classmates, phew, what can I say about them. I can only thank them for the non-stop entertainment that made two years seem such a short time. To my pal Aaron, I know we're going to miss this place, and our very own Changthang – the Tibetan Colony and its Momo's and all those other outrageous things that we did. Susaant, the physicist and Avin, the mystic, Pragya zooba, Bindu and Priya..its been a great time!

I'd also like to thank Raman and Soumya who so generously lent me her comp for the dissertation. In the hostel, Gopi (both of them), Nammi, Sabya and everybody else who made life so entertaining, thanks !

Last, and most importantly, I'd like to thank my parents who had the trust and confidence to always let me do whatever I wanted and support me. My father, who finally bought me a bike when travel in the field had come a big problem, for his understanding and patience, I thank. I hope I can continue to live upto their expectations.

SUMMARY

This study on Human Elephant Conflict was conducted in Jalpaiguri district of north West Bengal to identify the level of conflicts in different areas of the district, and to recognize it in connection with land-use patterns existing in the district. The study was conducted over five months and information on conflicts was collected from Tea Gardens and Wildlife Squads. Interviews and questionnaires were also used to survey the conflict affected villages.

The different conflict areas and the intensity of the conflicts in those areas were identified with the help of gridded maps. Results showed that although most of the conflict areas had remained the same from previous studies, some new conflict areas were also emerging. Seasonality of the conflicts was also found to be related to cropping patterns adopted. Information collected from the Tea gardens showed that the Tea gardens which had previously been categorised as high conflict areas had remained same to a great extent. The Tea gardens having the highest conflict incidences were frequented more by solitary animals rather than herds. The mean group size of the herds were found to show two distinct peaks in the months of May-June and September-November. Interviews with affected villagers provided a true picture of the difficulties faced by them during crop-raiding. In the absence of Wildlife Squads, villagers had to drive the elephants away with their own methods.

1. INTRODUCTION AND REVIEW OF LITERATURE

1.1 HISTORY AND DISTRIBUTION:

Elephants evolved in Africa 55 million years ago, and in India the oldest records have been obtained from sculptures, paintings, seals and coins dating as far back as the Harappan civilization of 2500-1500 B.C. The Asian Elephant (*Elephas maximus*) is one of the surviving species of the 352 members of the order Proboscidea. It belongs to the family Elephantidae. There are currently three recognized species: the African Savanna or bush elephant (*Loxodonta africana*,), the African forest elephant (*Loxodonta cyclotis*) and the Asiatic or Indian elephant (*Elephas maximus*) also known as the Asian elephant (Nowak 1995).

African elephants have only recently been recognized as two distinct species. The smaller, darker forest elephant which inhabits the rainforests of West and Central Africa (Nowak 1995) was previously thought be a subspecies of the African elephant (*Loxodonta africana cyclotis*) prior to genetic analysis (Roca *et al*. 2001). Macdonald (2001) also lists a smaller subspecies of the forest species, the pygmy elephant (*Loxodonta cyclotis pumilio*) found in the dense lowland jungles from Sierra Leone to Zaire (Nowak 1995). Pygmy elephants were originally described by Noack (1906) but many consider them to be small forest elephants or juvenile animals rather than a separate species (e.g. Western 1986, Nowak 1995). The African savanna elephant is larger and paler and is found in

wider range of habitats including deep forests, open savanna, wet marsh, thorn brush and semi desert scrub, in Eastern, Central and South Africa (WWF 2000; Nowak 1995)

There is considerable variability in the reported number of sub-species of the Asian Elephant (*Elephas maximus*) but Macdonald (2001) believes it to exist as four sub-species. They are *Elephas maximus maximus* found in Sri Lanka, *Elephas maximus bengalensis* found in mainland Asia, *Elephas maximus hirstutus* and *Elephas maximus sumatrana* found on the island of Sumatra.

In the past the Asian elephant ranged from the Tigris and Euphrates valleys in present day Syria and Iraq to south-east China and down to Sumatra in the south. In the Indian subcontinent, they inhabited all but the most arid areas, being recorded even from the dry tracts of Saurashtra and Punjab in the 4th century B.C. (Nair et.al. 1980). Subsequently, reduction of forest cover has taken a heavy toll on the distribution of the Asian elephant in India, which has gradually been pushed towards the east. The present distribution of Asian Elephants is:

Southern India – discontinuously distributed in the Western Ghats in the states of Karnataka, Kerala and Tamil Nadu.

Central India – discontinuously distributed in Bihar, South Bengal and Orissa.

North-western Indian population – in Uttaranchal and Uttar Pradesh.

Eastern population – discontinuously distributed in Northern Bengal, Assam and other states in Eastern India (Santiapillai and Jackson 1990)

1.2 African and Asian Elephants

Several distinct features distinguish the African and Asian species apart from body size which favours the African elephant. Africans have far larger ears than Asians and usually three nails in the hind feet compared to four in the Asian (Nowack 1995). Both female and male African elephants have large tusks which are modified incisors and grow throughout the elephants lifetime (Nowack 1995) Only male Asian elephants grow tusks and these are smaller versions of the African elephant's that protrude well beyond the lip, or small 'tushes' which are only just visible (Shoshani and Eisenberg 1982).

They also have quite a different profile: the back of African elephants slope down from the shoulders to the hips while that of the Asian is domed in appearance (Clutton-Brock 1999) African elephants also have two finger like processes at the tip of their trunk, one above and below, compared to just one on the upper part of the Asian elephants trunk (Nowak 1995; Clutton-Brock 1999). These are said to provide greater manipulative abilities to the African elephant for picking up things

while Asian elephants are more adept at using their feet in conjunction with their trunk (Sikes 1971).

1.3 Ecology:

Both the Asian and African elephants live in tropical regions of the world. The diet of African savanna elephants is composed primarily of grasses, particularly in the wet season, although they also feed on leaves, bark, twigs, herbs, roots, flowers and fruit (Wing and Buss 1970; Field 1971; Nowack 1995). Asian elephants also eat a wide range of grasses as well as bark, roots, leaves and small stems (McKay 1973; Nowak 1995; Sukumar and Ramesh 1995). A large portion of both species diet consists of low quality vegetation and consequently their digestive efficiency is far lower than that of cattle, sheep and horses (Shoshani 1992). Therefore a considerable proportion of their time has to be spent in feeding in order to fulfill their nutritional requirements during which they consume 150 and 350 kg of wet weight forage (Dougall 1964; Mckay 1973; Hanks 1979; Eisenberg 1981; Shoshani and Eisenberg 1982; Macdonald 1984; Karoor 1992; Shoshani 1992)

Asian elephants range widely as a result of their large body size and require large areas to forage and drink. There is a seasonal pattern to elephant distribution within an ecosystem, perhaps a strategy to find optimal feeding and drinking areas (Sukumar 1989).

With the exception of the effect of human activities, the spatial distribution of elephants in the wild is largely governed by the availability of food and water (Nowak 1995, Williams *et al.* 1997). When these are abundant, herds are relatively dispersed throughout their habitat, but when resources are scarce, such as during the dry season, densities can increase dramatically within certain areas. In areas where water is not a limiting source, availability of food may govern the home range size (Sukumar 1989; Olivier 1978) The diversity in habitat types may also influence range size. A more diverse region would be able to meet their varied seasonal requirements within a restricted area (Sukumar 1989)

1.4 Human Elephant Conflict

There are four principal situations in which people are likely to come into conflict with animals as a result of settlement. The first is when animals become a threat to human life. A second cause is the destruction of domestic stock by wild animals. The third reason why wild animals may not be favoured by people is the direct competition for food that can arise on natural grasslands between wild herbivores and domestic stock. Finally there are problems with crop-raiding herbivores (Eltringham 1990). The conflict problem is a cause for concern, because it threatens to erode support for local conservation efforts (Thouless 1994; Lahm 1996; Williams *et al.* 2001)

Human-elephant conflict (HEC) is closely related to the phenomenon of habitat loss and fragmentation, which cause elephants to stray out of forests. HEC is a major conservation issue faced by the species today, since it has negative implications for both elephants and people. HEC interactions between man and elephant comprise, crop-raiding, destruction of food stores, competing for water sources, manslaughter and killing of livestock by elephants. Depredation of crops by elephants occurs to varying extents throughout their present range in Africa and Asia, wherever cultivation abuts elephant habitat (Sukumar 1990). HEC can be one of the precursors to further decline in the species range (Hoare 2000). Previous studies in Africa and Asia have focused on different aspects of HEC such as:

Seasonal patterns of crop-raiding and preferred crops (Sukumar 1989, 1990; Nath and Sukumar 1998; Osborn 1998; Choudhury *et al.* 1997, Desai and Baskaran 1996);

Attitudes of people towards elephants in areas with HEC (Nath and Sukumar 1998; Tchamba 1995, Sam *et al.*1998, Bandara and Tisdell 2003);

Spatial analysis/determinants of HEC (Hoare 1999, Smith and Kasiki 2000); and

The economic implications of crop damage (Blair *et al.* 1979; Thouless 1994; O'Connell-Rodwell *et al.* 2000). These studies have identified several possible causes, for, HEC both proximate and ultimate.

The close proximity of people and elephants living in restricted habitats leads to constant man-elephant conflict.

Studies have identified crop raiding as the principal form of conflict between humans and elephants (Sukumar and Gadgil 1988, Santiapillai and Widodo 1993, Balasubramaniam *et al.* 1995, de Silva 1998, Thouless 1994, Barnes *et al.* 1995, Tchamba 1996, Williams *et al.* 2001) Crop raiding and depredation has been reported to be a major problem from parts of Malaysia (Blair *et al.* 1979), Sumatra (Santiapillai and Suprahman 1984) Sri Lanka (McKay 1973) and India (Mishra 1971; Lahiri Chowdhury 1980; Sukumar 1985). Its immediate negative effects on people and elephants are usually followed by progressively worse confrontations. The IUCN has also recognized the fact that Human Elephant conflict is one of the key conservation issues related to Asian elephants, especially in north Bengal (Santiapillai and Jackson 1990) Conflict situations in India are found mostly in the Southern Indian and the North Eastern populations.

1.5 Elephants in North Bengal:

North Bengal is bordered on the north by the princely state of Bhutan, and Nepal in the west. The Indian state of Assam lies to the east and Sikkim to the North. The elephants in north-eastern India together with those of Bhutan, Bangladesh, Nepal and Myanmar had an almost continuous distribution at the turn of the

century (Choudhury 1999). The elephants in North Bengal form the western most limit of the North Eastern population of the Asian elephant.

The elephants in North Bengal are mostly restricted to the Darjeeling and Jalpaiguri districts and are generally residential, although some movement does occur across interstate and international boundaries usually not going beyond the Jhapa and Ilam districts of Nepal (Choudhury 1999).. There are believed to be three separate populations, out of which the population west of the Torsa River is the one that is most threatened because of habitat fragmentation. This leads to constant conflict with humans (Lahiri Choudhury 1980, 1985).

The rapid conversion of forests to monoculture plantations like tea have driven the elephants out of their natural habitats into small fragmented and 'pocketed' populations (Lahiri Choudhury 1980, 1985). This has given rise to Human Elephant Conflict (Chowdhury *et al.*1997) Every year crops are destroyed, a number of people are killed and the government has to pay lakhs of rupees in compensation. This is inevitably followed by the killing of the 'problem animals'. Every year, the Forest Department has to settle a number of compensation claims and catch/kill the problem animals.

By 1980, 20% of north Bengal's forest cover had already been converted into plantations (Lahiri Choudhury 1980). Most of the major incidents of conflict take place in tea gardens and crop fields (Chowdhury *et al.* 1997). During the period 1980 to 1990, about 476 people have lost their lives due to elephant depredation

(Dey 1991). There are about 186 elephants in this region according to the census conducted by the West Bengal Forest Department in February 1992, spread over the districts of Darjeeling and Jalpaiguri. This gives an average of over 2.5 casualties per elephant, which is probably the highest rate anywhere in Asia where elephants exist (Barua and Bist, 1995)

The principal aim of the study is to assess the extent of HEC in Northern West Bengal in relation to seasonal and land-use patterns .

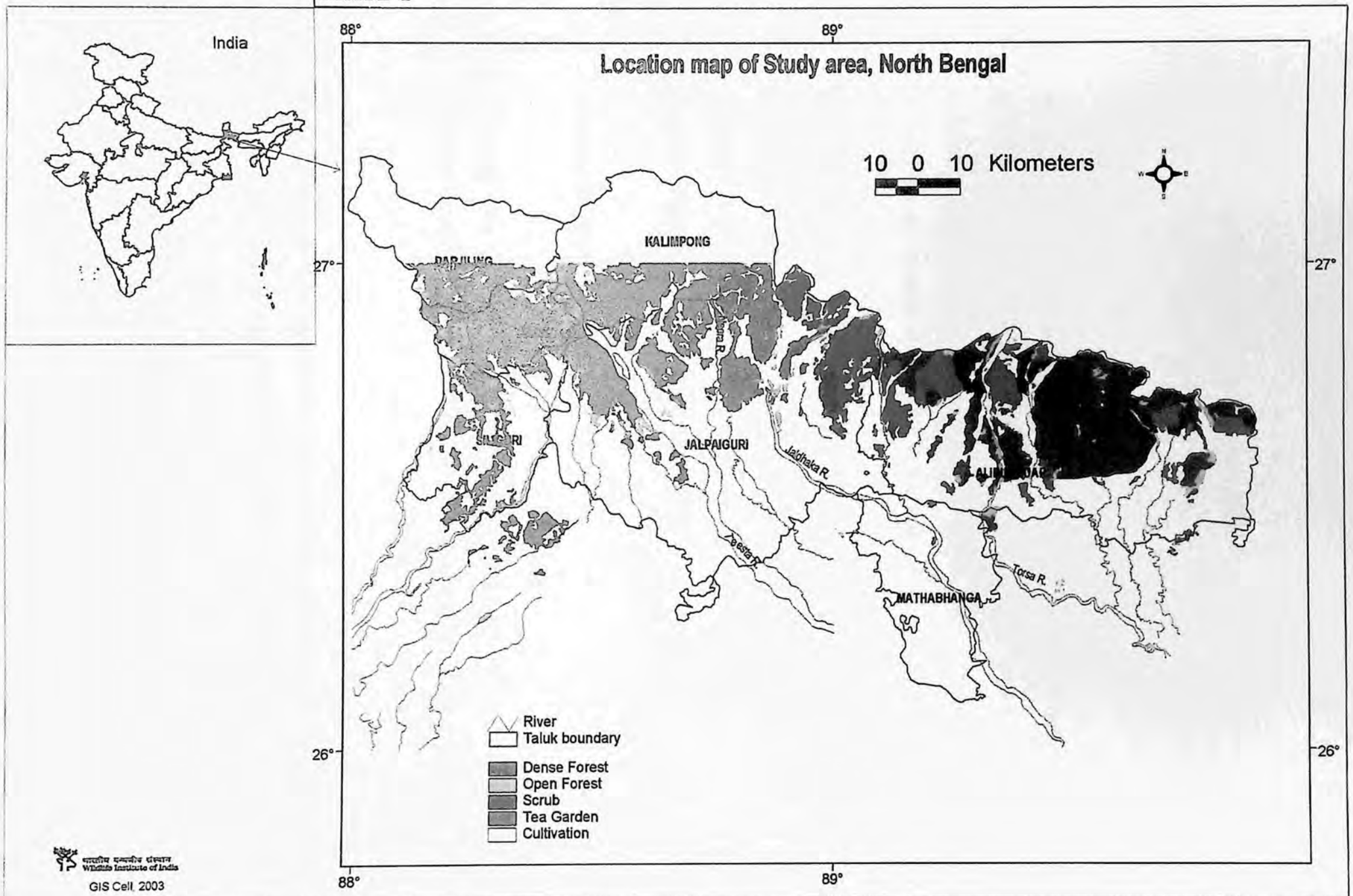
1.6 OBJECTIVES

1. To identify and assess the extent of principal conflict areas within the rivers Teesta and Torsa in North Bengal

2. To determine a seasonal pattern of HEC in North Bengal

3. To understand relationship between HEC and land-use changes and patterns

PLATE 1


India
Location map of Study area, North Bengal
88°
89°
27°
26°
10 0 10 Kilometers
KALIMPONG
DARJILING
JALPAIGURI
Jaldhaka R.
Torsa R.
Teesta R.
MATHABHANGA
River
Taluk boundary
Dense Forest
Open Forest
Scrub
Tea Garden
Cultivation
Wildlife Institute of India
GIS Cell, 2003

2 STUDY AREA

LOCATION

The study area is located between 26^0 - 27^0 N and 88^0 -89^0 E in the northern part of the state of West Bengal (Plate 1). The study was conducted in the administrative district of Jalpaiguri (Plate of Study Area) which is situated between the two districts of Darjeeling in the west and Coochbehar to the south. In the east it is bounded by the state of Assam. Jalpaiguri district also shares its boundary with two countries – Bhutan in the north and Bangladesh in the southeast. Northern West Bengal forms the meeting point for three distinct biogeographical zones. Rodgers and Panwar (1988) classified this area under Biogeographic Zone 7B, the Lower Gangetic Plain.

GEOLOGY, ROCK AND SOIL

The study area consists of the Daling series, a series of schists which extend from the Teesta valley into Sikkim and thence to Bhutan. It belongs to the Archaean system of rock classification (Wadia, 1919).

The area as a whole is covered with alluvial deposits except in the hilly northern fringes. The alluvium consists of coarse gravel near the hills, sandy clay and sandy loam on the south and some patches of black clay in the area between Teesta and Jaldaka (Sudhakar *et al.* 1999) The soil is shallow to moderately

deep and at places deep with medium to fine texture. It faces severe flood hazard and run-off problem (State Forest Report, 2000) The soil types found within the study area have been classified as Terai soils and Bhabar soils.

TOPOGRAPHY

The Dooars - as the rolling humid plains are called, form the gateway of the mountains, Western Dooars being the part of the tract which falls within the district of Jalpaiguri. There are five Dooars or passes to Bhutan in Jalpaiguri district viz. Chamurahi, Lakhimpur, Balla, Baksa and Kumargram (The Encyclopaedic District Gazetteers of India, Vol. 9) Elevation in Jalpaiguri district varies from 62m to 350m.

DRAINAGE:

The principal rivers from West to east are Mahananda and Teesta. Other smaller rivers in between these are the Saun, Karatoa, Chaol, Talma, Ponga and Karala.

RAINFALL AND CLIMATE

The climate is characterized by high humidity and high precipitation. The mean annual rainfall is 3000 – 3500 mm and the mean annual relative humidity is 75%.

The southwest monsoon starts in May and continues till the end of September. Heavy rainfall can cause flashing of rivers and floods in the plains and landslides and disruption of communication in the hilly areas. November, December and January are the driest months; January and February are colder with slight mists; by the end of March it begins to get warm and is very hot in April (Forest Cover mapping of West Bengal districts, 1994)

VEGETATION

The vegetation is generally Tropical moist deciduous/ semi evergreen with Sal (*Shorea robusta*) as the main species and associates of mixed nature. There is a mixing of Riverine forests with naturally growing mixed type of forests and Sal. A major component of the vegetation in North Bengal are the Tea Gardens interspersed with the patches of natural vegetation.

According to Champion and Seth (1964) the forests fall under two broader groups of Northern Tropical Semi-Evergreen forests (2B) and Tropical Moist Deciduous forests (3). The dominant species in these forests are Sal(*Shorea robusta*) associated with species of *Schima*, *Michelia*, *Chukrasia*, *Dalbergia* and *Acacia*. The riverine forests consist of tree species of *Acacia, Dalbergia, Lagerstromia, Albizzia, Gmelina, Bombax, Wrightia* generally associated with tall Thatch grasses.

FAUNA

The unique location of Northern West Bengal at the junction of three biogeographical zones confer it a variety of fauna. It forms the western-most limit of the North Eastern population of Asian elephants, which is incidentally the largest population in India. Jaldapara and Gorumara WLS are also home to the endangered one horned Rhinoceros (*Rhinoceros unicornis*). Some of the other mammals found in this area are Gaur (*Bos gaurus*), Tiger (*Panthera tigris*), Leopard (*Panthera pardus*), Chital (*Axis axis*), Clouded leopard (*Neophelis nebulosa*), Hog Deer (Axis porcinus) and Sambar (*Cervus unicolor*). The area is extremely rich in reptiles, birds, amphibians and insects too.

LAND USE PATTERNS

Agriculture and Tea-plantation form the major occupation of the people in North West Bengal. The land-use pattern of Jalpaiguri district has undergone drastic changes during the second half of the last century due to large scale migration and influx of people. This has resulted in extensive utilization of natural lands for man-made or artificial structures. Human density varies from 510 per km^2 in Darjeeling to 547 per km^2 in Jalpaiguri (2001 census). Over 20% of the forest area in this region has already been converted into plantations of Teak, Sal and other species of economic importance such as Tea (Barua and Bist, 1995) The

Decennial Growth Rate between 1991 – 2001 for the states of Darjeeling and Jalpaiguri were 23.54% and 21.52% respectively. The land-use pattern for the district is Forest (25%), Tea Gardens (15%), cultivated and non-cultivated land (43%) and others (17%).

3. METHODS

GENERAL

Fieldwork was conducted from December 2002 to April 2003. The initial part of the fieldwork was spent in co-coordinating with the Forest Department and Wildlife Squads and getting to know the area. Mobility was through buses or hired vehicles in the initial part of the study. Later, a motorbike was procured which was used to travel more than 2000 kms.

PREPARATION OF LAND-USE PATTERN MAPS

The preparation of Land-use pattern maps forms an important component of the study. This was done with the help of Vegetation Cover maps from the Forest Survey of India at 1:250,000 and 1:50,000 scale. This was supplemented with data from some SOI topographic sheets at a 1:50,000 scale.

The maps incorporate the following data:

Permanent Water Bodies such as Rivers and tributaries

Location of Villages which were visited for assessing the level of Human Elephant Conflict (HEC) (Plate 2)

Forest Cover

Vegetation types

Vegetation Cover maps were acquired from the Forest Survey of India on a 1:250,000 and 1:50,000 scale. The maps were digitized and edited on ArcView software.

GPS locations of different sampled villages and forest areas were overlaid on digitized maps.

Adjoining forest patches were identified with the help of the 1:50,000 forest cover maps from FSI and the SOI topographic sheets that were available.

IDENTIFICATION OF INTENSIVE STUDY AREA

Initially, the whole area from Teesta to Torsa was surveyed and information was gathered from the Forest Department Wildlife Squads about the areas most affected by Human Elephant Conflict (HEC). Previous reports on HEC (Chowdhury, 1997) were also consulted for identifying such areas. News paper reports and discussion with local experts also helped in identifying key areas of conflict in the recent past. On the basis of the above information and logistic considerations, conflict areas were identified and intensive study areas were finalized. The major study areas were identified as the Moraghat Range and the Mal Range.

LAND-USE PATTERNS IN RELATION TO ELEPHANT MOVEMENT

Locations of Tea Gardens which were most affected by elephant movement and depredation were overlaid on the map. Information gathered from the Wildlife Squads about the daily movement of elephants and the most affected areas were also overlaid on the map to show the areas that are most affected by the Human Elephant Conflict. This information was overlaid on the map using 2km x 2km size grids because of the lack of exact GPS location for all the areas.

DATA COLLECTION

Questionnaires

Data was collected in the form of open-ended semi-structured questionnaires and interviews with residents from Forest and Non Forest Villages in and around the intensive study areas. Depending on the situation, a small tape recorder was used to record views of the interviewees on other related aspects. A total of 27 villages were sampled, of which 4 of them were non Forest Villages.

Ten percent of the families in each village were sampled and interviews conducted. Interviews were usually conducted with the head of the house, although in some cases views were also recorded from older people who were able to provide information about elephant presence and depredation of times which the younger generations were not aware of.

The basic questionnaire consisted of a range of questions relating to cropping patterns adopted, elephant presence and level of conflict. Interviewees were also asked to evaluate the present state of conflict resolution and the measures adopted by them for protecting crop fields from elephants (Annexure).

Records From Wildlife Squads

Information was collected from the offices of two Wildlife Squads near the conflict prone areas viz. Binnaguri and Mal Wildlife Squads.

The data was in the form of Duty Registers which were signed and updated regularly by the Squad members. Information was present on the number of elephants found during their patrolling and the names of the villages or habitations where they were found. The squad register also contained the names of the Forests/Protected areas which were the destination of the elephants after they had been chased by the Wildlife Squads.

Information about the location, presence and number of elephants and the dates on which they were spotted by the Wildlife Squads was collected from the Duty Registers.

Records From Tea Gardens

The Tea Gardens were an invaluable source of data as most of the landscape of Northern West Bengal is interspersed with small and large aggregations of Tea Estates. Movement of elephants through Tea Gardens is quite common. This data about the movement of elephants through Tea Gardens are recorded by the concerned Tea Gardens and reported to the Dooars Branch Indian Tea Association (DBITA) office at Binnaguri.

Information on the movement of elephants for three years (1999, 2000 and 2002) was collected from the offices of the DBITA from the reports sent to the office by the different Tea Gardens.

The data includes the date of elephant presence and the nature of the group composition (Herd/ Loner/ Duo). Exact numbers of members of the herd were however not mentioned anywhere.

Vegetation Sampling

Vegetation sampling was used basically to evaluate elephant habitat by recording elephant food plants, density of trees, level of disturbance etc. Points for vegetation plots were randomly decided while walking along the forest trails or fire lines. All the compartments in a particular forested area was attempted to be sampled atleast once.

Due to lack of time, vegetation sampling could be done only in two protected areas viz. Gorumara National Park and Chapramari Sanctuary and three reserve forests viz. Moraghat, Panijhora and Apalchand.

Circular plots of 10m radius were used. A concentric circular plot of 5m radius was used for evaluating shrub cover. The following variables were recorded from the vegetation sampling :

Percent Tree canopy cover for the sampling spots

Numbers of trees, species and the GBH of trees within the 10 m radius.

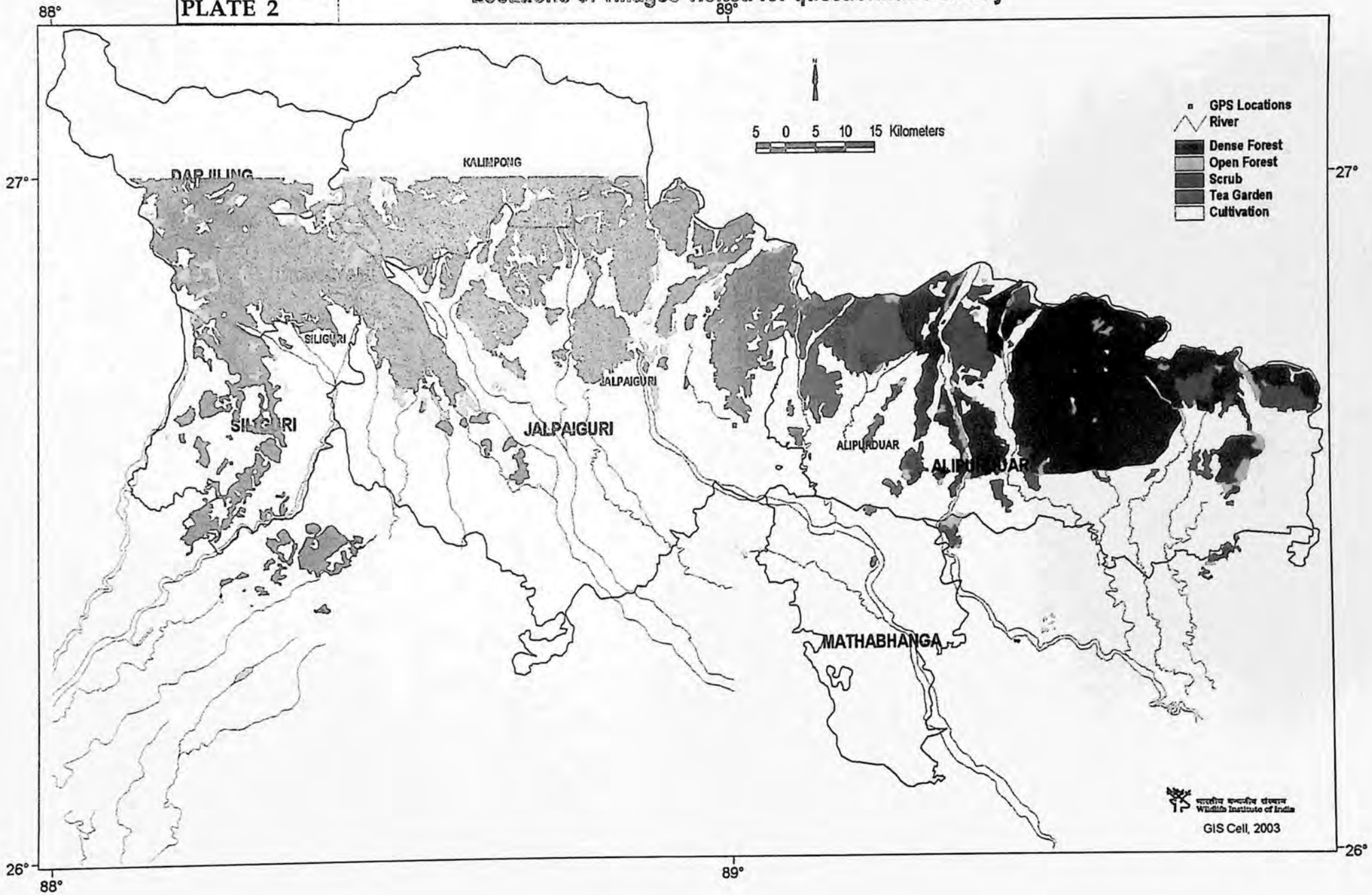
Presence of human activity within 10m radius.

DATA ANALYSIS

Data was analysed and graphs generated with the help of MS Excel package. Statistical analysis was done with the help of MINITAB 13.32 statistical packages.

PLATE 2

Locations of villages visited for questionnaire survey



4. RESULTS

4.1 IDENTIFICATION AND ASSESSMENT OF EXTENT OF CONFLICT:

One of the major aims of the present dissertation is to identify and assess the extent of conflict in North Bengal. I addressed this problem by collecting data from Wildlife Squads and Tea Gardens.

Information was collected from the Wildlife Squads present at Binnaguri and Mal Ranges about the presence and numbers of elephants over two years 2001 and 2002. These two squads covered almost the entire area between the rivers Teesta and Torsa. The entire study area was gridded with the help of 2km x 2km grids. The locations of the major conflict areas were then overlaid on the grid based on the presence of elephants in that area. This was done separately for the year 2001 and 2002. The conflict areas identified are :

4.1.1 Conflict Areas for the year 2001 identified on the basis of grids (Plate 3) :

Conflict Areas overlaid on the map was categorized into High, Medium and Low based on the number of visits by elephants to that area. The categorization followed was :

5 – 10 incidents (Low Conflict)

10 – 20 incidents (Medium Conflict)

>20 incidents (High Conflict)

Three major areas were identified as High Conflict. They are :-

Sylee Tea Estate and nearby areas including the Meenglas Tea Estate. This area lies to the east of the Leesh River, south of the Gorubathan Reserve Forests.

Garkhuta village lying to the south of the Moraghat Range.

Chanadipha village situated to the North – west of the Moraghat Range.

The areas which were identified as Medium Conflict Areas are :-

Areas around the Apalchand forests including Targhera.

Mogolkata, Duramari and Kalabari, adjoining the High conflict area of Chanadipha village.

Baradighi area adjoining the Gorumara National Park.

The areas which were identified as Low conflict areas are :-

1. Areas around Malbazaar v.i.z. Turibari, Meenglas, Odlabari and areas of the Apalchand forest.
2. Areas around Matiali v.i.z. Nipuchapur, Songachi, Nichchalsa, Anandapur, Barogharia and Damdim

3. Areas around Dhupguri v.i.z. Khutimari, Sonakhali and Niranjanpat.

4. Areas around Banarhat v.i.z. Hridaypur, Dhumpara, Debpara, Totapara, Gandrapara, Huldibari, Duramari and Salbari.

4.1.2 Conflict Areas for the year 2002 identified on the basis of grids (Plate 4) :

Information for the year 2002 shows only one area falling in the High Conflict category. The area is Sylee Tea Estate and adjoining areas. This area has already been identified as a high conflict area in 2001.

Four areas were identified as Medium Conflict areas :-

Targhera region in the Apalchand Reserve Forests

Garkhuta and Niranjanpat villages together form one conflict area south of the Moraghat Range.

The adjacent Tea estates of Huldibari and Telepara situated near the towns of Binnaguri and Goyerkata.

Dalmore region near the Dalmore Reserve Forests

4.1.3 Human Elephant Conflicts in Tea gardens:

Information was also collected from the offices of the Dooars Branch Indian Tea Association (DBITA) about incidences of elephant conflict from various Tea Gardens within the Dooars area. This information was available based on the communication received at the DBITA office from the affected Tea Gardens about incidences of elephant conflict within their Tea Gardens. Information was available for the years 1999, 2000 and 2002 (Fig 4.1).

Conflict data for the three years 1999, 2000 and 2002 was pooled and a total of 486 conflict incidences were found to be occurring in 64 Tea Gardens of the 135 Tea gardens under the DBITA. This constituted 47.41 % of the total number of Tea gardens.

In 1999, a total of 41 Tea gardens (30%) were involved in conflict incidences.
In 2000, 39 Tea gardens were involved (29%).
In 2002, 39 Tea gardens were involved (29%).

The High Conflict category accounted for 42.8% of all the conflict incidences in Tea Gardens.
Six Tea gardens were found to fall into the High Conflict category (> 20 visits by elephants). These are Bamnadanga Toondoo, Sylee, Telepara, Gairkata, Phaskhawa and Huldibari (Table 4.2)

PLATE 3

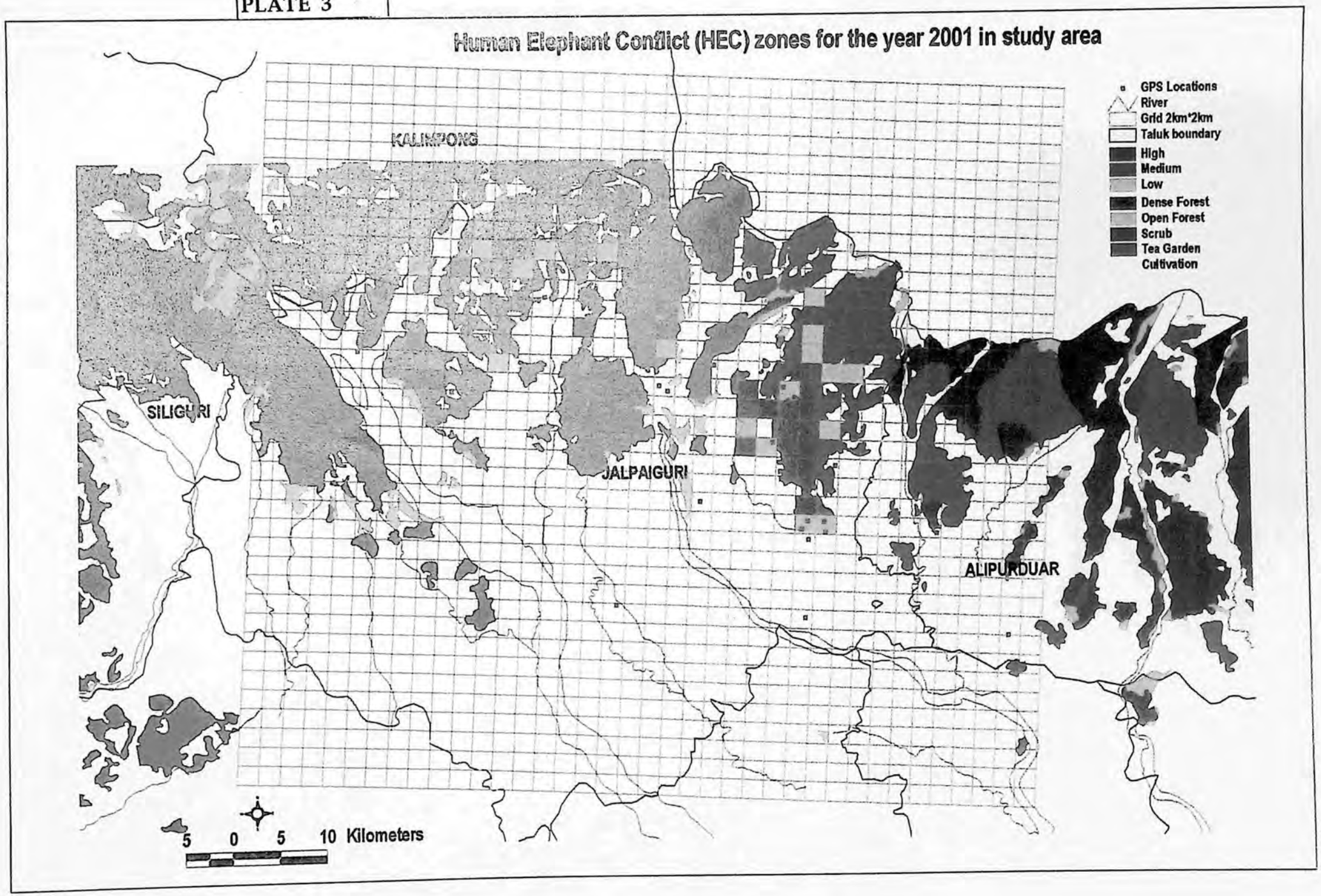
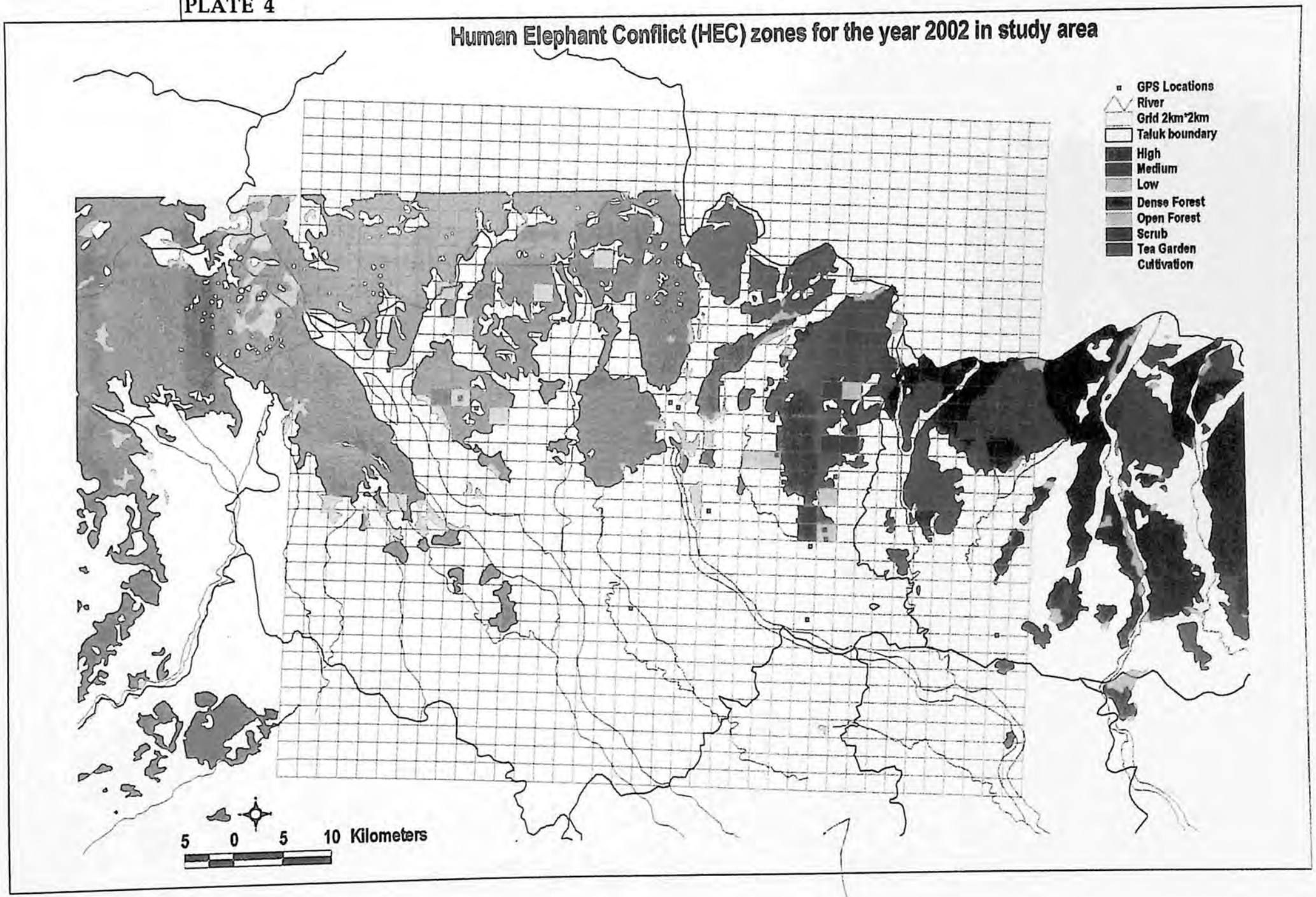

Human Elephant Conflict (HEC) zones for the year 2001 in study area
GPS Locations
River
Grid 2km*2km
Taluk boundary
High
Medium
Low
Dense Forest
Open Forest
Scrub
Tea Garden
Cultivation
KALIMPONG
SILIGURI
JALPAIGURI
ALIPURDUAR
5 0 5 10 Kilometers

PLATE 4


Human Elephant Conflict (HEC) zones for the year 2002 in study area
GPS Locations
River
Grid 2km*2km
Taluk boundary
High
Medium
Low
Dense Forest
Open Forest
Scrub
Tea Garden
Cultivation
5 0 5 10 Kilometers

The Medium Conflict category accounted for 27.16% of all the conflict incidences in Tea Gardens.

Ten Tea gardens were found to fall into the Medium Conflict category (11 - 20 visits by elephants). These are Ranicherra, Baradighi, Debpara,, Anandapur, Nangdala,, Karballa, DamDim, GoodHope, Jankapara and Meenglass (Table 4.3)

The Low Conflict category accounted for 12.96% of all the conflict incidences in Tea Gardens. (Table 4.1)

Eight Tea gardens were found to fall into the Low Conflict category (6 - 10 visits by elephants). These are NoweraNuddy, Kumlai, Binnaguri, Garganda, Hantapara, Birpara, Songachi and Dalmore (Table 4.4)

4.2 SEASONAL VARIATION IN CONFLICTS

4.2.1 Seasonal variation in conflicts in Tea Gardens

The presence of Herds and Solitary males in the different Tea Gardens were plotted for the years 1999, 2000 and 2002 (Fig 4.1). I used data collected from the offices of the Dooars Branch Indian Tea Association (DBITA). A distinct seasonality in presence of elephants was observed for all three years. The maximum number of conflict incidences in Tea Gardens were found to be between June to November.

Seasonality in incidences of HEC from Mal and Binnaguri Wildlife Squads:

Information on incidences of HEC for the years 2000 – 2002 was pooled and plotted to see the seasonal variation in intensity of HEC (Fig 4.2). Two distinct peaks are observed for the months of June and November showing a clear seasonality in the incidences of Human Elephant Conflicts.

The Mean group size of herds (Fig 4.9) during the years 2001 and 2002 provides an indication to the seasonal aggregation of herds. The average group size shows two distinct peaks in May-June and Sep-Nov. It is a clear illustration of the seasonal change in elephant numbers. The seasonality in presence of solitary animals and herds is observed from Fig 4.8.

4.2.3 Seasonality in human casualties of Human Elephant Conflict:

Information on human deaths due to HEC for the years 1996-2000 was graphically analysed (Fig 4.3). Of a total of 203 deaths 36 (17.73%) occurred in the month of July; 25 (12.32%) in August and 23 (11.33%) in September Most of the deaths occurred in the month of July while there were minor peaks for the months of May and November. Human casualties and elephant presence in Tea gardens was also graphically compared (Fig 4.4)

Relating human casualty and presence of solitary animals

Information on human casualties for the year 2001 was correlated to the presence of solitary animals during that period. Fig 4.5 shows the results of the regression between human casualties and presence of solitary animals in Tea gardens (R sq. = 32.5%)

4.3 Relating Human Elephant Conflict and Land-use

4.3.1 Presence of elephants in Tea gardens in different cropping seasons

Figure 4.9 shows the presence of elephants over the years 1999, 2000 and 2002 in Tea Gardens in different cropping seasons, v.i.z. Rabi, Summer and Kharif. Presence of elephants in tea gardens was found to be maximum in all three years for the Kharif crop period (June to October). The summer crop (February – May) periods show intermediate presence of elephants in Tea gardens while the Rabi crop period (December – February) sees the least (Fig 4.6)

4.3.2 Use of crop-fields by elephant during different seasons

Figure 4.7 shows the numbers of elephants present during the different cropping seasons in the years 2001 and 2002.

The Rabi season (December – February) crops are Wheat, Potato, Boropaddy and vegetables. Data obtained from Wildlife Squads indicates that in this season, 215 animals were seen in 2001 and 118 seen in 2002.

The summer season (February - May) crops are Maize, Boropaddy and vegetables. In this season, 568 animals were seen in 2001 and 659 seen in 2002.

The Kharif season (June - October) crops are AusPaddy, Amanpaddy and vegetables. In this season, 3967 animals were seen in 2001 and 1905 seen in 2002.

4.4 MITIGATORY MEASURES USED BY PEOPLE TO AVOID OR MINIMIZE CONFLICTS

A total of 27 villages were sampled and the number of responses that could be used for collecting information was 55.

4.4.1 Measures adopted by villagers to drive away elephants in the absence of the Wildlife Squads.

High Powered Flashlights were the most preferred and effective way of driving away elephants (45%) followed by Fire torches or 'mashaals' (20%) and Crackers (17%). The other methods such as ringing bells and shouting (9%), catapults (2%), rockets (2%) and other assorted methods (5%) were also reported (Fig 4.10).

4.4.2 Preferred Crop Raiding Time by Elephants as reported by sampled villagers (Fig 4.11)

According to the responses the time period of 1600 hours to 2000 hours is the most preferred time for crop raiding by elephants. Both the time periods of 1600 - 1800 hours (~30%) and 1800 - 2000 hours (~30%) were reported to be preferred by elephants. This was followed by the time period 1400 - 1600 hours (~19%) and 2000 - 2200 hours (~15%).

Table 4.1 Conflict Incidences in Tea Gardens based on DBITA records for the years 1999, 2000 and 2002

Number of conflict incidences	Category	Total Incidences	%
<5	Negligible	83	17.08
6 to 10	Low	63	12.96
11 to 20	Medium	132	27.16
>20	High	208	42.80

Table 4.2 Tea Gardens involved in High Conflict (>20) category

	No. of Elephant Visits			
Tea garden	Solitary	Herd	Total	%
Bamandanga Toondoo	47	7	54	11.11
Sylee	25	24	49	10.08
Telepara	20	18	38	7.9
Gairkata	7	15	22	4.5
Phaskhawa	5	17	22	4.53
Huldibari	10	11	21	4.32

Table 4.3 Tea Gardens involved in Medium Conflict category (11 -20 visits)

Tea garden	Solitary	Herd	Total	%
Ranicherra	12	5	17	12.88
Baradighi	5	10	15	11.36
Debpara	1	14	15	11.36
Anandapur	8	6	14	10.61
Nangdala	6	8	14	10.61
Karballa	3	10	13	9.85
DamDim	5	6	11	8.33
GoodHope	5	6	11	8.33
Lankapara	3	8	11	8.33
Meenglass	3	8	11	8.33

Table 4.4 Tea Gardens involved in Low Conflict category (5 – 10 visits)

Tea garden	Solitary	Herd	Total	%
NoweraNuddy	3	7	10	15.87
Kumlai	6	3	9	14.29
Binnaguri	3	5	8	12.70
Garganda	1	7	8	12.70
Hantapara	3	5	8	12.70
Birpara	1	6	7	11.11
Soongachi	2	5	7	11.11
Dalmore	1	5	6	9.52

Table 4.5 Comparison of HEC incidents in Tea gardens involving Herds and Solitary males in different conflict categories

(A) High Conflict Category

	Solitary	Herd
Total	114	92
%age	54.81	44.23

(B) Medium Conflict Category

	Solitary	Herd
Total	51	81
%age	38.64	61.36

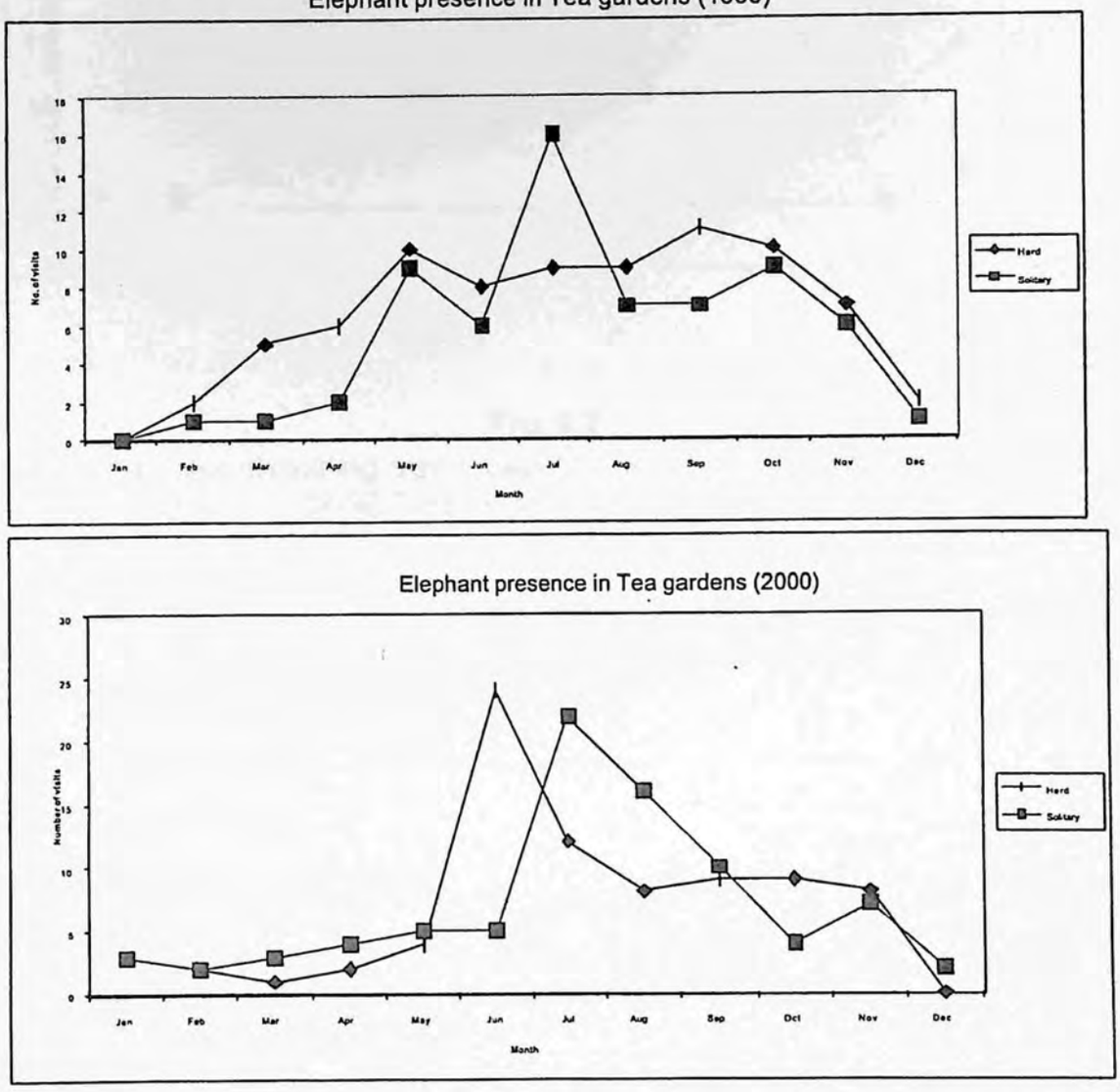
(C) Low Conflict Category

	Solitary	Herd
Total	20	43
%age	31.75	68.25

Table 4.6 Comparison of Tree density and canopy cover in P.A and non P.A's

Protected Area		Non Protected Area	
Tree Density(per ha.)	Canopy cover (%)	Tree density(per ha.)	Canopy cover (%)
32.8	74.28	16.8	34.28

Fig 4.1
(Number of Visits by elephants to Tea Gardens)



Elephant presence in Tea Gardens (2002)

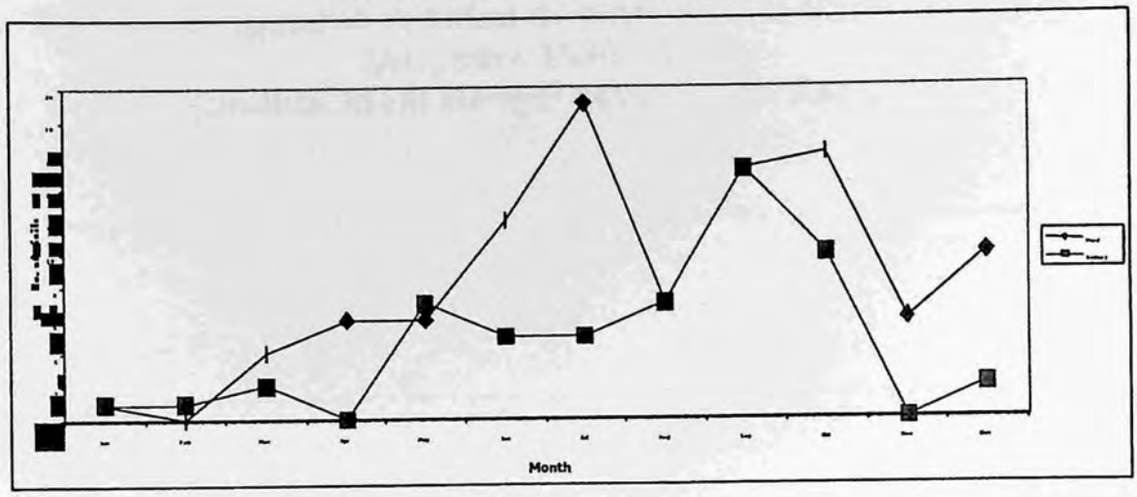


Fig 4.2
Pooled data showing seasonal change in incidents of HEC for the years 2000-2002 from Wildlife Squad records

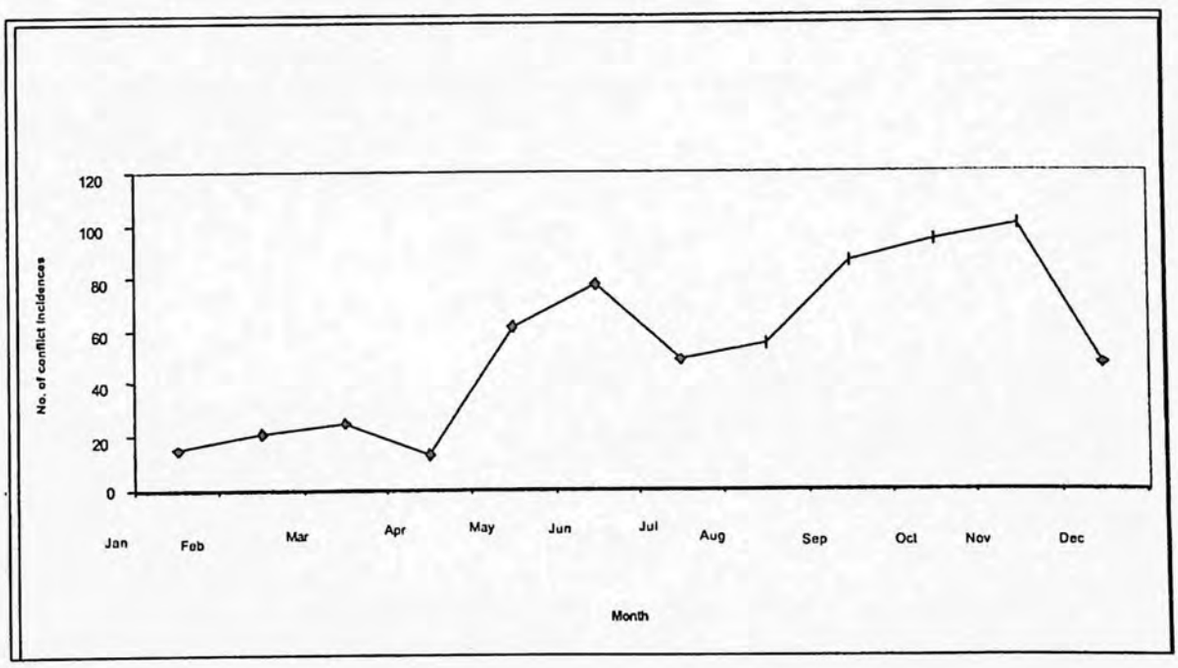


Fig 4.3
Data showing persons killed by elephants in North Bengal for the years 1996 – 2000
(Source: West Bengal State Forest Report)

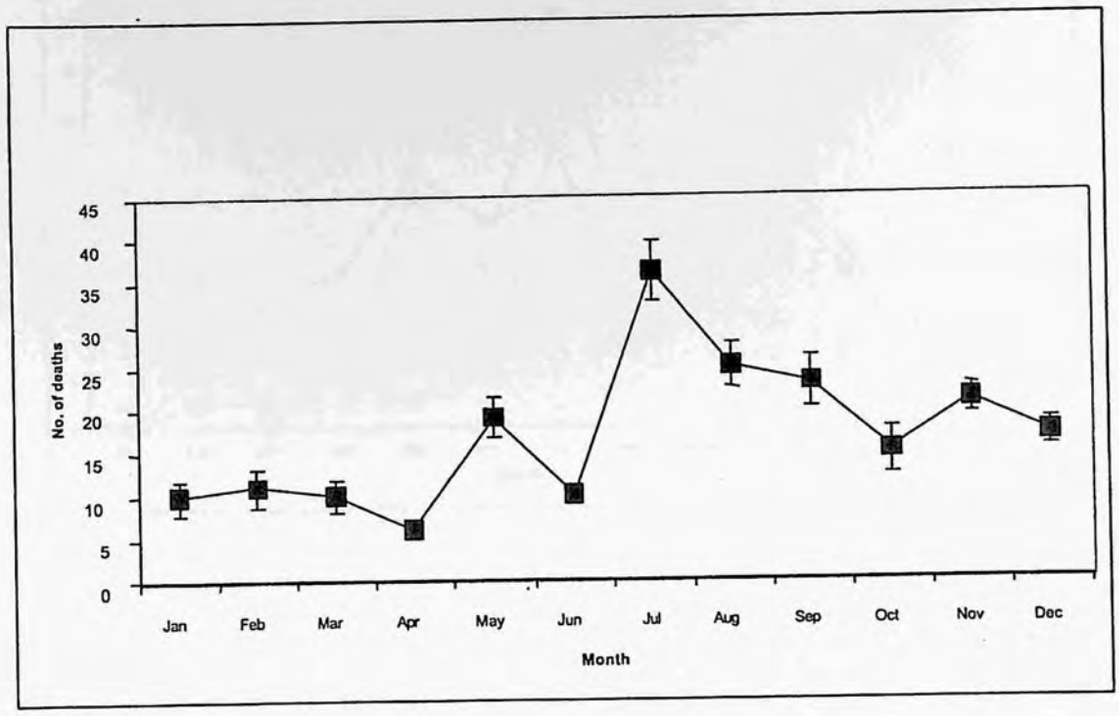


Fig 4.4 Elephant Presence in Tea Gardens and number of human deaths in North Bengal

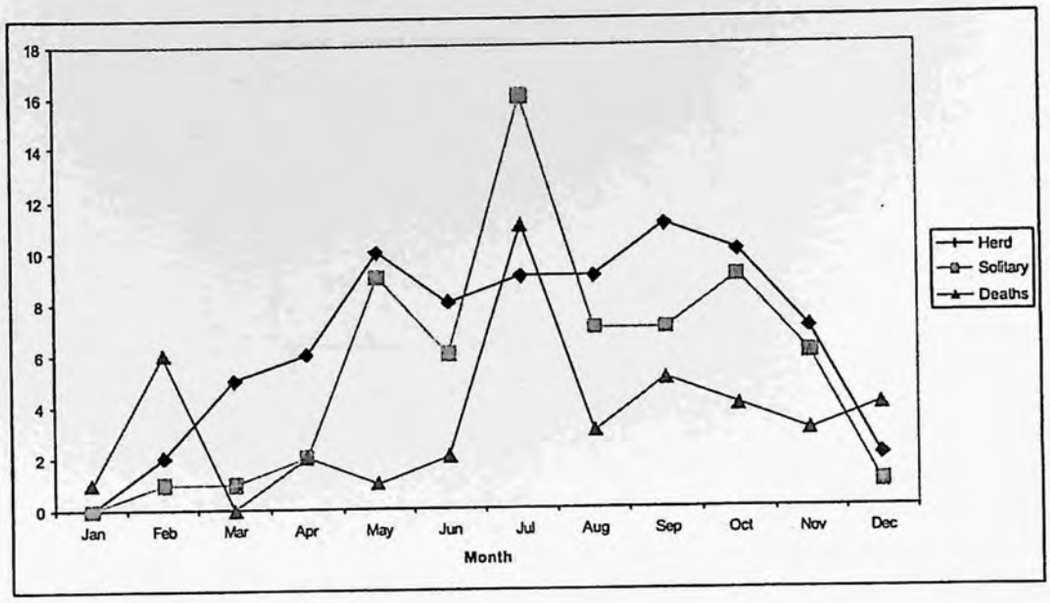
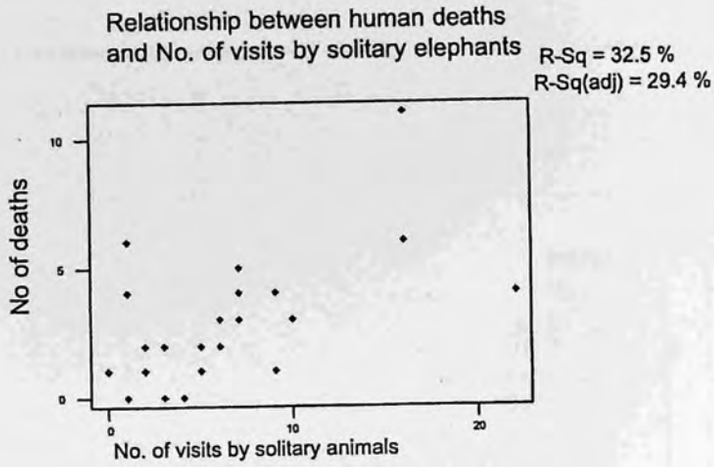


Fig 4.5



Pearson correlation of Solitary and Death = 0.615
P-Value = 0.033

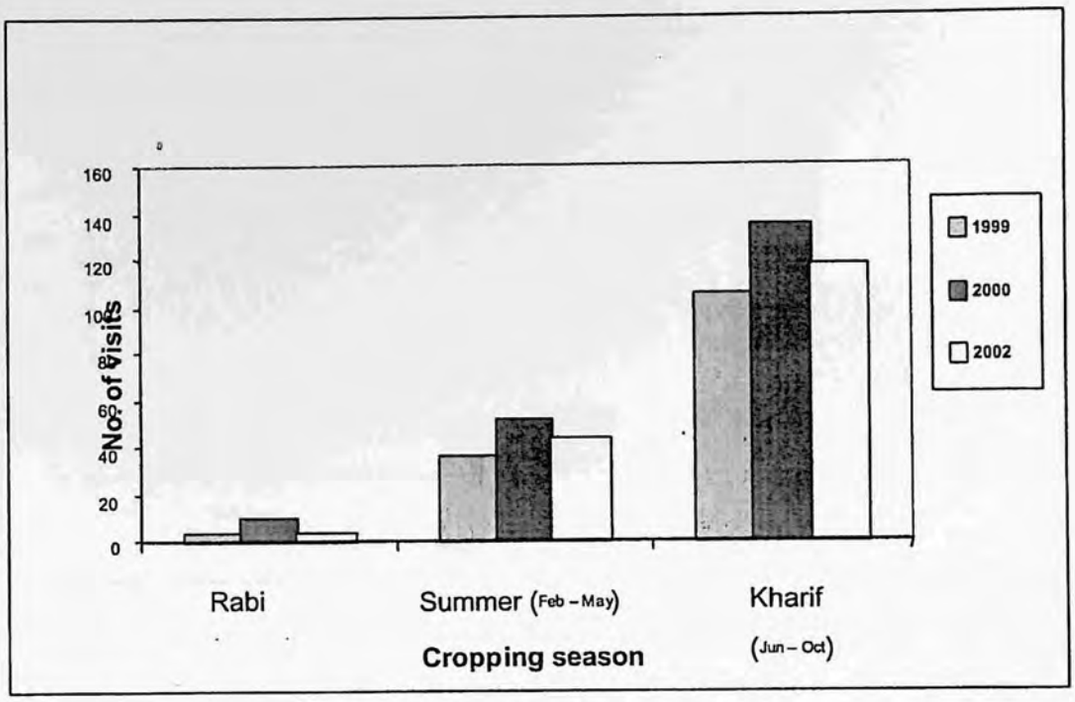
Regression Analysis: Death versus Solitary

The regression equation is
Death = 1.11 + 0.266 Solitary

Predictor	Coef	SE Coef	T	P
Constant	1.1070	0.6671	1.66	0.111
Solitary	0.26644	0.08191	3.25	0.004

S = 2.135 R-Sq = 32.5% R-Sq(adj) = 29.4%
PRESS = 141.655 R-Sq(pred) = 4.61%

Fig 4.6 Elephant Presence in Tea Gardens in different cropping seasons



Kharif = Jun - Oct (Aus, Aman, Vegetables)
Rabi = Dec - Feb (Wheat, potato, Boropaddy, vegetables)
Summer = Feb - May (Boropaddy, Vegetables,Maize)

Fig4.7 Elephant numbers in different cropping seasons (from Mal and Binnaguri WLSquads)

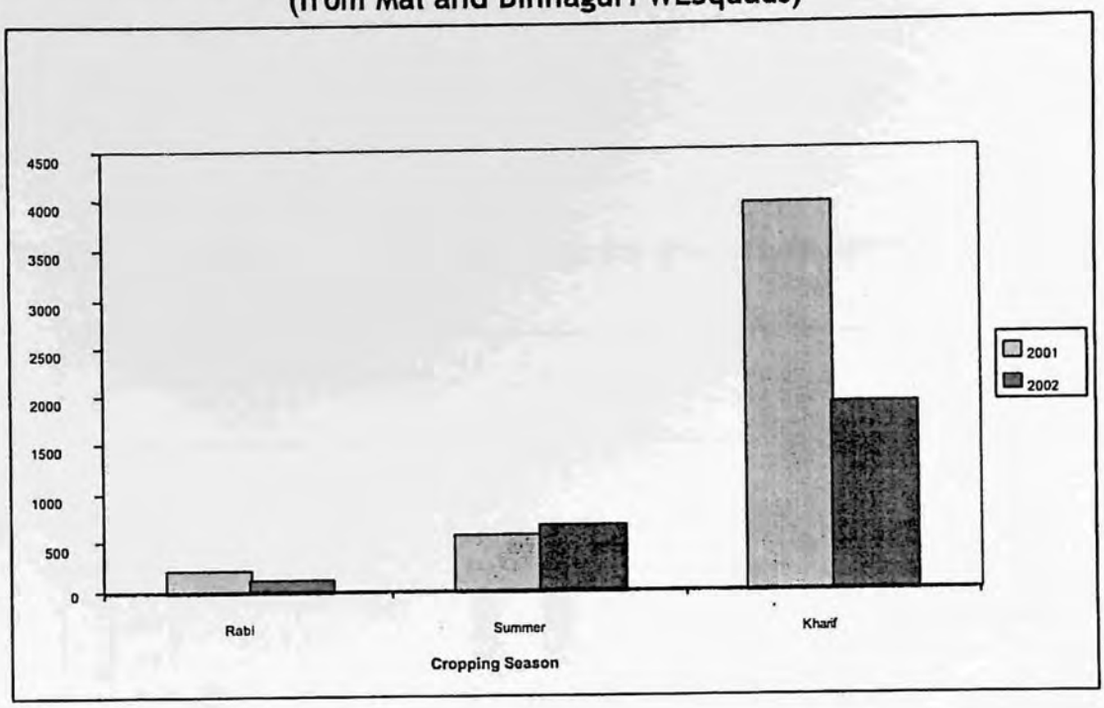


Fig 4.8 2001 Proportions of Solitary and Herds involved in HEC

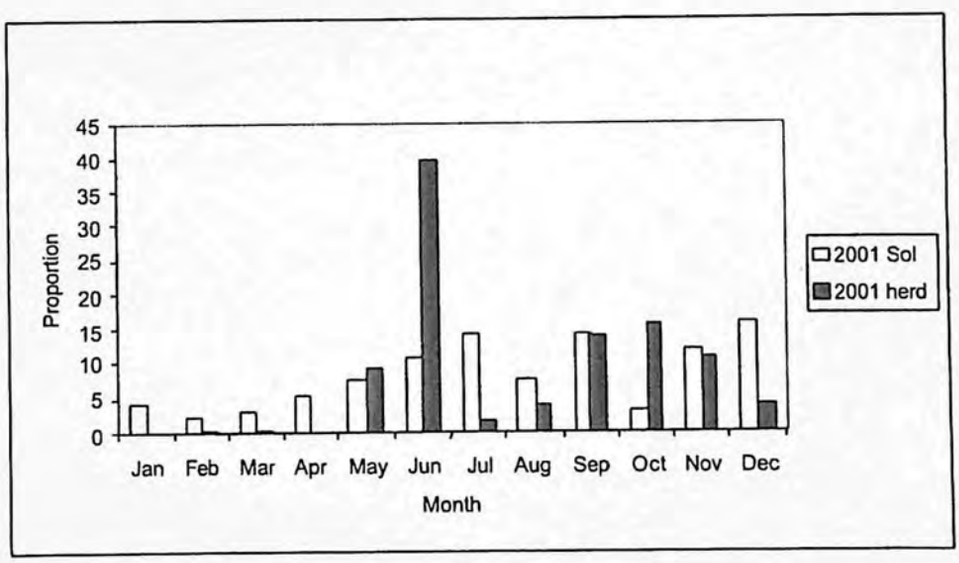


Fig 4.9 Mean Group Size of herds for the years 2001 and 2002

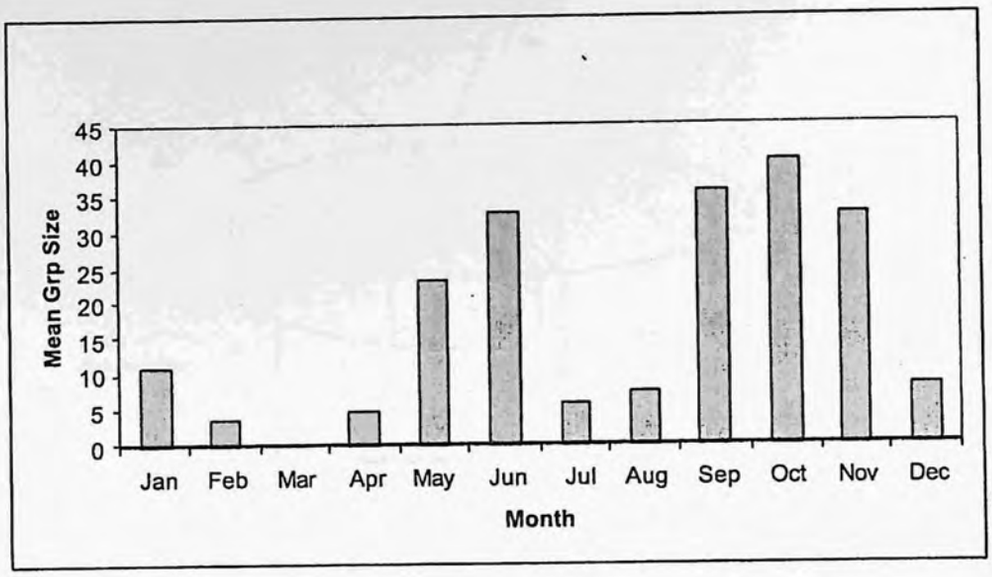


Fig 4.10
Methods reported successful by villagers in driving Elephants (N =58)

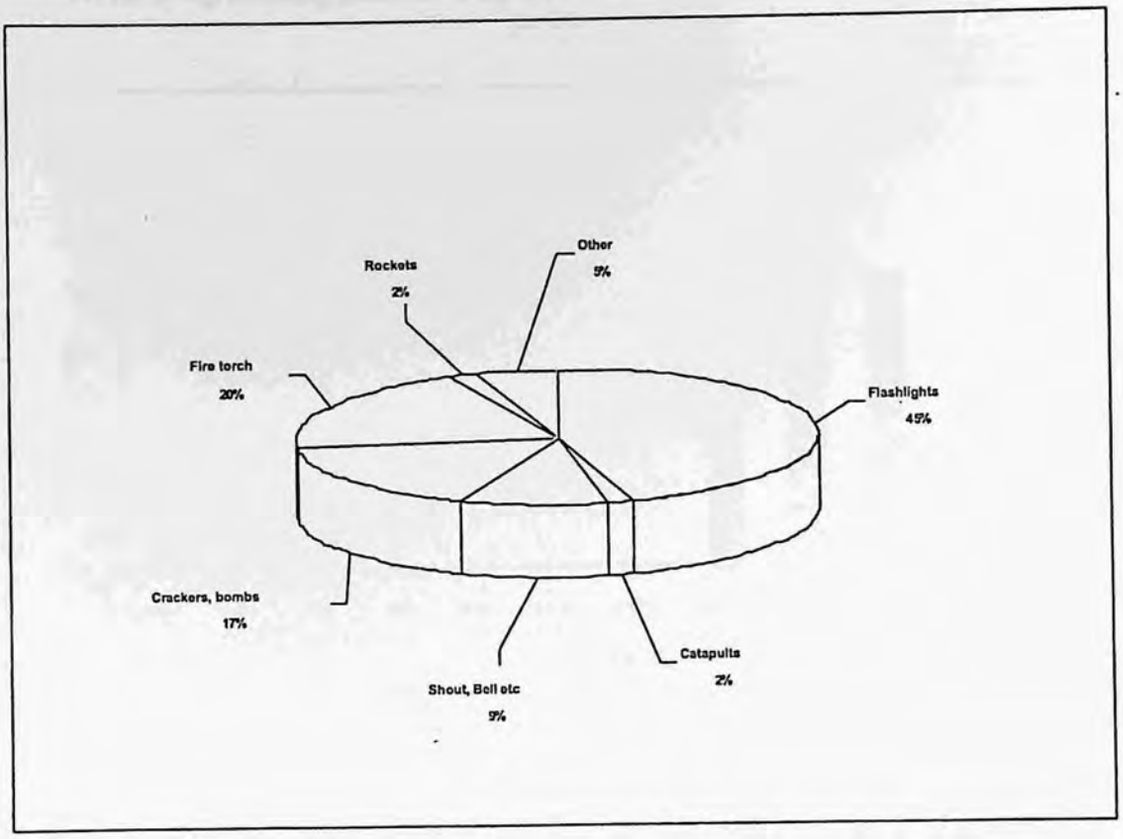
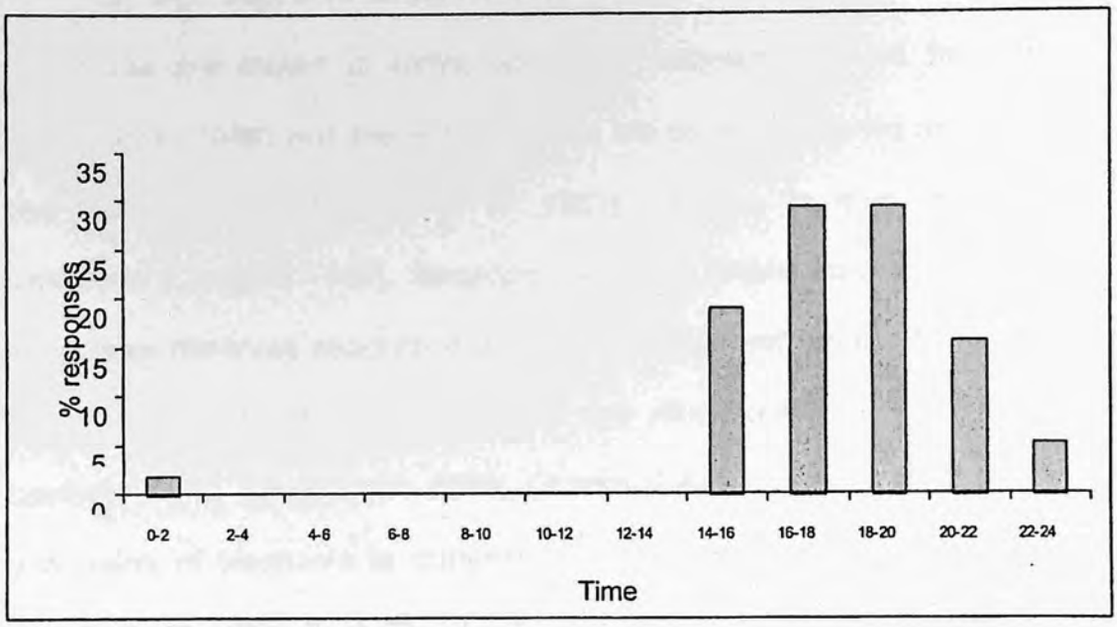


Fig 4.11

Preferred crop raiding time by elephants as reported by sampled villagers

(N=58)



5. DISCUSSION

Conflicts between humans and animals are on the rise in today's world and especially with elephants wherever they are found (Kemf and Jackson 1995). Herbivores are known to move seasonally between different home ranges (Owen-Smith 1988) and these movements are usually triggered by the need to find forage (Leader-Williams *et al.* 1981) and due to other environmental conditions (Christian 1968). Megaherbivores like elephants are also known to move large distances seasonally in search of forage and studies on elephants in Asia (Sukumar 1989, Ishwaran 1993) and Africa (Leuthold and Sale 1973, Leuthold 1977; Owen-Smith 1988; Osborn 1998) have found that seasonal distribution of elephants is determined by factors like quality of forage and availability of water. In such a situation, fragmentation of elephant movement routes increases the chances of conflicts between humans and elephants. Fragmentation of elephant habitat has already been identified as one of the major threats to the continued existence of a megaherbivore like the elephant (Sukumar 1989). Families in elephants are the basic social unit with females staying in their family group throughout their lifetime (Moss and Poole 1983; Sukumar 1989). Thus families typically contain an old, experienced female (the matriarch) who leads the herd, her dependent offspring and adult daughters with their immature offspring, including pre-pubescent males (Buss 1961; Douglas-Hamilton 1972; Moss and Poole 1983; Sukumar 1989). This implies that the traditional migratory routes followed by elephants are passed down from generations. The conflict between the interests of humans and animals are most

prominent when it involves major economic loss or more importantly, loss of human life. This is nowhere better found than in north Bengal where elephants regularly come into contact with habitations, crop fields and Tea gardens occasionally even straying into urban areas.

The present study attempted to identify the areas most affected in North Bengal by HEC. Information collected from the Wildlife Squads serve as a good source to identify the seasonal changes in the presence of elephants in crop fields and Tea gardens. This information was supplemented by information on the presence of elephants in Tea Gardens from the offices of the Tea garden association (DBITA). Information from the Tea gardens was however limited in its utility as it provided no insights into the numbers of elephants present in the Tea gardens at any point of time. Previous studies conducted by Lahiri Chowdhury (1980) and Chowdhury *et al.* (1997) had already identified key conflict areas which served as a good source of baseline information.

5.1 Conflict Areas

The results showed that the high conflict areas had remained the same as identified earlier. However, in addition to the previously identified areas, some new areas were found to show increased incidences of HEC. For example, areas like Moraghat, adjoining areas of Gorubathan and Apalchand forests, identified as conflict areas have been mentioned by Chowdhury *et al.* (1997). In addition to

these areas, a high conflict area to the south of the Moraghat range was newly identified. This area has not been mentioned as a major conflict area in any report before.

The present study concentrated on the elephant population conflicts between the Teesta and Torsa also called the Western Dooars, situated mostly in the district of Jalpaiguri. This area has already been identified as the zone with the highest conflict (Barua 1995, Chowdhury 1997) among all the three zones (Eastern Dooars, Western Dooars and the Terai)

Of the total gridded area in North Bengal 0.18 % of the area was found to belong to High conflict category. 0.63 % of the grids belonged to the medium conflict category and 1.80% was in the Low conflict category. However, this also includes areas where elephant movement has not been recorded because of the lack of forest cover and urbanization.

The major conflict zones identified from the present study are :

The most affected area was found to be area around the Gorubathan forests, specifically Sylee Tea Estate and adjoining areas. This was found to be the most affected area for both the years 2001 and 2002. Information from the Wildlife

Squads and DBITA offices also indicate that at present it is one of the most disturbed areas in terms of Human Elephant Conflicts.

Areas south of the Moraghat range which consisted principally of the villages of Garkhuta, Sonakhali, Niranjanpat.

Villages and Tea gardens present to the west of the Moraghat range. It consists of the villages like Chanadipha, Mogolkata, Duramari and Kalabari

Two other areas have been identified which are classified as Medium conflict areas.

Some areas in the Apalchand reserve forests extending from the Odlabari Tea Estate till the Targhera area including some forest villages

Dalmore appears to be a medium conflict area for the year 2002 while it does not appear as even a low conflict area for the year 2002.

Baradighi, adjoining Matiali area appeared as a medium conflict area in 2001 but did not reappear in 2002.

Information on the movement of elephants in Tea gardens for the years 1999, 2000 and 2002 was used to classify the Tea gardens into High, Medium and Low categories based on the number of conflict incidences. Six Tea gardens identified as High conflict areas were Bamnadanga Toondoo, Sylee, Telepara, Gairkata, Phaskhawa and Huldibari. Three of these Tea gardens, v.i.z. Telepara,

Gairkata and Huldibari had been found to belong to High conflict category by Chowdhury *et al.* (1997). This suggests that these may be important movement corridors for elephants.

The Tea gardens belonging to the Medium (61.36%) and Low (68.25%) conflict categories were found to have a very high percentage of conflicts caused by herds. This can be probably explained by the fact that that during the presence of migratory herds in particular seasons, the density of animals is much more than at other times of the year and animals may stray out from their traditional routes and visit Tea gardens which are not generally frequented by the resident animals.

The Reserve forests lack good canopy cover. In addition to forage, elephants also need cover and shade. This is not adequate in Reserve Forests as can be seen in Table 4.6. Thus the animals are forced to come out when the numbers increase, hence increasing chances of conflict with the adjoining habitations.

The presence of herds and solitary animals in Tea gardens shows a perceptible upward trend in the month of April, witnessing a peak in July. It is indicative of the seasonal migrations by elephants. This is supported by the data on the distribution of human casualties across the months from 1996 to 2000. The deaths showed an upward trend in the month of April and continued to be higher than normal till the month of December.

The seasonal increase in the level of conflict can also be understood by Fig 4.9. The mean group sizes for the herds show distinct peaks in the major cropping seasons. The first peak in May - June corresponds to the Maize raiding season and the second peak in September to November coincides with the Paddy crop.

The data for human casualties in the year 2001 shows an interesting correlation with the presence of solitary animals. This evidence supports other studies which have concluded that solitary animals, usually lone bulls are more responsible for human casualties (Sukumar 1989; Singh *et al.* 2002).

5.2 HEC IN RELATION TO CROPPING PATTERNS:

There are three major cropping seasons, v.i.z. the Rabi, summer and Kharif season. Incidences of elephant presence in Tea Gardens were found to be the highest for all the three years in the Kharif season (June to October) (Fig 4.6)

Elephant numbers were also found to be high in the Kharif season for the years 2001 and 2002 followed by summer and Rabi season. Paddy is the major crop for the Kharif season. The elephant movement seems to be influenced by the timing of the Kharif crop and there is extensive crop raiding in that period. A mega herbivore like the elephant needs large amount of food and availability of

seasonal food would influence their seasonal movement patterns as has been found in most large herbivores (Eisenberg 1981)

The increase in conflict incidences south of Moraghat near the Garkhuta village is of special interest. This area has been identified as a high conflict area in the present study although there is no prior evidence of such high conflict in this area.

One of the ways conflicts were minimized in North Bengal based on recommendations from previous studies was by change in cropping patterns. Many areas have changed from the traditional paddy crop to other economically important crops which may not be so attractive to elephants. The answer to the emergence of Garkhuta as a high conflict area may lie in the change in cropping patterns adopted recently in some villages in that area. Potato has been promoted in recent times as an alternative crop for rice based cropping systems (Bardhan Roy *et al* 1998). It has already established itself in parts of southern West Bengal and has recently been popularized in North Bengal. Garkhuta and its adjoining villages have been growing it for the last 2 to 3 years. Eyewitness reports speak of elephants having taken a fancy to this crop and raiding potato fields indiscriminately and even digging up the tubers and eating them. This is however not a totally new phenomenon and has been reported recently in South Bengal (Singh *et al.* 2002). Potato crop was found to be significantly more utilized compared to its availability.

This is a dangerous trend and cultural transmission could soon make the elephants of North Bengal take to potato raiding in other parts too. This is also a reminder of the adaptability of elephants to changes in cropping patterns. Interestingly, Bist (1998) had in fact recommended potato as an alternative crop in areas of high crop raiding.

5.3 MITIGATORY MEASURES TO MINIMIZE CONFLICTS:

Raiding elephants are usually driven away by the Wildlife Squads who are equipped with vehicles, firearms, crackers and powerful lights. However, the area that they cover is extremely large and they are unable to reach a place on the day of raiding. Usually, they patrol the affected areas the next day. This was however found to be quite ineffective in most places as people reported that elephants would retreat as soon as they heard the approach of the squad vehicle and reappear as soon as they left. Thus, in most cases the local villagers themselves have to try to drive the elephants away.

Interviews and questionnaire surveys were used to determine the methods used by villagers to drive the elephants. Majority of people (45%) reported that high powered flashlights were the most effective ways to drive away elephants followed by fire torches (20%), Crackers and bombs (17%).

In addition to these, people also reported that electrification of the villages would also help as they would have electric lights and be able to spot the elephants before they approached too near the village. Electric fencing was also unanimously desired by most villages as they had all heard of the reduction of conflict in villages which had electric fences installed.

Interviews and questionnaires were also used to find the preferred crop raiding time by elephants. 60% of the respondents put it between 1600 to 2000 hours. However, there are drawbacks to the sampling strategy used to draw this conclusion. Nonetheless, it is a good indicator of the fact that elephants raid only after sunset.

REFERENCES

BALASUBRAMANIAN, M., BASKARAN, N., SWAMINATHAN, S. AND DESAI, A. A. 1995. Crop raiding by Asian elephants (*Elephas maximus*) in the Nilgiri Biosphere Reserve, South India. In A week with elephants. Proceedings of the International Seminar on the Conservation of the Asian Elephant, (Eds, Daniel, J. C. and Dayte, H. S.) Bombay Natural History Society, Bombay.

BANDARA, R. AND C. TISDELL. 2003. Comparison of rural and urban attitudes to the conservation of Asian elephants in Sri Lanka: empirical evidence. Biological Conservation. 110: 327-342.

BARDHAN ROY, S.K., T. WALKER, V.S. KHATANA, N.K. SAHA, V.S. VERMA, M.S. KADIAN, A.J. HAVERKORT AND W. BOWEN. 1998. Intensification of potato production in rice-based cropping systems: A Rapid Rural Appraisal in West Bengal. CIP Program Report.

BARNES, R. F. W, S. AZIKA AND B. ASAMOAH-BOATENG. 1995. Timber, Cocoa and crop-raiding elephants: a preliminary study from southern Ghana. Pachyderm. 19:33-38.

BARUA, P. 1995. Managing a problem population of elephants, pp. 150-161 in A week with elephants, J.C.Daniel and Hemant Datye, Eds., Bombay Natural History Society, Oxford University Press, Bombay.

BARUA, P. AND BIST, S.S. 1995. Changing patterns in the distribution and movement of wild elephants in North Bengal, pp. 66-84 in A week with elephants, J.C.Daniel and Hemant Datye, Eds., Bombay Natural History Society, Oxford University Press, Bombay.

BIST, S.S. 1998. Elephant-Human conflict in West Bengal. Envis Biannual Bulletin. Vol 1 (1) Spring, March 1998.

BLAIR, J.A.S., G.L. BOON AND N.M. NOOR. 1979. Conservation or cultivation: The confrontation between the Asian elephant and land development in peninsular Malaysia. Abstract of Land Development Digest. 2(1):25-58.

BUSS, I.O. 1961. Some observations on food habits and behaviour of African elephants. Journal of Wildlife Management. 25 : 131-148

CHOUDHURY, A. 1999. Status and conservation of the Asian Elephant *Elephas maximus* in north-eastern India. Mammal Review. 29 (3): 141-173.

CHOWDHURY, S., M.A. KHALID, M. ROY, A.K. SINGH, R.R. SINGH,. 1997. 5 MANAGEMENT OF ELEPHANT POPULATIONS IN WEST BENGAL FOR MITIGATING MAN-ELEPHANT CONFLICTS Final report to the West Bengal Forest Department as part of West Bengal Forestry Project.

CHRISTIAN, C.S. 1968. Habitat manipulation: Part 1: regional surveys for habitat studies, pp: 231-235. In: A practical guide to the study of the productivity of large herbivores. Eds. Golley, F.B., Buechner, H.K. Blackwell Scientific Publications, Oxford and Edinburgh.

CLUTTON-BROCK, J. 1999. A Natural History of Domesticated Mammals. Cambridge, UK, Cambridge University Press.

DE SILVA, M. 1998. Status and conservation of the elephant (*Elephas maximus*) and the alleviation of man-elephant conflict in Sri Lanka. Gajah. 19:1-68.

DESAI, A.A. AND N. BASKARAN. 1996. Impact of human activities on the ranging behaviour of elephants in the Nilgiri biosphere reserve, South India. J. Bombay nat. Hist. Soc. 93 : 559-569.

DEY, S.C. 1991. Depredation by Wildlife in fringe areas of North Bengal forests with special reference to elephant damage. Indian Forester: 117 (10), Dehradun.

DOUGALL, H.W. 1964. The chemical composition of a day's diet of an elephant. East African Wildlife Journal 2:51-59

DOUGLAS-HAMILTON.1972. On the ecology and behaviour of the African elephant. PhD thesis. University of Oxford.

EISENBERG, J.F. 1981. The Mammalian Radiations : an analysis of trends on evolution, adaptation and behavior. Chicago, IL, University of Chicago Press.

ELTRINGHAM, S.K. 1990. Wildlife carrying capacities in relation to human settlement. Koedoe. 33 (2): 87-97. Pretoria. ISSN 0075-6458.

FIELD, C.R. 1971. Elephant ecology in the Queen Elizabeth National Park, Uganda. East African Wildlife Journal 9: 99-123.

HANKS, J. 1979. A Struggle for Survival : The Elephant Problem. Country Life Books.

HOARE, R. 1999. Determinants of human-elephant conflict in a land-use mosaic. Journal of Applied Ecology. 36:689-700.

HOARE, R. 2000. African elephants and humans in conflict: the outlook for coexistence. Oryx. 34 (1): 34-38.

ISHWARAN, N. 1993. Ecology of the Asian elephant in lowland dry-zone habitats of the Mahaweli river basin, Sri Lanka. Journal of Tropical Ecology. 9:169-182.

JACHMANN, H. AND R.H.V. BELL. 1984. The use of elephant droppings in assessing numbers, occupation and age structure: a refinement of the method. African Journal of Ecology. 22: 127-141.

KAROOR, J.J. 1992. Some aspects of the ecology and behaviour of Asian Elephant in the Periyar Wildlife Reserve, Kerala (India). The Asian Elephant: Ecology, Biology, Diseases, Conservation and Management. Silas, E.G., Krishnan Nair, M. and Nirmalan, G. (Eds) Kerala Agricultural University, south India, Kerala.

KEMF, E. AND P. JACKSON. 1995. Asian Elephants in the wild. A WWF species status report. WWF – worldwide, Gland, Switzerland.

LAHIRI CHOUDHURY, D.K. 1980. An interim report on the status and distribution of elephants (*Elephas maximus*) in North East India (August, 1980). In Daniel, J.C. (1980).

LAHIRI CHOUDHURY, D.K. 1985. Elephants in North East India. In: Elephants in Asia, P. Jackson (ed), IUCN/SSC Asian Elephant Specialist Group, Bandipur, India.

LAHM, S.A. 1996. A nationwide status survey of crop raiding by elephants and other species in Gabon. Pachyderm. 21:69-77.

LEADER-WILLIAMS, N., T.A. SCOTT AND R.M. PRATT. 1981. Forage selection by introduced reindeer on South Georgia, and it's consequences for the flora. Journal of Applied Ecology. 18(1): 83-106.

LEUTHOLD, W. 1977. Spatial organization and strategy of habitat utilization of elephants in Tsavo National Park, Kenya. Z.saugetierkunde. 42:358-379.

LEUTHOLD, W. AND J. SALE. 1973.Movements and patterns of habitat utilization of elephants in Tsavo National Park Kenya. E.Afr.Wildl.J. 11:369-384.

MACDONALD, D., Ed. 1984 The Encyclopedia of Mammals. UK Andromeda

MACDONALD, D. 2001. the New Encyclopaedia of Mammals. Oxford University Press.

MANI, M.S. 1974. Ecology and Biogeography in India. Dr. W. Junk, B.V. Publishers, The Hague.

MCKAY, G.M. 1973. Behaviour and ecology of the Asiatic elephant. Smithsonian contribution to Zoology, No. 125; Smithsonian Instutution Press, Washington DC; 113p.

MISHRA, J. 1971. An assessment of annual damage to crops by elephants in Palamau district, Bihar. J. Bombay Nat. Hist. Soc. 68: 307-310

MOSS, C.J., AND POOLE, J.H. 1983. relationships and social structure of African elephants. Primate Social Relationships : An Integrated Approach. Hinde, R.A. (Ed.). Oxford Blackwell Scientific, Oxford. 315-325

NAIR, P.V., R. SUKUMAR AND M. GADGIL. 1980. The elephant in south India. A review. In: The status of the Asian elephant in the Indian sub-continent, IUCN/SSC report, J.C. Daniel (ed), pp. 9-19, Bombay Natural History Society, Bombay.

NATH, C. & SUKUMAR, R., 1998. Elephant-human conflict in Kodagu, southern India: Distribution patterns, people's perceptions and mitigation methods. Asian Elephant Conservation Centre, Bangalore.

NOACK, T. 1906. Eine Zwergform des Afrikanischen Elefentan. Zoologischer Anzeiger. 29: 631-633.

NOWAK, R. M. 1995. Walkers Mammals of the World. London, The John Hopkins University Press.

O'CONNELL-RODWELL, C.E., ARNASON, B.T. AND HART, L.A. 2000. Seismic properties of Asian elephant (*Elephas maximus*) vocalizations and locomotion. Jour. Acoustical Society of America 108(6):3066-3072

OLIVIER, R. 1978. Distribution and status of the Asian elephant. Oryx 14:380.

OSBORN, F.V. 1998. The ecology of crop-raiding elephants in Zimbabwe. PhD dissertation, University of Cambridge.

OWEN-SMITH, N. 1988. Megaherbivores: the influence of very large body size on ecology. Cambridge University Press, Great Britain.

ROCA, A.L., N. GEOGLIADIS, J. PECON-SLATTERY, AND S.J. O'BRIEN. 2001. Genetic evidence for two species of elephant in Africa. Science. 293: 1473-1477.

RODGERS, W. A. & PANWAR, H.S. (1988) Planning a wildlife protected area network in India. Vol I and II, Wildlife Institute of India, FAO Project, WII, Dehradun.

SAM, MK, BARNES, R.F.W AND OKOUMASSOU, K 1998. Elephants, humán ecology and environmental degradation in north-eastern Ghana and northern Togo. Pachyderm 26.

SANTIAPILLAI, C. AND H. SUPRAHMAN. 1984. Habitat management in way Kambas Game Reserve with reference to the elephant population; WWF\IUCN Project 3133-No.2; A report for the Directorate General Protection and Nature Conservation (PHPA), July 1984;. 21-27.

SANTIAPILLAI, C AND JACKSON, P. 1990. The Asian Elephant: An Action Plan for its Conservation. IUCN/SSC Asian Elephant Specialist Group.

SANTIAPILLAI, C. AND WIDODO, R. 1993. Why elephants raid crops in Sumatra. Gajah, 11, 55-58.

SHOSHANI, J. AND EISENBERG, J.F. 1982. *Elephas maximus*. Mammalian Species 182: 1-8.

SHOSHANI, J. 1992. Anatomy and Physiology. Elephants: Majestic creatures of the wild. Shoshani, J. (Ed.) Simon and Schuster, London:66-81

SIKES, S.K. 1971. The Natural History of the African Elephant. London, Ebenezer baylis and Son Ltd.

SINGH, A.K., R.R. SINGH. AND S. CHOWDHURY. 2002. Human-elephant conflicts in changed landscapes of south West Bengal, India. The India Forester. 128 (10): 1119-1132.

SMITH, R.J. & S.M. KASIKI 2000. A spatial analysis of human-elephant conflict in the Tsavo ecosystem, Kenya. Human Elephant Conflict Taskforce, IUCN. Gland, Switzerland.

Sudhakar, S., I.V. Ramana, K. Rajesh, D. Chakraborty, A.K. Raha and S. Choudhury .1999. Remote Sensing and GIS for Wild life habitat management in West Bengal in Proc. of ISRS National Symposium on Remote Sensing applications for Natural Resources: Retrospective and Perspective; ISRS and NNMRS.

SUKUMAR, R. & RAMESH, R. 1995. Elephant foraging : Is browse or grass more important? A week with elephants : Proceedings of the International Seminar on the Conservation of Asian Elephants. Daniel, J.C. and Datye, H.S. (Eds.) Oxford University Press, Oxford:368-374

SUKUMAR, R. 1990. Ecology of the Asian Elephant in Southern India. II. Feeding Habits and Crop Raiding Patterns. Journal of Tropical Ecology. 6:33-53.

SUKUMAR, R. , 1989. The Asian Elephant : ecology and management. Cambridge: Cambridge University Press

SUKUMAR, R. AND M. GADGIL. 1988. Male-female differences in foraging on crops by Asian elephants. Animal Behaviour. 36:1233-1235.

SUKUMAR, R. 1985. Ecology of the Asian elephant (*Elephas maximus*) and its Interaction with man in south India - Vol.I; Indian Institute of Science, Bangalore; 285p.

TCHAMBA, M.N. 1996. History and present status of the human/elephant conflict in the Waza-Logone region, Cameroon, West Africa. Biological Conservation. 75:35-41.

THOULESS, C.R. 1994. Conflict between humans and elephants on private lands in Northern Kenya. Oryx. 28 (2):119-1127.

WESTERN, D. 1986. The pygmy elephant: a myth and a mystery. Pachyderm. 7: 4-5.

WILLIAMS, A. C., P. KUMAR, A.J.T. JOHNSINGH, S.P. GOYAL, G.S. RAWAT, A. RAJVANSHI AND P. KRAUSMAN. 1997. The inter-relationships between large herbivores, habitat and humans in Rajaji-Corbett national parks, UP :Technical report (October 1996 to September 1997); Wildlife Institute of India, Dehra Dun; 23p.

WILLIAMS, A.C., A.J.T. JOHNSINGH AND P. KRAUSMAN. 2001. Elephant-human conflicts in Rajaji National Park, northwestern India. Wildlife Society Bulletin, 29(4):1097-1104.

WING, L.D. AND BUSS, I.O. 1970. Elephants and forests. Wildlife Monographs 19: 1-87.

WWF. 2000. African Elephant. Eleventh Meeting of the Conference of the Parties to CITES, Nairobi, 10-20 April. Species Fact Sheet. WWF. Available online at http://www.panda.org/resources/publications/species/cites/fs_afeleph.html

Annexure

Questionnaire for Interviewing villagers on HEC

Village **GPS location** **Forest Village/Non F.V**

Name
Nearby Forests
Forest Edge Distance
Crops grown **Sowing** **Reaping**

Average Income
Elephant Presence (Seasonal/Permanent)
Season
Approach
Retreat
Time and duration of raiding
Stage of crop during raiding
Group/Solitary
Numbers of group
Deterrents and success levels
Nearby affected villages
Elephant presence + or - (last 5 years)
Frequency (last 5 Years)
Forest products used
Govt. responsive to problems?
Measures?
Suggested measures

Notes