Elephants and Their Interactions with People and Vegetation in the Waza-Logone Region, Cameroon

Olifanten en hun interacties met mensen en met de vegetatie in het Waza-Logonegebied, Kameroen

(met een samenvatting in het Nederlands)

PROEFSCHRIFT

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Preface

This thesis is a compilation of separate articles, each illustrating a different aspect of elephant ecology in the Waza-Logone region of northern Cameroon. All aspects are interrelated and must together provide us with a deeper understanding of the dynamics of elephant populations and their interactions with the environment.

It is a result of field observations and laboratory analyses but hardly dependent on advanced theorizing. It forms part of the research programme of the Centre for Environmental Science and Development in Cameroon (CEDC), a joint cooperation between the ex-Ministry of Higher Education, Computer Science and Scientific Research (ex-MESIRES) in Cameroon and the State University of Leiden in the Netherlands (RUL). The research programme of CEDC aims at the conservation and sustainable use of natural resources in northern Cameroon. In this region, elephants come into conflict with the local people by destroying crops and even killing people. This creates considerable antipathy between local people and wildlife authorities and is a deterrent to conservation efforts. Effective management tools have to be sought to reduce this conflict if humans and elephants are to coexist in the Waza-Logone region.

The Dutch Directorate General for Development Cooperation (DGIS) together with the Cameroonian University of Dschang gave financial and logistical support to the field research. The information contained in this thesis is based on field data obtained between January 1991 and December 1994. During these years the project has accomodated ten biology students who made significant contributions to the collection and analysis of data. This thesis is *not* a prescription for how to make the human-elephant conflict disappear. The data presented do provide a framework and a variety of options for how to understand and deal with the human-elephant conflict in the Waza-Logone region.

Acknowledgements

I wish to express my gratitude to the Ministry of Environment and Forests to grant me permission to carry out research in the Waza-Logone region, and to the Conservator of Waza National Park and its Game Warden for their cooperation. Particular thanks are due to my technicians Mr. Tiawoun Tiawoun Sylvain and Mr. Hamadou Paul.

I also wish to acknowledge my indebtedness to Prof. H.A. Udo de Haes, Prof. J.A.R.A.M. van Hooff and Mr. Hans de Iongh for their supervision of all stages of this project. I am grateful to Dr. J. Ngog of the Ecole de Faune in Garoua and Dr. S. de Bie of the Nederlandse Aardolie Maatschappij in Assen for their support as senior advisors. The administrative and technical staff of the Centre of Environmental Science, University of Leiden, helped me in numerous ways for which I am grateful. I thank my colleagues at the Centre of Environmental Science and Development in Cameroon for valuable discussions about this research. During the research period many students helped me. I am very grateful to them and especially want to mention Hans Bauer and Weladji Bertrand Robert. I also would like to make mention of the efforts of a number of people who participated in the elephant surveys and the elephant tagging operations. I am grateful to all concerned.

Further I wish to thank Dr. Holly Dublin for kindly critisizing the manuscript and Mr. Paul Langeveld who admirably assisted me in making the figures for this thesis. The co-authors of some chapters in this thesis allowed me to pick their brains, both during field work and during writing-up. I hope that they benefited too from our cooperation.

The present study was supported by a grant from the Netherlands Ministry of Foreign Affairs (Directorate General for International Cooperation) and the Netherlands University Foundation For International Cooperation (NUFFIC). It benefitted also from financial support of a number of organisations or foundations which I would like to acknowledge here: the University of Dschang (Cameroon), the United States Fish and Wildlife Service, the IUCN/SSC Sir Peter Scott Fund and the Foundation for Psychobiology.

Finally I am very much indebted to my wife Marie-Louise and my children Rosine, Patrick, Lynn and Yvan Junior. Their sacrifices made it possible for me to complete this thesis.

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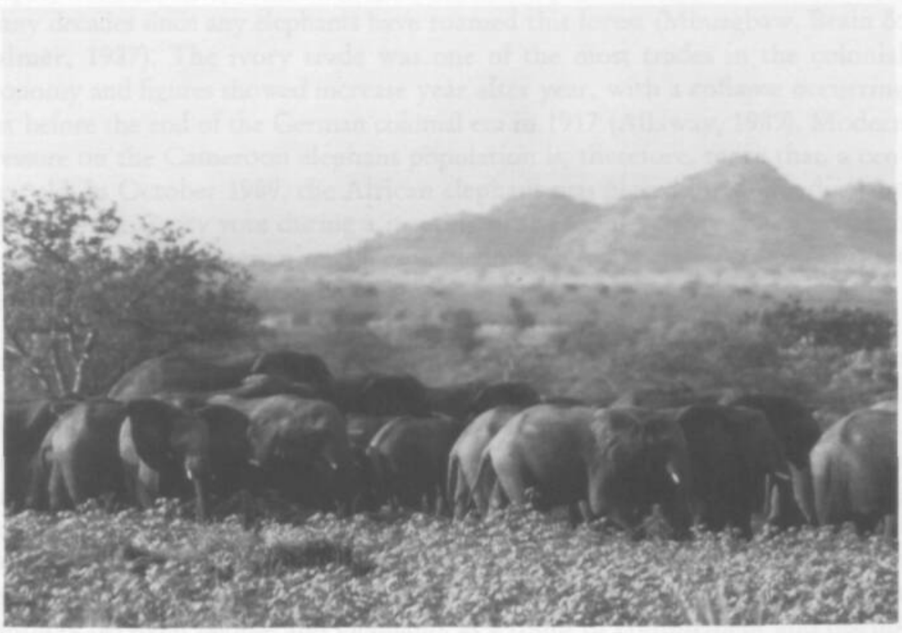
Part I

Introduction and General Background



During the first rains in June a large herd of elephants migrates more than 100 km south of Waza National Park, where they cause extensive damage to crops

1.1

The Problem

Origin of the Elephant Problem

The tragedy of the African elephant *Loxodonta africana* Blumenbach is that its total numbers are falling (Douglas-Hamilton, Mitchelmore & Inamdar, 1992) but that at the same time conservationists have to deal with the build-up of elephant numbers in some protected and unprotected areas (Barnes, 1983; Damiba & Ables, 1993). The basic problems of elephant management are due to a fundamental change in land-use pattern and life styles that has taken place in Africa since the onset of colonial contacts in the last century.

There is evidence that major changes in elephant distribution and population density in Cameroon began to occur during the colonial epoch. For example, Barombi lake is marked on colonial maps as 'Elefanten Sea' but it is many decades since any elephants have roamed this forest (Mbuagbaw, Brain & Palmer, 1987). The ivory trade was one of the most trades in the colonial economy and figures showed increase year after year, with a collapse occurring just before the end of the German colonial era in 1917 (Allaway, 1989). Modern pressure on the Cameroon elephant population is, therefore, more than a century old. In October 1989, the African elephant was placed on Appendix 1 by a two-third majority vote during a meeting of the Conference of the Parties to the Convention on International Trade in Endangered Species (CITES). This set up the international ban on ivory trade.

Over the past 100 years, human populations have increased exponentially. In order to satisfy the food requirements, shifting cultivation has intensified in the poor African countries and has led to a dynamic mosaic of settlement and wilderness. In addition, unsustainable development has led to deforestation, fragmentation and reduction of natural habitats. Natural reserves have been transformed to isolated islands. Increased insularity of protected areas, failing management and ineffective law enforcement have set the stage for the classical elephant problem. The main elements of this problem are the impact of high densities of elephants on the woody vegetation in many protected areas, and the conflicts between people and elephants as a result of confinement and disruption of the patterns of dispersal.

Woodland-Elephant Interaction

In many protected areas where elephants occur, the relevant authorities have expressed concern over elephant impact on vegetation and the risk of irreversible habitat change (Dublin, Sinclair & McGlade, 1990; Lindsay, 1993). The increase in elephant numbers often leads to the decline in woody vegetation and even local extinction of certain tree species such as baobab, *Adansonia digitata*, *Acacias* and some *Commiphoras* (Douglas-Hamilton, 1972; Laws, Parker & Johnstone, 1975; Caughley, 1976; Barnes, 1985; Jachmann, 1984; Spinage, 1990). It has been speculated that the build-up of elephant numbers might also lead to changes in the population of other animals and birds and in some cases cause erosion problems (Caughley, 1976; Leuthold, 1977; Barnes, 1983). The question of whether elephants can exist in equilibrium with woodland has been the subject of much discussion. Some experts maintain that elephant and tree populations may be capable of equilibrium because there are feedback mechanisms which will restore the equilibrium, or because the problem is part of a naturally-occurring cycle, and they use these arguments as a support for non-interference (Phillipson, 1975; Craig, 1992). Other experts argue however that an equilibrium between elephant and tree populations can not be reached because a stable limit cycle requires a closed system with the elephant and tree populations being interdependent, a situation which cannot apply anymore (Caughley, 1976; Barnes, 1983). Noy-Meir (1975) and May (1977) have presented theoretical mathematical models which describe a non-cycling relationship between herbivores and vegetation populations. Applied to elephants, these models indicate that changes in population size represent imbalances that should be corrected. Another argument against non-interference in national parks to relieve the pressure of an increasing population is that a number of artificial factors are introduced into their environment (*e.g.* waterholes, early burning, anti-poaching patrols, salt licks) and these may lead to changes in the ecosystem which should be counter-balanced by management. In practice, this is the predominant situation in northern Cameroon.

Human-Elephant Interaction

The second component of the elephant problem is the conflict between humans and elephants. Wherever elephants and men have coexisted, interaction has been inevitable. The cave paintings of North Africa (Carrington, 1958) and the rock paintings in southern Africa (Sikes, 1971) amply demonstrate the importance of proboscideans as prey for preagricultural man. To agricultural man the elephant assumed new significance. He became a resource to be exploited for the beauty of ivory, a status symbol, an object of reverence, an instrument of war, a beast of burden, an agricultural pest (Sikes, 1971).

In more recent years elephants and humans have been in more prolonged and more intensive contact (Taylor, 1987; Damiba & Ables, 1993; Hoare & Mackie, 1993; Taylor, 1993; Thouless, 1994) and it is here that the significance of the elephant to man has become the most complex. It is broadly believed in village societies of Cameroon that people can and do transform themselves into elephants. Thus crop raiding is not a simple matter of a hungry elephant in a field of corn, it is also a matter of which neighbour wished the farmer enough ill to transform himself into an elephant and destroy his crops.

Elephants come into conflict with people by destroying agricultural crops, damaging properties and even killing people. In northern Cameroon, as is generally the case in central and west Africa, conservation 'success' has been achieved at the price of direct conflicts between the park authorities and the local people. Frustrated at being displaced to make room for protected areas, forbidden the access to natural resources of these protected areas and bedeviled by elephant depredations, local communities threaten lands set aside by 'governments' and antagonism grows.

Specialized Approach and Controversial Solutions

In a world in which the biophysical environment and the socio-cultural systems are changing rapidly, conflicts between humans and wildlife or protected areas in general are inevitable. The challenge is how to manage these conflicts to honour both human well being and the protection of the natural environment. The 'solution' to a conflict can be either procedural or substantive (Lewis, 1992). An example of a procedural solution would be a decision to establish a park or wildlife management committee. An example of a substantive solution would be deciding to build a fence to keep animals away from farmers' fields. Strategies that are being used to alleviate the human-elephant conflict include the development of ecological infrastructure (Seidensticker, 1984), fencing (Hoare, 1992), damage compensation or incentives (Western, 1982; McNeely, 1988; Balakrishnan & Ndhlovu, 1992), culling and disturbance shooting (Bell, 1984; Whyte, 1993).

The major area of controversy surrounding the elephant problem concerns the question: Should management interfere to limit elephant numbers? This issue generates considerable emotion, with both sides (pro and anti-culling or hunting) using scientific arguments to back their claims. Managers should be careful to clearly differentiate value judgments from technical decisions based on scientific evidence.

Because each conflict is unique, with its own peculiar ecological, cultural, political, economical, and historical context, each will require a specialized approach. The Waza-Logone area is a good example of the elephant problem. It provides a case from which we may learn how to cope with woodland-elephant interaction and human-elephant conflict in the region in the future, and also provides more general aspects which can be at value for comparable areas with the same problems. The primary purpose of this thesis is not to make a value judgment, but to examine the technical aspects of elephant population, the woodland-elephant interaction and the human-elephant interaction in order to identify technically sound and financially feasible management options. These should lead to the integration of the needs of the local people and elephants in a sustainable agricultural and pastoral system in the Waza-Logone region.

1.2

The Study Area

Physical and Human Environment

The Waza-Logone region is situated in the extreme north of Cameroon and is defined here as the region extending from the divisions of Mayo Kani (Kaélé) and Mayo-Danai (Yagoua) in the south to the Lake Chad in the north (Fig. 1.1). It covers an area of approximately 29,800 km² and lies between 10°25' and 12°50' north, and 14°05' and 15°15' east. The area includes two national parks: Waza (1,700 km²) and Kalamaloué (27 km²).

The climate varies from soudano-sahelian in the south to sahelian in the north. The dry season lasts for 6 to 8 months, and the rainfall varies from about 1,000 mm per year in the south to less than 350 mm in the north. The region includes three distinct vegetational communities: periodically flooded grasslands of the Logone and Chari, and Lake Chad floodplains with *Echinochloa pyramidalis, Hyparrhenia rufa, Oryza longistaminata and Pennisetum ramosum*; thorny shrub savanna with *Acacia spp., Balanites aegyptiaca, Piliostigma reticulatum, Calotropis procera and Ziziphus spp.*; and woodland savanna with *Combretum spp., Feretia apodenthera, Acacia dudgeoni* and *Anogeissus leiocarpus*. The main land uses in the area are small-scale agriculture, pastoralism, fisheries and the establishment of protected areas to conserve wildlife.

The Waza-Logone region contains one of the largest elephant populations in the soudano-sahelian region and Waza National Park is one of the most well-known parks of central and west Africa. Waza is also the major touristic attraction in northern Cameroon. Its diverse wildlife populations include elephant (*Loxodonta africana africana*), giraffe (*Giraffa camelopardalis*), lion (*Panthera leo*), ostriches *Struthio camelus* and various species of antelopes and palaearctic migratory birds. On the other hand, human exploitation of natural resources, increased elephant numbers and the decrease in rainfall has seriously depleted the Kalamaloué National Park's biological resources (SPTEN, 1986).

In 1987, the total human population in the Waza-Logone region was estimated at 1,464,000 with 49 persons/km² (MINEF, 1993). The annual population growth rate (3.7%) is higher than the national average of 2.9% (MINPAT, 1990). Subsistence farming is extensive and based on 'slash and burn' shifting cultivation methods, using rudimentary equipment. The major crops are millet *(Penni*

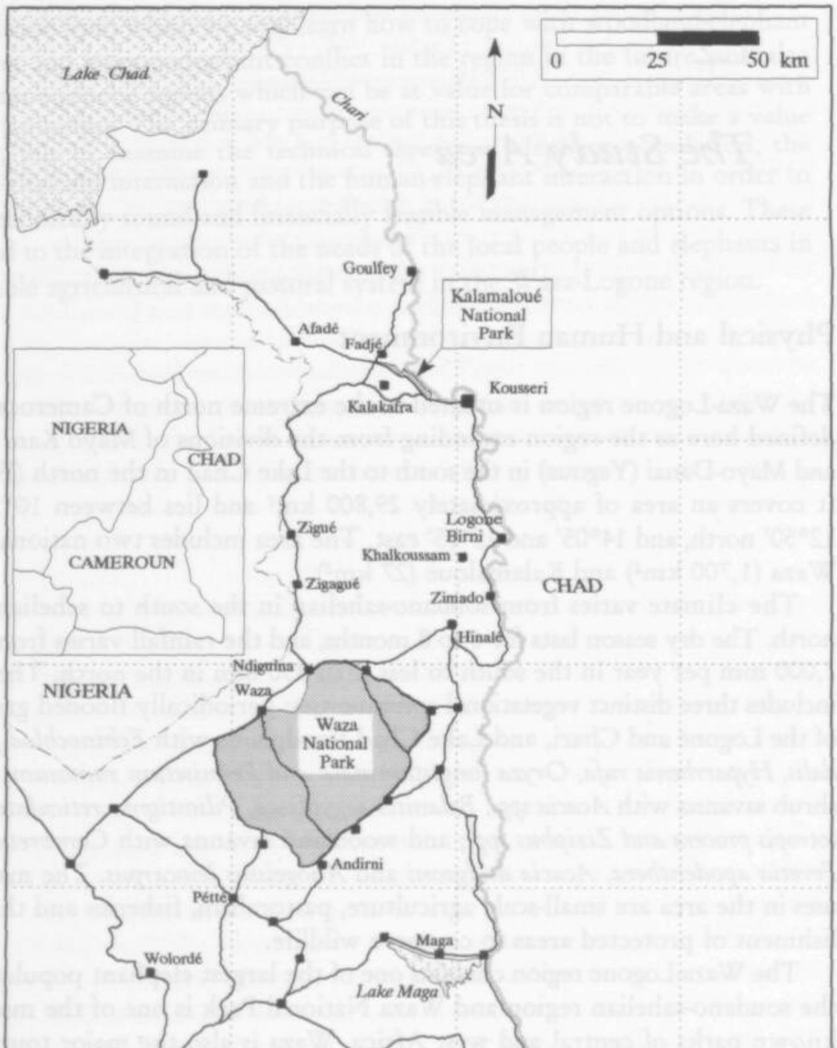


Figure 1.1
The Waza-Logone region and study areas

setum typhoides), sorghum (*Sorghum bicolor)*, corn (*Zea mays*), peanuts (*Arachis hypogea)*, cowpeas (*Vigna unguiculuta)* and a variety of legumes. Cotton *(Gossypium hirsutum)* and rice (*Oryza sativa)* are the main cash crops. Cropland covers about 37% of the Waza-Logone region (MINEF, 1993).

Recent Changes in the Ecosystem

A large part of the study area is in the Waza-Logone floodplain. Originally, the area consisted for more than 60% of a plain which became inundated for 6 to 8 months a year (between August and March) because of flooding of the Logone river. The construction of a large dam for the SEMRY II rice project at Maga has caused, in combination with a decreased rainfall, a disruption of the annual hydrological regime (Tchamba, Drijver & Njiforti, 1995). Inundations have been disrupted and the flooded area has been reduced considerably, leading to a desiccation of the floodplain and a reduction of forage for wildlife and cattle (Oijen & Kemdo, 1986). In addition, smaller irrigation schemes in the Mandara mountains south-east of the floodplain may have had a negative impact on the depth of the water table in the floodplain area, which has dropped markedly in recent years (Tchamba, Drijver & Njiforti, 1995). This reduction in availability of water affects the whole of the floodplain, locally called 'yaérés', downstream of the Maga dam, including almost the entire eastern part of Waza National Park. People in the floodplain have been forced to change their resource use systems (Njiforti *et al.*, 1989). Traditional fishermen have adopted the cultivation of mouskouari (dry season millet) and some nomads have sedentarized in order to cut and sell firewood. These activities coupled with human population growth have led to the fragmentation and loss of elephant habitat.

Three years ago, The World Conservation Union (IUCN) started the Waza-Logone Project in this area. The objective of this project is the restoration of the floods which will, at least in part, contribute to the provision of increased amounts of water in the southern half of Waza National Park and the adjacent floodplain.

Present Knowledge of Woodland-Elephant and Human-Elephant Interactions

The Waza-Logone region was devoid of elephants until 1947 when they crossed the Logone river near Kousseri and took up residence in Kalamaloué National Park (Flizot, 1948). Since then numbers have increased steadily as shown by Flizot's estimates: 250 in 1961, 400 in 1964 and over 600 in 1969 (Fizot, 1969).

In 1971, increasing elephant numbers were already cause for concern as elephants were destroying trees in the *Acacia* woodland of Waza National Park (Corfield & Hamilton, 1971). Most of the increase was due to immigration into northern Cameroon from Chad, probably resulting from disturbances there such as the deforestation of the Mandelia Faunal Reserve (Fry, 1970). The elephant population of Waza National Park was estimated at 478 individuals in 1976 (Esser & Van Lavieren, 1978) and at 750 individuals in 1987 (Eijs & Ekobo, 1987; Steehouwer & Kouahou, 1988). The dry season distribution of elephants within Waza National Park was described by Vanpraet (1977), Okula (1979), Esser & Van Lavieren (1979), Meijvogel & Ekobo (1986) and Tobias & Vanpraet (1980). They all noted that water availability in the dry season was the most important factor determining elephant distribution. Elephant distribution during the wet season has not been documented yet.

Steehouwer & Kouahou (1988) noted that elephant movement patterns inside the park have considerably changed, probably in relation to the desiccation of the floodplain. This set the stage for elephant impact on woodland vegetation in Waza National Park. They indicated that elephants spent more time in the *Acacia seyal* shrub savanna where more than 25% of the shrubs exceeded the 75% damage level. Earlier studies conducted in 1978 noted that only 11% was browsed at that level (Okula & Sise, 1986).

Elephant movement between Waza National Park and Kalamaloué National Park was mentioned by Eijs & Ekobo (1987), and Steehouwer & Kouahou (1988). However, the pattern of these movements has not been fully investigated. It is known that Kalamaloué National Park provides the migrant herds with drinking water during the dry season and that these herds cause damage to crops in the vicinity of the park (SPTEN, 1986).

The southward migration patterns of elephants are far less documented than their northward migration. In 1980, a herd of more than 30 elephants were roaming in the Mindif area throughout the wet season (DDA, 1981). Two elephants were killed and 10 ha of cropland was devastated by elephants. Between 1980 and 1990, a total of 25 elephants were killed on damage control but no statistics were kept on the actual extent of cropland damage by elephants (SPTEN, 1990). The origin of these elephants remain uncertain. However, it was speculated that some of these elephants might have come from the north (Waza) and others from the south (Chad).

The present trend of increasing woodland-elephant interaction and human-elephant interaction in the Waza-Logone region urgently requires relevant policies and management actions. This thesis hopes to help decision-makers in the selection of these policies.

1.3

The Research Questions and the Hypotheses

The thesis aims to contribute to the integration of the needs of local people and elephants in a sustainable agricultural and pastoral system in the Waza-Logone region. Five key questions present themselves:

1. what is the trend in the elephant population (size, distribution, dynamics and migration patterns) and what are the causes?;
2. what is the extent of the woodland-elephant interaction?;
3. what is the extent of the human-elephant interaction?;
4. what are the factors determining the distribution of elephants and their movement patterns?; and
5. what management actions could be taken to alleviate the elephant problem in the Waza-Logone region?

Many factors act in different proportions in the elephant problem. Some of them are presented in Fig. 1.2. Woodland decline and human-elephant conflicts originate from the changes in elephant numbers and elephant movements. These two proximate factors are termed as 'disturbing' factors. Elephant numbers and elephant movement patterns are affected by a set of factors termed here as 'steering' factors. Elephant numbers are impacted by: culling or professional hunting, poaching, immigration/emigration, natality/natural mortality and management actions (*e.g.* installation of artificial waterholes, construction of dams). 'Steering' factors that influence elephant movements comprise: management actions, water availability, forage availability and quality and local disturbances (*e.g.* hunting, poaching, war, deforestation). Finally, it is important to note that the two 'disturbing' factors are related to one another.

Based on this theoretical analysis of the factors affecting the elephant problem, the three basic research hypotheses of this thesis are:

1. There is a trend of increasing elephant numbers in the Waza-Logone region, and consequently: (1) a trend of increasing woodland damage inside the parks and (2) a trend of increasing and expanding human-elephant conflict outside the parks.

2. Reduced availability of water during the dry season forces part of the elephant population to migrate out of Waza National Park. Lack of water is the 'push' factor that determines elephant distribution during the dry season;
3. During the wet season, another part of the elephant population is attracted outside the Waza National Park by the quality and quantity of forage. Forage is the 'pull' factor that determines elephant distribution during the wet season.

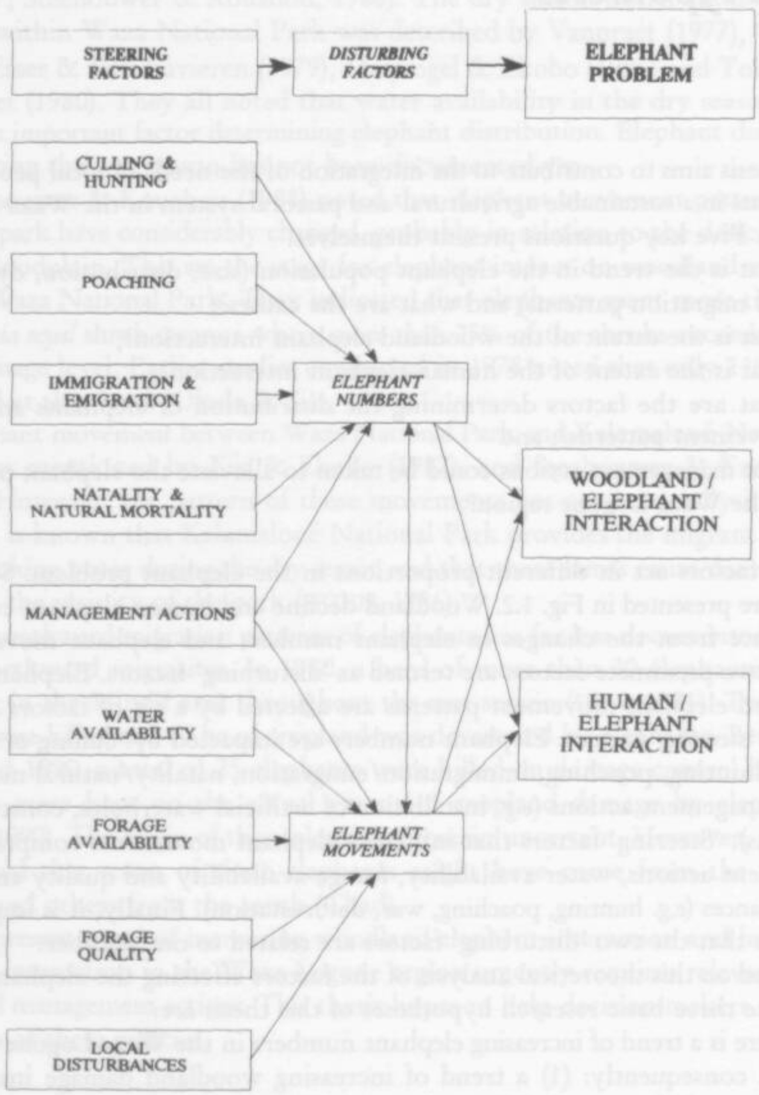


Figure 1.2
Factors affecting the classical elephant problem

1.4

The Organization of the Research and the Description of the Data Collected

Four years were devoted to collecting field data. Ten students contributed significantly to the collection of data. The region north of Waza National Park became so insecure (armed robbery, tribal war) in 1993 that all field work in that area had to be interrupted. Most of the necessary data were already collected, however. Laboratory analyses and data processing took about one year.

As mentioned earlier in this chapter, in African conservation areas the elephant is one of the most important species, mainly because large numbers are capable of intensively modifying the habitat and because of their crop raiding behaviour, whereas on the other hand large numbers of elephant are a major attraction to tourists. It is obvious that sufficient technical information concerning the population and its habitat should be at hand before a specific policy can be pursued. This thesis is divided into six parts. Part I, the present part, gives the general background of the elephant problem, describes the study area and presents the research questions and hypotheses. To establish the trend in elephants numbers in the Waza-Logone region, the description of the elephant population size, dynamics, distribution and migration patterns was needed (Part II).

When information concerning elephant numbers and movement patterns is at hand, the next step is to investigate the impact of elephants on the natural vegetation and the local agriculture (Part III). Information on factors involved in habitat selection and elephant movements should provide a class of possible options to reduce elephant movements and alleviate elephant crop damage. Part IV is devoted to the description of habitat selection by elephants in Waza National Park, the analysis of the seasonal forage utilisation by elephants in the Waza-Logone region and the determination of the nutritional value of some elephant browse.

The available information on elephant numbers, movements and habitat utilisation, and extent of elephant crop damage enables to impart a number of sound management options in order to secure the survival of elephant in the Waza-Logone region and simultaneously maintain the ecosystem within the limits set by management and integrate the needs of the local people.

In Part V attention is drawn to the management options available for reducing the human-elephant conflict. Finally, Part VI summarizes the major findings of this study and evaluates the contributions of this thesis project to the understanding of the elephant problem in northern Cameroon and the identification and selection of sound management strategies to deal with it.

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Part II

Elephant Population Size, Dynamics, Distribution and Migration Patterns

During the present study for every group encountered, size, sex composition and family structure, were noted

2.1

Numbers and Movement Patterns of Savanna Elephants (Loxodonta africana africana) *in Northern Cameroon*

Summary

The Sudanian region of Cameroon covers about 198,000 square kilometres and comprises two major domains: the sahelian and the sudanian. The Waza-Logone floodplain lies in the sahelian domain and contains one of the largest elephant populations of the soudano-sahelian region of West and Central Africa (approximately 1,100 elephants) (Tchamba & Elkam, 1995). In the dry season elephants stay in Waza and Kalamaloué National Parks because of water availability and move out during the rains when there is also less perennial grass available inside the parks. A sub-population of elephants migrates between Waza and Kalamaloué. In the dry season they are in Kalamaloué and in the wet season they move back towards Waza. The extensive use by an increasing number of elephants is having deleterious effects on the vegetation in Kalamaloué Park and Waza Park.

There is another major population of elephants located in the band of sudanian vegetation which lies north of the Adamawa Plateau and south of the sahelian domain (approximately 1,620 elephants) (Tchamba *et al.*, 1991). The three national parks of Faro, Bénoué and Boubandjidah lie in this zone. Seasonal movements again appear to be correlated with water and food availability, but are limited.

Since 1992 a herd of more than 300 elephants roams in the Kaélé region (70 km south of Maroua) during the wet season. The available evidence suggests that these elephants come from Waza National Park. The causes of their seasonal migrations need to be urgently determined if measures have to be taken to prevent further crop damages (estimated to more than $ 200,000) and human lost (3 dead) from immigrants (Thouless & Tchamba, 1992).

Elephant migrations in northern Cameroon are cause for concern to farmers, local authorities and conservationists. Elephants are killed, farms are damaged and crops lost. Elephants might lose the battle unless the sources of conflict are removed.

Introduction

The vast majority of Cameroon's elephant live in the dense forest zone, and most of them inhabit areas outside of the country's protected area system. There are populations, particularly of the savanna elephants, living inside the protected area system, most notably the Waza-Logone floodplain. However, their seasonal migration has become a serious concern to farmers, economists and project designers.

The situation of elephants in northern Cameroon is different from that of elephants in southern Cameroon in that the elephants in the north are under far greater pressure from human populations competing for space and altering natural habitat.

Northern Cameroon comprises two major domains: The sahel domain and the sudanian domain. Elephants were rare in the sudanian domain in 1933 (Flizot, 1948). There were small numbers reported (20) in Boubandjidah and the Vina valley, south of Ngaoundéré, but they were not known to occur in the Bénoué and Faro Reserves until 1946 and 1947. Since then the number of elephants in the region has continued to increase. Flizot (1968) believed that many of the elephants moving into the Bénoué region came from Nigeria, where the British authorities were less interested in game conservation.

The Sahel domain in which the Waza-Logone floodplain is located was devoid of elephants until 1947 when the first ones crossed the Logone near Kousseri and took up residence in the Kalamaloue Reserve. Since then their numbers have grown steadily as shown by Flizot's estimates: 250 in 1961, 400 in 1964, and over 600 in 1969 (Flizot, 1969). Most of this increase was believed to be due to immigration from Chad.

A first attempt to assemble all existing information on elephants in northern Cameroon and to determine their conservation status was made within the framework of the National Plan for Elephant Conservation (Tchamba *et al.*, 1991). The present investigation is based on this plan, but it is adding much historical and more detailed local information collected since 1990 by the elephant project of the Centre for Environmental Science and Development in Cameroon.

Study Area

The sahel domain of northern Cameroon extends from Lake Chad southwards as far as 10° N and covers 36,000 square kilometres. It includes two distinct vegetational communities: thorny grasslands with *Acacia spp.*, *Balanites aegyptiaca*, *Tamarindus indica*, *Calotropis procera*, *Ziziphus spp.*, and periodically flooded grasslands of the Logone-Chari and Lake Chad floodplains with *Echinochloa pyramidalis*, *Hyparrhenia rufa*, *Oryza longistaminata* and *Pennisetum ramosum*.

Waza and Kalamaloué National Parks are located in this domain (Fig. 2.1). The rainfall is about 1,000 mm per year in the south diminishing to less than 350mm in the north. The dry season last six to eight months. The expansion of agricultural farm lands and wood cutting activities in the Waza-Logone floodplain have led to human-elephant conflicts and to changes in migration patterns.

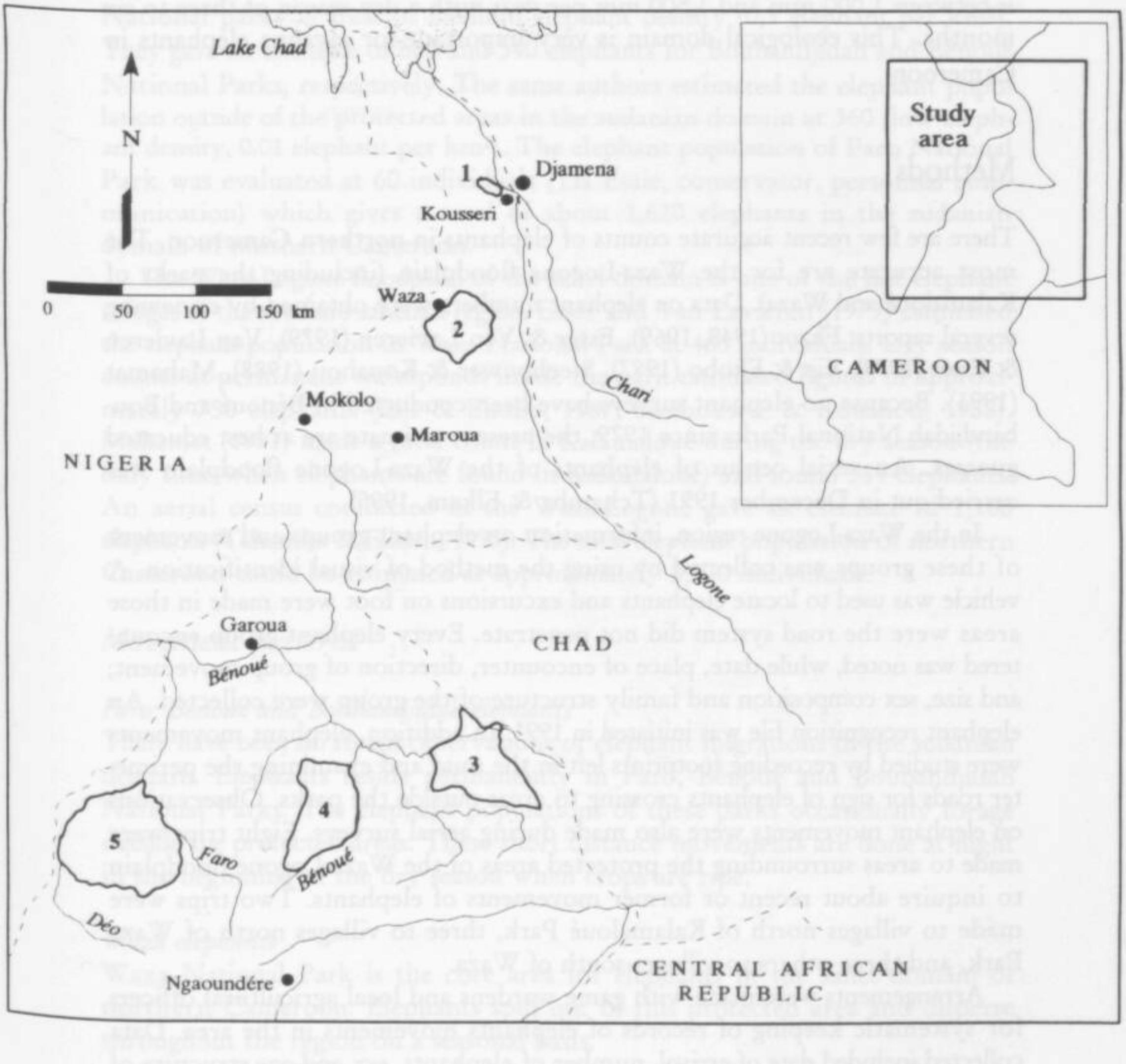

Figure 2.1
Location of the study area
(1 - Kalamaloué, 2 - Waza, 3 - Boubandjidah, 4 - Bénoué, 5 - Faro)

The sudanian domain extends south from 10° N as far as the 800 meter contour on the southern slopes of the Adamawa plateau and covers about 162,000 square kilometres. Faro, Bénoué and Boubanjidah National Parks are the only protected areas of this domain (Fig. 2.1). This domain is covered with savanna woodland in which *Terminalia laxiflora, Isoberlinia doka, Monotes kestingii* and *Anogneissus leiocarpus* are the common species interspersed with fire- resistant trees like *Daniella olivieri, Lophira lancoelata, Borassus aethiopium.* The rainfall is between 1,000 mm and 1,500 mm per year with a dry season of three to six months. This ecological domain is very important for savanna elephants in Cameroon.

Methods

There are few recent accurate counts of elephants in northern Cameroon. The most accurate are for the Waza-Logone floodplain (including the parks of Kalamaloué and Waza). Data on elephant numbers were obtained by reviewing several reports: Flizot (1948, 1969), Esser & Van Lavieren (1979), Van Lavieren & Esser (1979), Eijs & Ekobo (1987), Steehouwer & Kouahou (1988), Mahamat (1991). Because no elephant surveys have been conducted in Bénoué and Boubandjidah National Parks since 1979, the present estimate are at best educated guesses. An aerial census of elephants of the Waza-Logone floodplain was carried out in December 1991 (Tchamba & Elkam, 1995).

In the Waza-Logone region, information on elephant groups and movement of these groups was collected by using the method of visual identification. A vehicle was used to locate elephants and excursions on foot were made in those areas were the road system did not penetrate. Every elephant group encountered was noted, while date, place of encounter, direction of group movement, and size, sex composition and family structure of the group were collected. An elephant recognition file was initiated in 1991. In addition, elephant movements were studied by recording footprints left in the mud and examining the perimeter roads for sign of elephants crossing to areas outside the parks. Observations on elephant movements were also made during aerial surveys. Eight trips were made to areas surrounding the protected areas of the Waza-Logone floodplain to inquire about recent or former movements of elephants. Two trips were made to villages north of Kalamaloué Park, three to villages north of Waza Park, and three others to villages south of Waza.

Arrangements were made with game wardens and local agricultural officers for systematic keeping of records of elephants movements in the area. Data collected included date of arrival, number of elephants, sex and age structure of the group, date of departure and direction of travel.

Results

Numbers

Van Lavieren and Esser (1979) estimated the elephant population of Boubandjidah National Park at 232 and 150-300 by aerial and ground sample counts, respectively. Tchamba *et al.* (1991) considered the Boubandjidah and Bénoué National parks as areas of medium elephant density (0.3 elephant per km²). They gave an estimate of 660 and 540 elephants for Boubandjidah and Bénoué National Parks, respectively. The same authors estimated the elephant population outside of the protected areas in the sudanian domain at 360 (low elephant density, 0.01 elephant per km²). The elephant population of Faro National Park was evaluated at 60 individuals (Tia Esaie, conservator, personnal communication) which gives a total of about 1,620 elephants in the sudanian domain of northern Cameroon.

The Waza-Logone floodplain of the sahel domain is one of the last elephant refuges of the soudano-sahelian region. Esser and Van Lavieren (1979) estimated the elephant population in Waza National Park at 465 individuals. Dry season counts at permanent waterponds inside the park estimated figures of approximately 750 elephants (Eijs & Ekobo, 1987; Steehouwer & Kouahou, 1988). Mahamat (1991) made a total count in Kalamaloué during the dry season (the only time when elephants are found in Kalamaloué) and found 384 elephants. An aerial census conducted in the Waza-Logone gave an estimate of 1,100 elephants (Tchamba & Elkam, 1995). The total elephant population of northern Cameroon could be estimated at approximately 2,720 individuals.

Movement patterns

Faro, Bénoué and Boubandjidah elephants

There have been no recent observations of elephant migrations in the sudanian domain. Elephants reside permanently in Faro, Bénoué and Boubandjidah National Parks. The elephant populations of these parks occasionally forage outside the protected areas. These short distance movements are done at night in the beginning of the dry season when crops are ripe.

Waza elephants

Waza National Park is the core area for elephants in the sahel domain of northern Cameroon. Elephants spill out of this protected area and disperse throughout the region on a seasonal basis.

In december 1990 a group of approximately 150 individuals was followed in its movement from Waza National Park till Kalamaloué National Park (Fig. 2.2). They travelled approximately 120 km north. Because the floodplain was still flooded these elephants migrated along the western part of the floodplain 5 to 10 kilometres from the paved road 'Waza - Kousseri', following a corridor dominated by *Acacia seyal*. They stayed 5 months in Kalamaloué with occasional trips to Lake Chad and frequent night incursions into farms. In June this group of elephants moved back to Waza following a corridor on the eastern part of the floodplain, 10 km from the Logone River. This corridor went through the villages of Kalakafra, Oulouf, Logone Birni, Khalkoussam, Hinalé, Kaoussen and Bélé (Fig. 2.2). In Waza National Park the elephants of this group resided in the northern part.

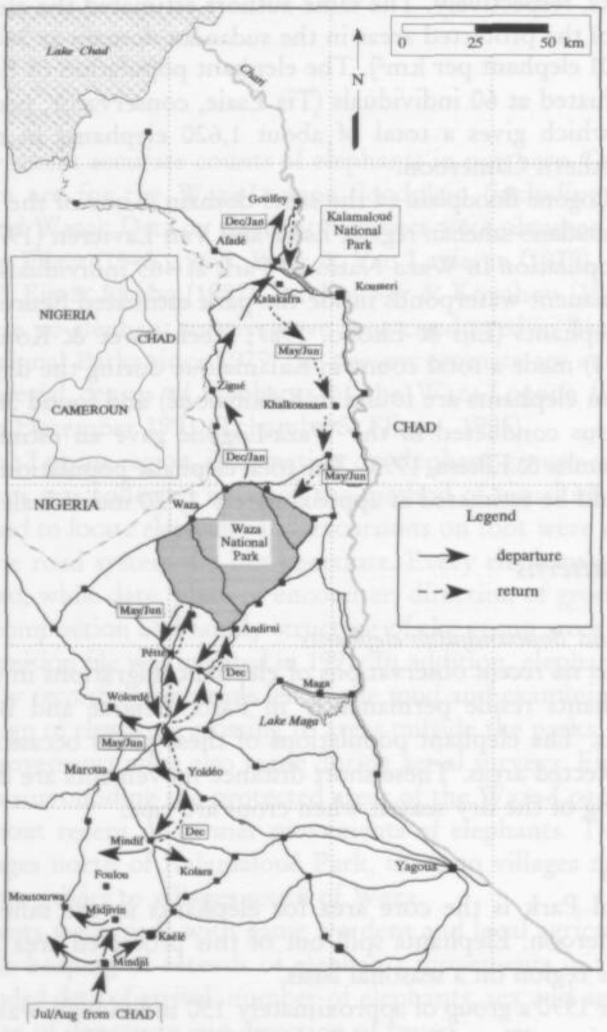

Figure 2.2
Elephant migration patterns in northern Cameroon

The second group comprised the resident elephants of Waza National Park which remained in the Park year-round. In the wet and early dry seasons (May to November) they used the southern and western parts of the park. This region is covered with woodland savanna dominated by *Sclerocarya birrea, Anogeissus leiocarpus* and *Lannea humilis*. In December, January and February (mid-dry season) they moved to the floodplain and *Acacia seyal* woodland. At the end of the dry season (March-April), the resident elephants concentrated in the central part of the Park covered by *Acacia seyal*.

The third group of Waza elephants used the southern and central part of the Park (forest and *Acacia* zone) in the dry season (December to June). At the onset of the rains in june 1991 these elephants spilled out of the Park, entered and ate the rich patches of food in local gardens of millet, corn, peanuts and beans. These elephants were divided into two sub-groups. The first sub-group went out of the Park through Andirni, then passed Alagarno, Fadare and Doubbel. The second sub-group crossed the Park boundary towards Bandalaré, then went to Petté and Doubbel. The village of Doubbel seemed to be the elephant's meeting point during their departure and return to Waza.

A few individuals stayed around Doubbel with trips to Wolorde. Most of the elephants continued their journey southward, going through Balaza alcali, Djoulgouf, Yoldéo, Ourozangui and Mindif. The elephants of this group migrated up to 100 km from Waza. They returned to Waza in October 1991.

Since july 1992 an important herd of more than 300 elephants roams in the Kaélé region during the wet season. Thouless & Tchamba (1992) speculated that these elephants all migrated northward either from south west of Chad or from Boubandjidah National Park located only about 150 km south of the region. Their conclusions were based on investigations made along the Maroua-Bogo-Maga road (mandatory crossing for elephant moving south from Waza) which indicated that such a number of elephants have not passed through the area in June-July 1992. More recent telemetry evidence suggests that at least part of these elephants seasonally migrate from Waza National Park (Tchamba, Bauer & Iongh, 1995).

Discussion

Over the past 40 years the elephant population of northern Cameroon has been increasing (Corfield & Hamilton, 1971). It is alleged that most of this increase is due the direct result of immigration from Chad, probably resulting from disturbances there such as the deforestation of the Mandelia Faunal Reserve (Fry, 1970), but observations indicate that considerable breeding is taking place. The elephant of northern Cameroon generally carries small tusks rarely exceeding 25 kg each side, a factor which has doubtlessly weighed in their favour. In order to determine the conservation status of elephants in the sudanian domain of northern Cameroon, it is necessary to investigate the population size in each protected area (Bénoué, Faro, Boubandjidah), their degree of isolation and the possibility of interchange between neighbouring elephant populations.

Direct observations of elephant herds coupled with extensive ground-truthing suggest that the Waza elephant population is divided into three sub-populations with distinct migration patterns. A limiting factor for this method is found to be the low frequency in which particular individuals and family units are encountered, and the very limited observations made during the wet season because of flooding and inaccessibility. However, the observations made so far might be of good use, in view that data on elephant population dynamics and movement patterns will be collected for a number of years. Additional ground-truthing, more detailed population dynamics studies and intensive radio/satellite tracking of elephants from separate herds should yield more information about the elephant sub-populations and their movement patterns.

When one sub-population leaves Waza Park in December-January and travels north to Kalamaloué Park, another sub-population returns to Waza after spending the wet season raiding crops south of Waza. The factors driving these migrations are probably similar. Water is available during the dry season only in the two artificial waterholes of Waza and in the Logone river bordering Kalamaloué Park. To avoid competition for limited food and water in Waza, elephants are forced to move. Part of the elephants move to Kalamaloué where there is more water and more diverse savanna woodland. These elephants are replaced by elephants confining themselves to within 10 km foraging radius of the artificial waterholes.

Elephants often begin to move within a few hours of the first rains of the season, long before vegetation has responded to it. The observation that elephants stay longer in the Mindif area where boreholes were sunk in 1985 for livestock further supports the hypothesis that water restricts the movements of migrants during the dry season.

Seasonal patterns of movement and habitat selection have been reported for many elephant populations (Laws *et al.*, 1975, Eltringham, 1977; Caughley & Goddard, 1975, Western, 1975; Short, 1983; Jachman, 1983, 1988; Butynski, 1986; Merz, 1986; Roth & Douglas-Hamilton, 1991). Seasonal movements generally coincide with changes in food and water availability. Water availability alone cannot fully explained the migration patterns of Waza elephants. Forage requirements also contribute to their leaving Waza Park. The reduction of the flooded area of the Waza-Logone floodplain has led to the replacement of perennial grasses by annual grasses which do not produce nutritive regrowth for wildlife and cattle (Oijen & Kemdo, 1986).

The expansion of agricultural land and wood cutting activities coupled with the construction of the Maga dyke (Fig. 2.2) have resulted in a competition for space between elephants and people, and changes of elephant migration patterns. Farmers continually face the threat of extensive elephant damage on crops and elephants are subsequently killed to protect people and crops. Elephant crop damages in the Kaélé region were estimated at more than 200,000 US dollars between July and October 1992 (Thouless & Tchamba, 1992). Three persons were reported killed by elephants in the same period.

Elephant migrations also have an impact on the natural vegetation. (Tchamba & Mahamat, 1992) observed that the 'elephant problem' in Kalamaloué National Park was significant. They noted large-scale killing of mature trees and serious damage on the regeneration of vegetation, and concluded that woodlands were on the decline with mortality exceeding replacement.

A good understanding of elephant movement patterns is necessary for a better management of protected areas to the benefit of both elephant and man. A study is currently being conducted to determine the natural factors (vegetation composition, structure, productivity, digestibility and succulence, phenology, water availability) and human factors (crop presence, forms of disturbance and distance to them, poaching) which influence movements and the most important ones in time and space. Radio/satellite telemetry is also being used to determine elephant home ranges. The ultimate goal of this study is to propose solutions that would allow the coexistence of the presently opposing domains of agricultural development and conservation in northern Cameroon.

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2.2

Status and Trends of Some Large Mammals and Ostriches in Waza National Park, Cameroon

Summary

An aerial count of large mammals and ostriches was carried out in the Waza National Park, Cameroon, using systematic transect sampling. Total population estimates are given and distribution maps are presented for seven species. Results are compared with three previous estimates.

Population sizes of giraffe (*Giraffa camelopardalis*), roan antelope (*Hippotraginus equinus*), kob (*Kobus kob*) and topi (*Damaliscus korrigum*) showed a slight between 1962 and 1977, and had apparently increased between 1977 and 1991. Red-fronted gazelle (*Gazella rufrifons*) and ostrich (*Struthio camelus*) maintained their numbers between 1962 and 1991. Elephants (*Loxodonta africana africana*) showed a significant increase of 6.1% per year since 1977.

The *Acacia seyal* zone was an important wildlife habitat. This habitat should be permanently monitored given the relative increase in wildlife numbers and the changes in local hydrological conditions.

The cost of the aerial survey was about US$ 2.30 per km^2, an expensive operation for most African wildlife departments and research institutes.

Introduction

Large herbivores are an important natural resource of Cameroon. They are a source of food/protein for local people and they contribute to social and economic development through the tourism and the safari hunting industries. Their conservation and management require regular monitoring to provide a basis for measuring trends in population size and distribution, and for determining offtake quota.

Four major survey techniques are used to count animals in Africa. Foot surveys are used in small, accessible areas and show little bias when carefully designed and carried out (Burnham *et al.*, 1980). Vehicle surveys are limited by the available road system and may be of poor accuracy for species with a clumped distribution (Jachmann, 1991). The dropping-count method has been widely used to estimate elephant densities (Wing & Buss, 1970; Short, 1983; Jachmann & Bell, 1984; Merz, 1986; Barnes & Jensen, 1987; Fay, 1991). The advantage of dropping count method is that it provides relatively good results for its cost (Jachmann, 1991), but there are several potential sources of error related to deriving the index of abundance and turning this index into an estimate of elephant numbers (Barnes & Barnes, 1992; Tchamba, 1992; Barnes, 1993). Aerial surveys are widely used in large, inaccessible areas, but may be of limited value depending upon visibility, topography, distribution of animals and survey design (Norton-Griffiths, 1978). They may lead to high variance and bias, particularly in the case of clumped species or those which are difficult to spot from the air (Craig, 1993).

The use of light aircraft in censusing large mammal populations is widespread in east and south Africa, but in west and central Africa it is not commonly used. Animals are difficult to spot from the air during the greater part of the year and the costs of aerial surveys are often a limiting factor for low-budget wildlife departments and research institutes. The last aerial survey of Waza National Park was conducted in December 1977 (Esser & Van Lavieren, 1979). Ground counts of large mammals have been carried out occasionally by staff and students of the College of Wildlife Management, Garoua. However, only small areas of the park surface can be sampled from the ground.

This chapter gives the result of an aerial survey of Waza National Park. The survey objectives were to: (a) estimate the numbers of large mammals (paying particular attention to the elephant population) and ostrich; (b) plot the dry season distribution of large mammals and ostrich; (c) determine population trends; (d) evaluate the cost of aerial surveys in this region.

Study Area

Waza National Park is located in Northern Cameroon (Fig. 2.3) between 11°03' N and 11°30' N and 14°28' E and 14°56' E. The park covers an area of about 1700 km². Topography is generally flat except for three basaltic hills rising to an elevation of 600 m above sea level at the western entrance of the park. The altitude of the park varies between 310-350 m in the West and South and is around 305 m in the east. The Central part is in a depression which is at 300 m.

The climate and the wild fauna are described in Chapter 1.2. The vegetation has been described in detail by Wit (1975) and Esser & Van Lavieren (1979). The park comprises three main vegetation zones (Fig. 2.3). The woodland zone covers approximately 31% of the park and consists mainly of *Sclerocarya birrea,*

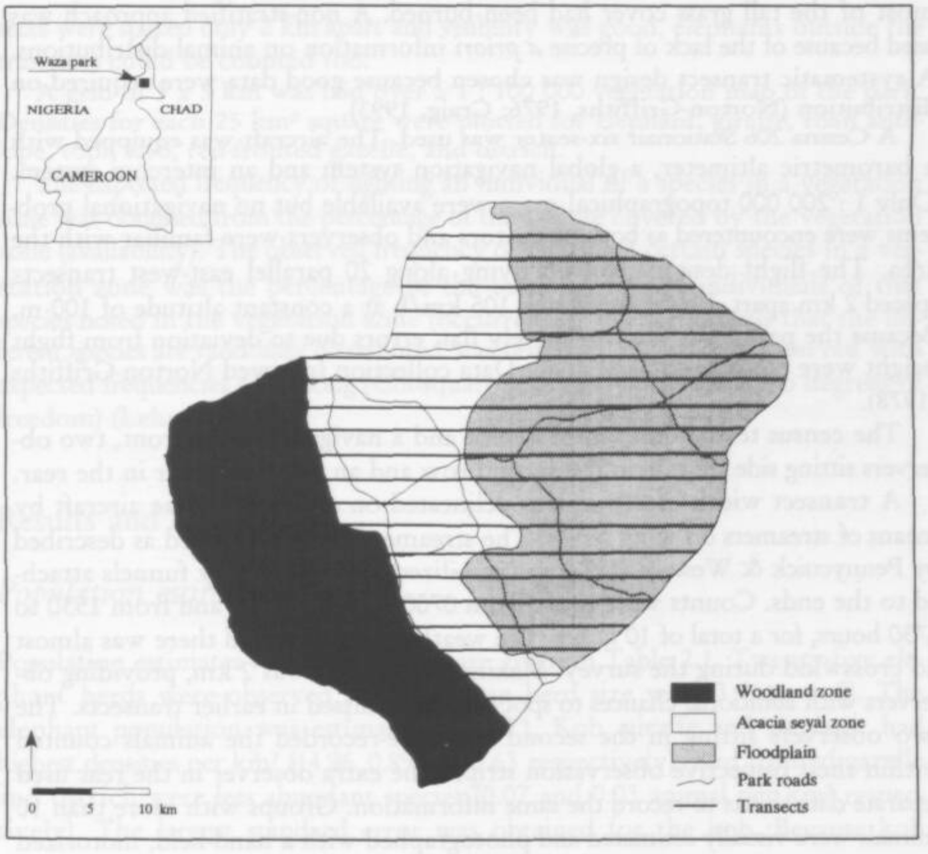

Figure 2.3

Major vegetation zones of Waza National Park and approximate location of transects flown

Lannea humilis and *Anogeissus leiocarpus*. The shrub savanna covers approximately 27% of the park and is dominated by *Acacia seyal*. The floodplain grasslands locally known as 'yaérés', consist of perennial grasses such *Vetiveria nigritana* that are being replaced by annuals like *Sorghum arundinaceum, Melocia corchorifloria* and *Celosia argenthea* (Oijen & Kemdo, 1986). It covers approximately 42% of the park.

Methods

Sample design and data collection

The aerial survey was carried out from 14 to 16 December, 1991, just at the beginning of the dry season. Most trees and shrubs had lost their leaves and most of the tall grass cover had been burned. A non-stratified approach was used because of the lack of precise *a priori* information on animal distributions. A systematic transect design was chosen because good data were required on distribution (Norton-Griffiths, 1976; Craig, 1993).

A Cessna 206 Stationair six-seater was used. The aircraft was equipped with a barometric altimeter, a global navigation system and an intercom system. Only 1 : 200 000 topographical maps were available but no navigational problems were encountered as both navigators and observers were familiar with the area. The flight design involved flying along 20 parallel east-west transects spaced 2 km apart. Flight speed was 105 km/h at a constant altitude of 100 m. Because the park's surface is relatively flat, errors due to deviation from flight height were considered very small. Data collection followed Norton-Griffiths (1978).

The census team consisted of a pilot and a navigator in the front, two observers sitting side by side in the second row and an extra observer in the rear.

A transect width of 200 m was delineated on each side of the aircraft by means of streamers on wing struts. The streamers were positioned as described by Pennycuick & Western (1972) and stabilized during flight by funnels attached to the ends. Counts were made from 0700 to 1000 hours and from 1530 to 1730 hours, for a total of 10 hours. The weather was clear and there was almost no crosswind during the survey. Maximum visibility was 2 km, providing observers with additional chances to spot elephants missed in earlier transects. The two observers sitting in the second row tape-recorded the animals counted within their respective observation strips. The extra observer in the rear used separate data sheets to record the same information. Groups with more than 10 animals were visually estimated and photographed with a hand-held, motorized 35 mm camera using high speed film (ASA 500) for later counting.

The time at which animals were seen along the transect line was noted using stop-watches and converted into distance from starting point of the transect. The time spent in each vegetation zone was noted and converted into distance and area covered in each vegetation zone.

Data analysis

The area of each transect was calculated from the product of the strip width and the transect length (measured from the map and checked with flight time). The average transect length was 30 km. The transects covered approximately 14% (30 km x 0.2 km x 2 x 20 = 248 km^2) of the park. The total area of approximately 248 km^2 covered by the aerial survey consisted of about 27% woodland, 29% *Acacia* and 44% floodplain. The population estimates, variances and 95% confidence limits were calculated by Jolly's method for unequal-sized sample units (Jolly, 1969). During the survey elephants were very clumped and for that reason, an attempt was made to count all the elephants. Because transects were spaced only 2 km apart and visibility was good, elephants outside the transects could be counted too.

A grid of 5 x 5 km was laid over a 1 : 100 000 vegetation map of the park. Densities for each 25 km^2 square were plotted for elephant, giraffe, roan antelope, topi, kob, red-fronted gazelle, and ostrich.

The expected frequency of sighting an individual of a species in a vegetation zone was obtained from the percentage of the sample covered by the vegetation zone (availability). The observed frequency of sighting a certain species in a vegetation zone was the percentage of the total sighting of individuals of that species noted in the vegetation zone (occurrence). The hypothesis that the different species are randomly distributed was tested by comparing observed with expected frequencies of sighting (Chi-square goodness-of-fit with two degrees of freedom) (Lehner, 1979).

Results and Discussion

Population estimates

Population estimates for seven species are given in Table 2.1. Twenty-five elephant herds were observed and the mean herd size was 43 (S.E. = 8). The elephant population was estimated at 1,071. Kob, giraffe and elephant had highest densities per km^2 (14.96, 0.89 and 0.63 respectively). Red fronted gazelle and ostrich were less abundant species (0.07 and 0.03 animal per km^2 respectively). The largest standard error was obtained for the kob. Because kob

Table 2.1

Population estimates, standard errors, 95% confidence limits and density estimates for some large mammals and ostriches in Waza National Park in December 1991 (sampling intensity = 14%, 20 transects)

Species	Population estimate	Standard error	95% confidence limit	Density (per km^2)
Elephant	1071	0	0	0.63
Giraffe	1516	130.43	273	0.89
Roan antelope	372	29.62	62	0.22
Topi	928	93.16	195	0.54
Kob	25427	1335.88	2796	14.96
Red fronted gazelle	112	38.70	81	0.07
Ostrich	53	17.78	37	0.03

distribution was not uniform, systematic sampling of this species resulted in counting bias. Kobs were mainly observed in the vicinity of waterholes.

Comparison with earlier estimates

Table 2.2 compares actual estimates with previous ones made by Flizot (1962), Van Lavieren (1977), and Esser & Van Lavieren (1979). The January 1977 aerial census results (Van Lavieren, 1977) were very low when compared to the estimates of Flizot (1962) which were at best educated guesses. A second census was carried out in December 1977 (Esser & Van Lavieren, 1979) with the same sampling intensity to verify and eventually confirm the results of the previous census. Because the distribution of giraffe, roan antelope, topi and kob tended to be more uniform in December 1977 than in January 1977, systematic transect sampling of these species resulted in more precise estimates in December 1977 than in January 1977 (Esser & Van Lavieren, 1979). Therefore, all comparisons with the year 1977 will be made only with the December 1977 estimates. Available literature provides the 95% confidence limits for population estimates of giraffe and kob only and for the December 1977 census only. Consequently, a true statistical comparison is not possible as measures of variance are lacking.

Table 2.2

Comparisons between actual and previous population estimates

Species	Flizot (1962)	Van Lavieren (Jan. 1977)	Esser & Van Lavieren (Dec. 1977)	This Study (Dec. 1991)
Elephant	250	478	465	1071
Giraffe	2000	1091	1262 ± 156	1516 ± 273
Roan antelope	4000	349	233	372 ± 62
Topi	20000	794	605	928 ± 195
Kob	25000	21933	13238 ± 1163	25427 ± 2796
Red fronted gazelle	-	147	10	112 ± 81
Ostrich	300	64	42	53 ± 37

In as far as value can be attached to the data of Flizot (1962) a comparison between 1962 and 1977 suggests a decline of animal numbers, except for elephants. This decline may stem first from the drought of the year 1972-1973, and secondly from the rinderpest epidemic (Vanpraet, 1976; Beauvilain, 1989). In addition, these species (kob in particular) are exposed to heavy poaching in the dry season when they leave the park in search for water and good forage and disperse in the 'corridor' between the park and the Logone River. It is alleged that most of the elephant population increase during this period was due to immigration into the area from Chad, mainly due to disturbances there such as the deforestation of the Mandelia Faunal reserve (Flizot, 1969; Fry, 1970).

The elephant population has increased by 5.9% per year between 1977 and 1991 (overall increase of 130%). Without immigration, this annual growth rate would be considered very high for elephants living under natural conditions (Moss, 1992). Tchamba (1993) noted that there were three distinct elephant sub-populations in Waza. The first sub-population migrates North to Kalamaloué national Park in November-December, an is estimated to more than 100 individuals. The second sub-population is resident and the third sub-population migrates South of Waza in the wet season (May-June). During the present study, Kalamaloué Park was surveyed but no elephants were spotted, indicating that elephants were still in Waza. It is possible that Esser & Van Lavieren (1979) missed the sub-population migrating to Kalamaloué in their counts. If that were the case, the annual growth rate between 1977 and 1991 would be lower.

Ngog (1983) indicated that the giraffe population was stable between 1977 and 1980. With the calculated confidence limits presented in Table 2.1, one can only say that it is possible that the giraffe population went slightly up between 1977 and 1991. The giraffe suffers little poaching, and although it has not yet been scientifically documented, its principal habitat (*Acacia seyal* zone) might be extending at the expense of the floodplain. This extension could be related to changes in hydrological conditions in the floodplain, due to the construction of a dam for rice culture and the resulting reduction of flooding in the park.

The populations of roan antelope and topi went slightly up between 1977 and 1991 (annual growth rate of 3.3% and 3%, respectively; overall increase of 60% and 53%, respectively). It is possible that the population of kob has also gone up during this period. However, an annual growth rate of 4.7% and overall increase of 90% are very unlikely. Either the December 1977 aerial count of the kob population was underestimated or the January 1991 was overestimated. Overestimation during the January 1991 survey might have resulted from counting large numbers of kob that usually spend most of their time in the floodplain adjacent to the Logone River, and which might have dispersed along the park's boundaries at the time of the survey.

There was no estimate of red-fronted gazelle in 1962. The December 1977 estimate of this small and cryptic species was underestimated (Esser & Van Lavieren, 1979) and consequently it is difficult to determine the trend in the gazelle population. Red fronted gazelle leather is very much appreciated and used for making bags and belts. There are indications that gazelles are heavily poached. On a single day's investigation in the local market, 27 red-fronted gazelle skins were found on sale. The origin of these skins could not be determined. Ostrich declined between 1962 and 1977 but seemed to stabilize for the past 14 years. However, ostrich suffers poaching because its eggs are collected, feathers used for ornamental purposes and skin for making hand bags.

Distribution and relative habitat preference

As can be seen from Fig. 2.3 the transect length flown in each of the three zones is proportional to the areas of this zones. Therefore, it could be concluded that the vegetation zone distribution which was sampled was sufficiently representative of the park.

If one treats the individuals as independent units than the relative distributions of the seven species, as derived from animal distributions plotted on a 1:100 000 vegetation map of the park, are given in Table 2.3. Distribution maps are shown in Figs 2.4-2.7. However, we have to realize that most animals tend to move in herds and in this case herds are the independently moving units. All the seven species were not distributed according to vegetation zone availability. The highest densities of most species were found in the *Acacia seyal* zone. Elephant, giraffe, red fronted gazelle and ostrich showed a significant preference for the *Acacia seyal* zone ($X^2=117$, $X^2=63$, $X^2=149$ and $X^2=65$, respectively; df=2; $P<0.001$). Kob had a clear preference for the floodplain ($X^2=53$; df=2; $P<0.001$). Roan antelope and topi had a small preference for the woodland zone when compared to the *Acacia seyal* zone ($X^2=65$ and $X^2=62$, respectively; df=2; $P<0.001$).

Table 2.3

Relative distribution of some large mammals and ostrich in Waza National Park

Species	Percentage of numbers sighted		
	Woodland zone (27% of area sampled)	*Acacia seyal* zone (29% of area sampled)	Floodplain (44% of area sampled)
Elephant	5	78	17
Giraffe	21	64	15
Roan antelope	53	42	5
Topi	54	39	7
Kob	0	23	77
Red fronted gazelle	0	84	16
Ostrich	29	62	9

For elephants it was easier to distinguish between herds. Elephant were distributed throughout the *Acacia seyal* zone in large (> 50 individuals) and small (< 50 individuals) herds (Fig. 2.4). One large herd was observed in the northern part of the floodplain. Three large herds totalling 323 elephants were recorded in the northern part of the *Acacia seyal* zone, close to the park's border. These elephants might have been congregating prior to northern migration to Kalamaloué National Park.

As expected, giraffe was found predominantly in the *Acacia seyal* zone (Fig. 2.5). The *Acacia seyal* is its principal food item. Some giraffes were found in the woodland zone where they feed on *Cadaba farinosa, Capparis tomentosa* and *Combretum spp.*

Figure 2.6 strongly suggests that kob avoided the woodland and preferred the floodplain. However, their distribution over the northern part of both the floodplain and the adjoining *Acacia* zone suggests that other factors are involved as well as the near presence of human habitation in the south. Esser & Van Lavieren (1979) indicated that 80% of the kob stay year-round in the floodplain where they feed on their preferred grazing, including *Vetiveria nigritana*, a perennial grass found exclusively there.

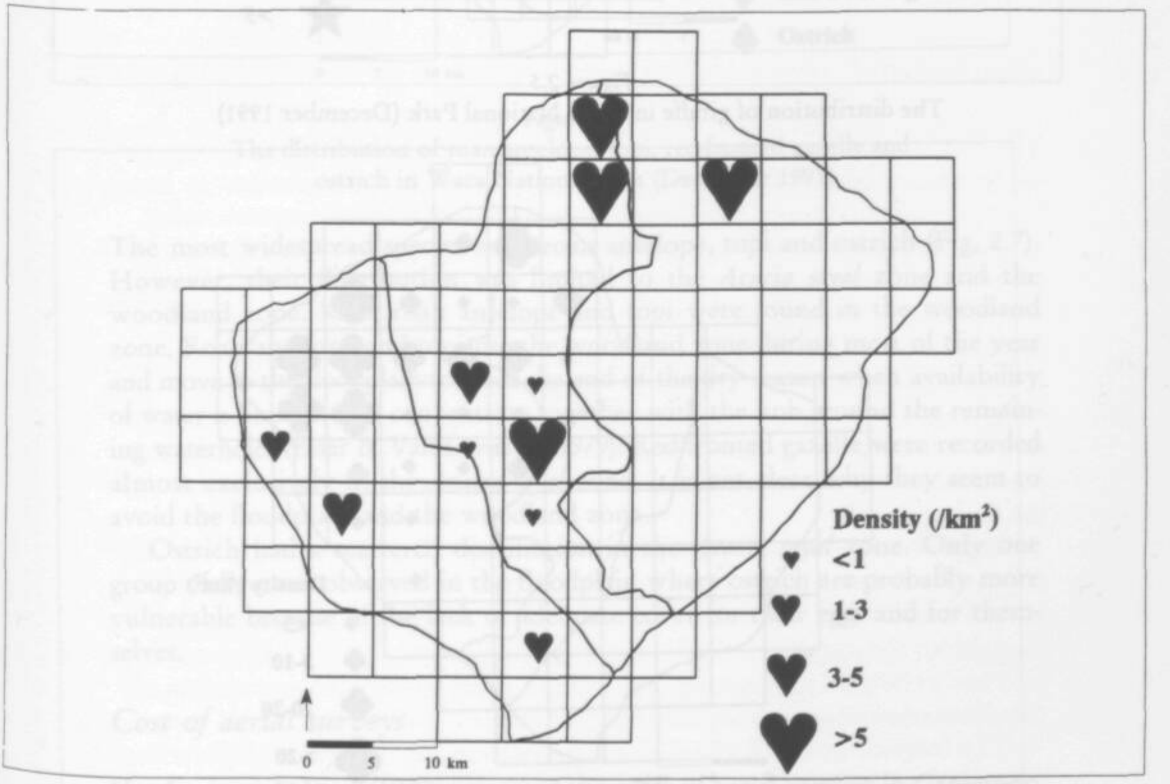

Figure 2.4
The distribution of elephants in Waza National Park (December 1991)

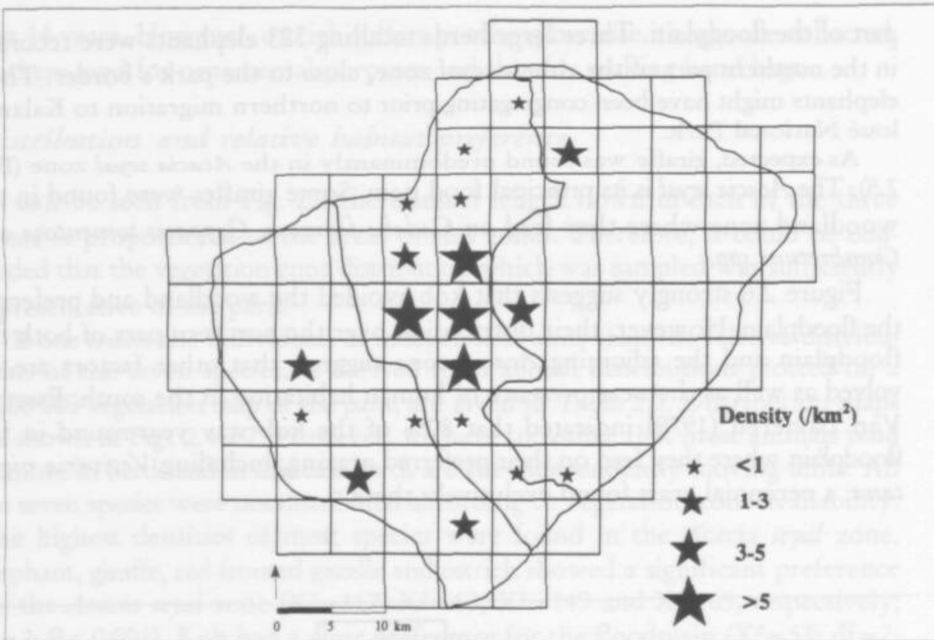

Figure 2.5
The distribution of giraffe in Waza National Park (December 1991)

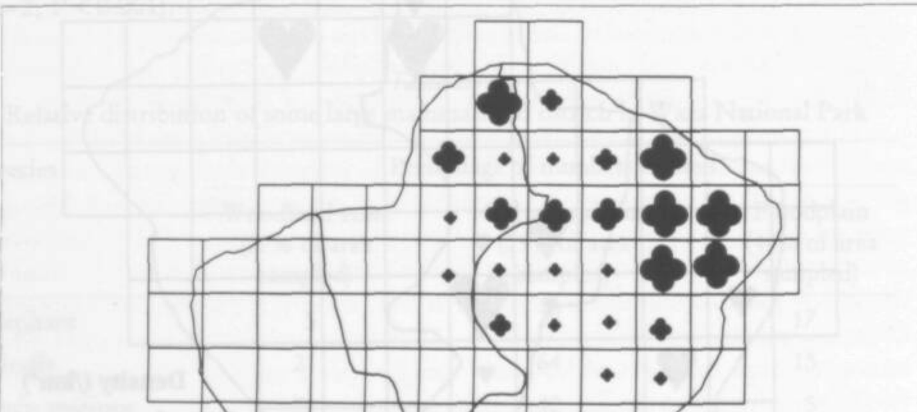

Figure 2.6
The distribution of kob in Waza National Park (December 1991)

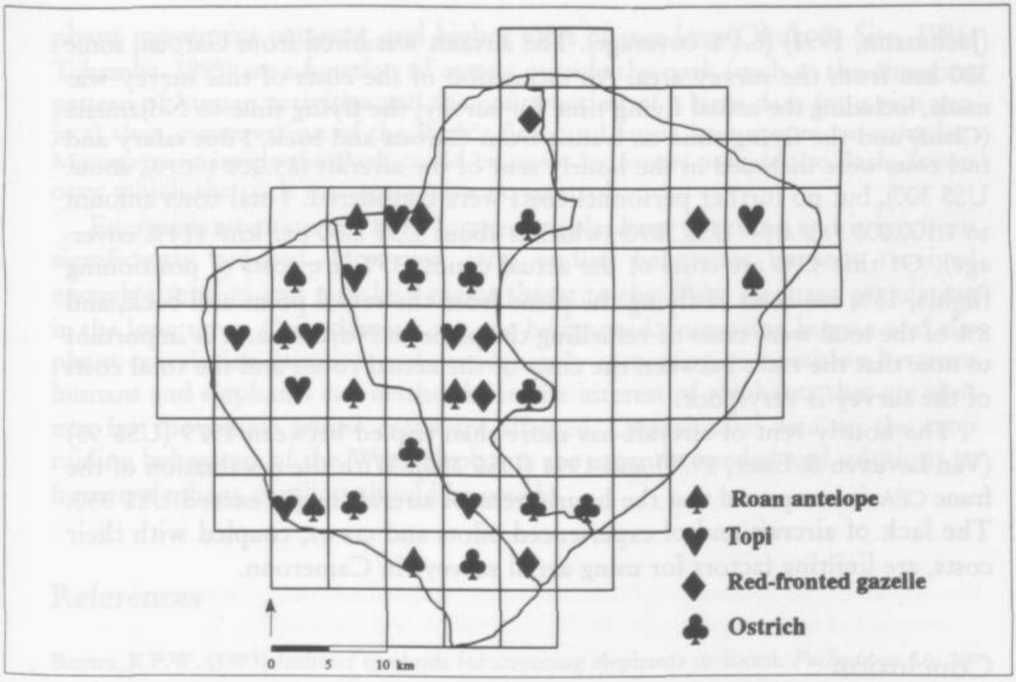

Figure 2.7
The distribution of roan antelope, topi, red-fronted gazelle and ostrich in Waza National Park (December 1991)

The most widespread species were roan antelope, topi and ostrich (Fig. 2.7). However, their distribution was limited to the *Acacia seyal* zone and the woodland zone. Most roan antelope and topi were found in the woodland zone. Roan antelope and topi use the woodland zone during most of the year and move to the floodplain towards the end of the dry season when availability of water is limited, and concentrate together with the kob around the remaining waterholes (Esser & Van Lavieren, 1979). Red-fronted gazelle were recorded almost exclusively in the *Acacia seyal* zone. It is not clear why they seem to avoid the floodplain and the woodland zone.

Ostrich had a scattered distribution in the *Acacia seyal* zone. Only one group of five was observed in the floodplain where ostrich are probably more vulnerable because of the lack of adequate cover for their eggs and for themselves.

Cost of aerial surveys

Van Lavieren & Esser (1979) estimated the costs of aerial surveys in Cameroon to be about US$ 1.00 per km² (9.3% coverage). At the Nazinga Game Ranch (Burkina Faso), costs were estimated at approximately US$ 1.30 per km²

(Jachmann, 1991) (6.1% coverage). The aircraft was hired from Garoua, some 300 km from the survey area. An estimation of the costs of this survey was made, including the actual flying time for survey, the flying time to Ndjamena (Chad) and the flying time en transit from Garoua and back. Pilot salary and fuel costs were included in the hourly rent of the aircraft (85.000 F.CFA, about US$ 300), but no further personnel costs were considered. Total costs amount to 1.100.000 F.CFA (= US$ 3890), which is about US$ 2.30 per km² (14% coverage). Of this 42% are costs of the actual count, 35% are costs of positioning flights, 15% are costs of flying the plane from the rental point and back, and 8% of the total were costs of refuelling the plane in Ndjamena. It is important to note that the ratio between the costs of the actual count and the total costs of the survey is very poor.

The hourly rent of aircraft has more than tripled between 1979 (US$ 93) (Van Lavieren & Esser, 1979) and 1991 (US$ 300). With the devaluation of the franc CFA, it is expected that the hourly rent of aircraft might exceed US$ 350. The lack of aircraft and of experienced pilots and crews, coupled with their costs, are limiting factors for using aerial surveys in Cameroon.

Conclusion

The *Acacia seyal* zone is a very important wildlife habitat in Waza. Given the increasing wildlife numbers (especially elephants) and the changes in local hydrological conditions, this habitat type should be monitored continually.

For the past two years ago, the protection of the park has significantly improved with the acquisition of new vehicles, motorcycles, uniforms and a communication system. It is expected that wildlife numbers could continue to grow. However, poaching will still continue in the wet season when the park is inaccessible and foot and vehicle patrols are reduced. Efforts should focus not only on law enforcement as it is now but also on conservation education for people living around the park. The development of a buffer zone management plan should be considered in order to integrate people in the management of the park.

Consistent with conservation goals, Waza National Park could provide support for local development, and large herbivores have the potential to be used in such connections. Continuous monitoring of large herbivore populations is essential for the sustainable maintenance of wildlife resources. Particular attention has to be paid to elephants and kobs in order to establish sustainable offtake quota for safari hunting and local hunters.

The increase of the Waza elephant population has important implications not only for the Park management but also for those concerned with land use planning and regional development. If events inside the Park (increasing elephant densities, disruption of the annual hydrological regime, changes in elephant movement patterns, and higher rates of tree loss (Okula & Sise, 1986; Tchamba, 1995) are a function of events outside the park (such as the changing pattern of human activities and the construction of a large dam for a rice project) then conservation of the Park's flora and fauna becomes more complex. Management inside the Park could be upset by forces outside the Park, forces over which the park managers have no control.

Enormous attention has been focused on elephant poaching and it has been significantly reduced. However, crop raiding behaviour has not received enough attention and may be a major threat to the Waza elephant population in the long term. Crop damage can not be ignored. Increasing human and elephant population numbers and consequently increasing competition between humans and elephants can neither be in the interest of elephants that are shot nor for the people whose crops are affected. Quantitative data on the crop raiding behaviour of the Waza elephants are urgently needed and solutions to human-elephant conflicts should be sought.

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2.3

Some Preliminary Observations on Age and Sex Structure, Growth and Mortality Rates of Elephants in Waza National Park, Cameroon

Summary

Photogrammetric methods were used to obtain data on the age structure of the elephant population of Waza National Park, Cameroon. The results show that the present elephant population is stable. The reproductive potential of this population is high. The mean calving interval is currently estimated at 3.1 years, while the age at first conception is estimated at 10.2 years. The mean annual growth rate is estimated at 6.3%. Mortality, based on the revised method of Laws (1966), occurs at a mean annual rate of 9.2%. Consideration is given to the possibility that the discrepancy between the age structure, the mortality rate and the annual growth rate is a combination of the artefact of the techniques used and undocumented immigrations from Chad. It is recommended that further research be conducted on elephant age structures, and mortality and growth rates, for a better understanding of elephant population dynamics and sustainable control of elephant numbers in the region.

Introduction

In the last 25 years, the Waza National Park's management objective has been to reduce poaching and increase wildlife numbers. This goal has been relatively met. The elephant population has almost doubled since 1977 (Tchamba, 1993), resulting in increased pressure on the natural vegetation (Okula & Sise, 1986; Steehouwer & Kouahou, 1988) and growing conflict between humans and elephants (Thouless & Tchamba, 1992). The elephant management problem has been reversed from an attempt to increase the population size to one of controlling elephant numbers. This situation provides an interesting context in which to examine the dynamics of an elephant population which may now decline following increased shooting for crop protection. There are strong political and social pressures on the wildlife authorities to reduce elephant numbers through the development of a culling scheme. The alternative of professional hunting is also considered in order to generate revenues for damage compensation and elephant management.

The present study has been initiated in the hope that the information gathered will be utilized to resolve the 'elephant problems' in the region. The main objective is to determine age and sex structure, growth and mortality rates of the population, in order to formulate alternative management and conservation strategies.

Methods

The present study, carried out from January 1992 to February 1993, includes both the dry and wet seasons in the study period. Every three days, elephants were located during patrols carried out by car from 0700 to 1100 h and from 1430 to 1730 h local time. Data were also collected in Kalamaloué National Park, a dry season habitat for part of the Waza elephants. For every group encountered, date, time, location, vegetation type at the location, size, sex-composition, and family structure, were noted. In order to reduce multiple recording of the population structure of the same group and to avoid a biased sample of cow/calf groupings an elephant recognition file, initiated in 1991 and frequently updated for births and deaths, was used to recognize 21 family units, comprising 207 members in total and 17 adult males excluded from these family units. Therefore, the number of individuals that were most probably measured only once could be estimated at 224 individuals, which represents about half the number of elephants measured (451 animals).

Information on the ages of the individual elephants was estimated using the equation describing the relationship between shoulder height (asymptotic height) and age, given by Laws *et al.* (1975) and Jachmann (1986). Laws *et al.* dealt with the differences between males and females by fitting a different equation for males above twenty years because after that age, the male seems to have a second spurt of growth. The shoulder height was obtained using the simple pole-method (Douglas-Hamilton, 1972). In this method the lateral view of the elephant is photographed and at exactly the same place a second photograph is taken from the same angle, of a measuring pole. By comparison of these two photographs which are on the same scale, the shoulder height of the elephant can be obtained.

For the smaller family units the interval between surviving calves was calculated by taking the mean of the age intervals of the calves that accompanied the cow and subtracting a gestation period of 22 months. The approximate age at sexual maturity was estimated by subtracting the age of the oldest calf from the age of the mother.

Finally, 57 lower jaws (collected by the Park's Conservator, the Centre for Environmental Science and Development in Cameroon and the Tourism Department over the past 4 years or found during the study) were aged according to Laws (1966). During an elephant's lifetime, in each quadrant, six molars develop of which no more than two molars are in wear in one time. Laws' method of ageing dead elephants is based on the stage of molar progression and uses thirty more or less arbitrarily assigned age classes, each with a specific diagram of tooth eruption and wear. Age estimates derived from jaws were then subdivided into age classes and plotted as a survivorship curve. Mortality rates were calculated indirectly by considering the sampled lower jaws as an imaginary elephant cohort (Caughley, 1977).

The rate of increase of the Waza elephant population was calculated with the following equation (Caughley, 1977):

$$N_t = N_0 e^{rt}$$

where N = number of animals, t = time, r = rate of increase.

Results

Age structure of the population

Four hundred and fifty-one out of a population of 1,100 elephants were measured (41% of the population). Fig. 2.8 shows the age structure of elephants in Waza National Park in 1992, expressed as percentages of age classes in the total sample. The elephant population consists of individuals mainly over 10 years. Calves (less than one year old) represent 14% of the sample population.

Mean calving interval, age at attaining of sexual maturity and sex ratios

The mean calving interval was estimated as 3.1 ± 0.6 years, while the mean age at first conception was estimated as 10.2 ± 1.9 years. Assuming the age at sexual maturity to be 10 years, the male:female ratio for immature elephants was 1:0.8, whereas in mature elephants it was 1:1.4. The percentage of immature elephants was estimated at 46.8%. With an elephant population of approximately 1071 animals, there are estimated to be approximately 332 mature females in the population. If the mean rate of reproduction for these females is one calf per 3.1 years, the recruitment rate is 110 calves per year or 10.0% per year.

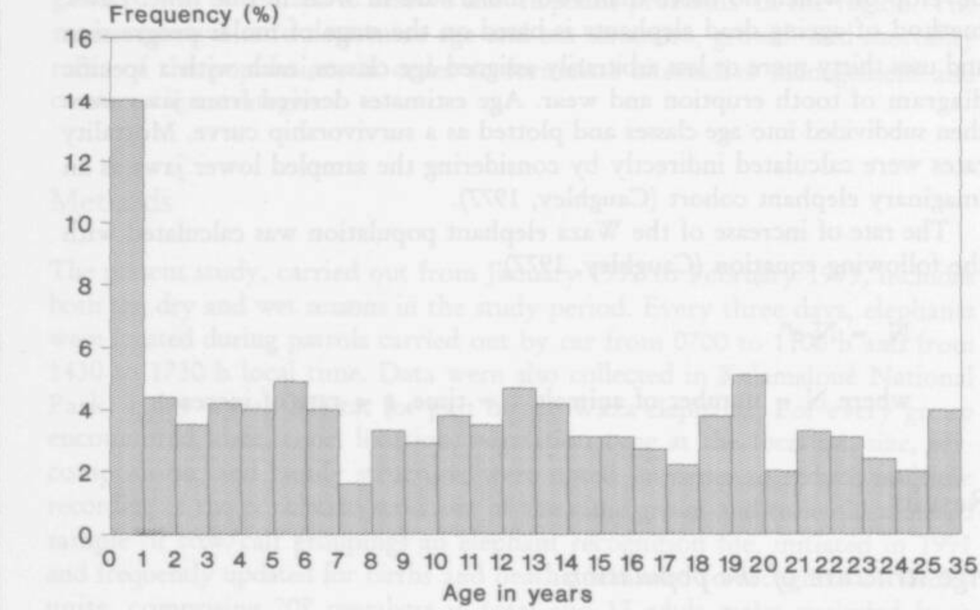

Figure 2.8
The age structure of the Waza elephants during the 1992 survey (n = 451)

Mortality and growth rates

The ages of 57 jaws of both sexes were estimated. In Fig. 2.9 the natural logarithms of the number of survivors have been plotted against age to produce a survivorship curve. The slope of the successive age classes are shown in Table 2.4. Overall mean mortality, calculated from the survival curve, is 9.2% per annum.

Esser and van Lavieren (1979) estimated the Waza elephant population as 465 individuals in 1977, and in 1991 it was estimated at 1,071 individuals (chapter 2.2). The mean annual rate of the elephant population growth between 1977 and 1991 has been approximately 5.9%.

Table 2.4

Annual mortality per age class calculated from the survivorship curve

Age class (years)	Slope
0	-
0-5	0
5-10	- 0.02
10-15	- 0.02
15-20	- 0.04
20-25	- 0.06
25-30	- 0.10
30-35	- 0.12
35-40	- 0.10
40-45	- 0.24
45-50	- 0.22
Mean mortality rate	9.2%

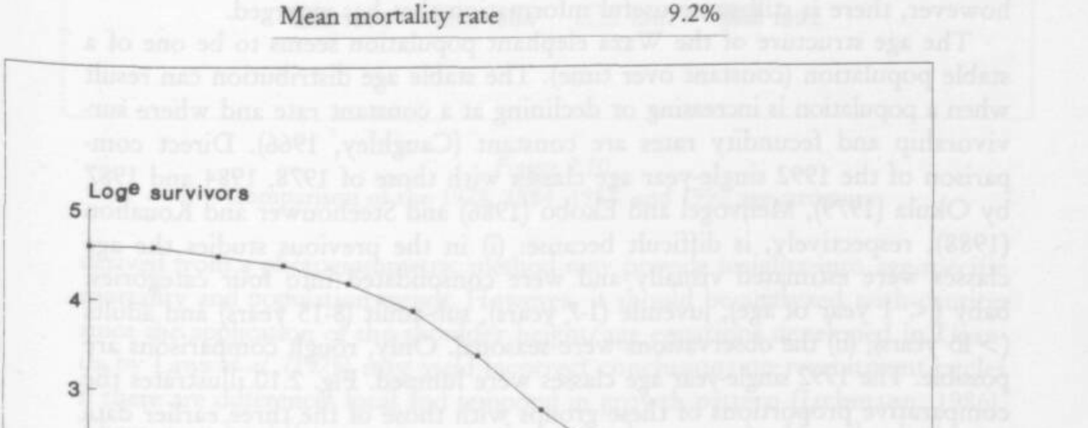

Figure 2.9

Survival curve for the Waza elephant

Discussion

As with other studies, the examination of age and sex structure, growth and mortality rates of elephants in Waza National Park have not been entirely satisfactory as there are limitations with these kinds of data. The major limitations with these kinds of data. The major limitations during this study were that:

1. It was likely that about half of the total sample of 451 elephants was measured more than once, producing biased results. Most likely this bias was, if not randomly distributed among age-classes, more towards older age classes, since the latter were more easy to recognise as individuals;
2. Survivorship curves were constructed using collections of found jaws, ageing each using Laws' method (Laws, 1966), and developing from each of these data the frequency-distribution of ages. This method is known to be incorrect for some age classes and give artificial peaks and troughs in age-distribution curves for populations (Jachmann, 1985).

Given these two shortcomings and in the absence of any better data sets, however, there is still some useful information that has emerged.

The age structure of the Waza elephant population seems to be one of a stable population (constant over time). The stable age distribution can result when a population is increasing or declining at a constant rate and where survivorship and fecundity rates are constant (Caughley, 1966). Direct comparison of the 1992 single-year age classes with those of 1978, 1984 and 1987 by Okula (1979), Meijvogel and Ekobo (1986) and Steehouwer and Kouahou (1988), respectively, is difficult because: (i) in the previous studies the age classes were estimated visually and were consolidated into four categories: baby (< 1 year of age), juvenile (1-7 years), sub-adult (8-15 years) and adults (> 15 years); (ii) the observations were seasonal. Only, rough comparisons are possible. The 1992 single-year age classes were lumped. Fig. 2.10 illustrates the comparative proportions of these groups with those of the three earlier data sets. It shows that probably, there have not been considerable changes in the age structure among Waza elephants over the past 14 years. In 1992 there was a slight relative increase of juveniles and sub-adults and a small decline in the number of adult animals. These changes may be attributed to an increase in professional hunting of elephants around Waza National Park and the increase in elephant shooting to control crop damage over the past 4 years (10 to 20 elephants killed per year). It may also be an artefact of the various techniques used to obtain data on age structure.

Comparison of the age structure of the Waza elephants with that of the Kasungu elephants (Malawi) (Jachmann, 1986), both derived from a photogrammetric method, indicates that the Kasungu elephants are younger and that this population is expanding faster. Information supplied by the age structure

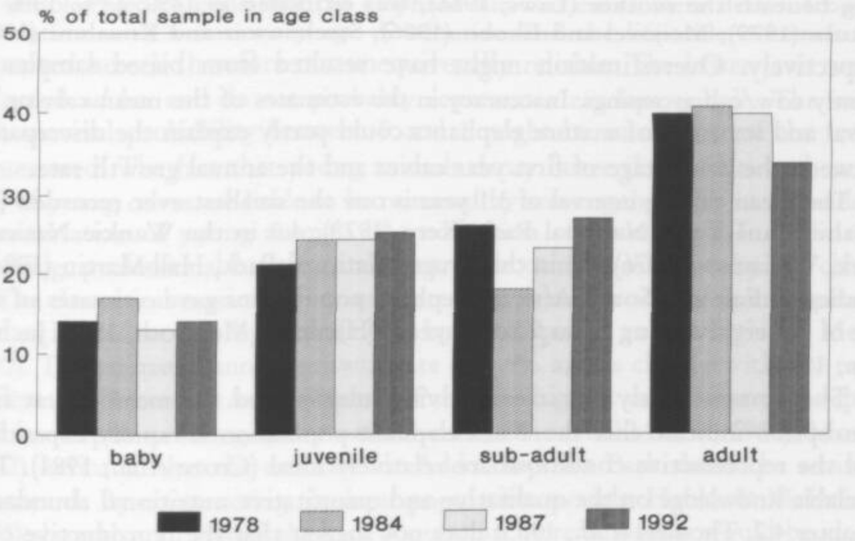

Figure 2.10
Comparison of the 1978, 1984, 1987, and 1992 age structure

derived from a photogrammetric method may provide insights into age-specific mortality and population trends. However, it should be analyzed with caution since the application of the shoulder height/age equations developed in Uganda by Laws *et al.* (1975) may yield incorrect conclusions on recruitment cycles if there are differences local and temporal in growth pattern (Jachmann, 1986). There may be differences in growth pattern between the Uganda elephants, the Kasungu elephants and the Waza elephants, resulting from the difference in the genetic background in relation to the dominating vegetation-type and nutritional abundance. The static character of the population suggested by the age structure presented in Fig. 2.8 may be exaggerated.

Calef (1988) indicated that a population sample showing more than 6.8% calves should be viewed with suspicion unless it is a rapidly increasing population. The age structure of the Waza elephants does not indicate that the population is expanding. It could be that the elephant population has been subjected to high adult mortality. However, at present, this is not the case for Waza park. It is possible that the number of calves was overestimated, some 1-2 year olds being included with less than 1 year olds. This error may result from the estimation of the actual scapula height. No information is available on the error in the growth equations used in the relevant literature. The percentage of first year calves estimated by counting all those capable of passing beneath the mother (Laws, 1966), was estimated as 14%, 17%, 13% by Okula (1979), Meijovel and Ekobo (1986), Steehouwer and Kouahou (1988) respectively. Overestimation might have resulted from biased samples of mostly cow/calf groupings. Inaccuracy in the estimates of the mean calving interval and sex ratio of mature elephants could partly explain the discrepancy between the percentage of first year calves and the annual growth rate.

The mean calving interval of 3.1 year is one the smallest ever recorded (3.5 in the Mana Pools National Park, Kerr (1978); 4.3 in the Wankie National Park, Williamson (1976); 4.5 in the Kruger National Park, Hall-Martin (1984)). Studies on East and South African elephant populations gave estimates of the age of puberty varying from 9 to 22 years (Hanks & McIntosh, 1973; Jachmann, 1986).

The comparatively low mean calving interval and the mean age at first conception indicate that the Waza elephant population is rapidly expanding and the reproductive conditions are relatively ideal (Croze *et al.*, 1981). The available knowledge on the qualitative and quantitative nutritional abundance (chapter 4.2, Thouless *et al.*, 1995) does not suggest that the reproductive conditions are exceptionally ideal in Waza National Park. These two reproduction indices must therefore be considered very rough approximations because calf mortality and adoption influence the estimates (Jachmann, 1980). The age structure of the Waza elephant population indicates that there are more than twice as many individuals below the age of one year than individuals between one and two years old. This suggests a high calf mortality, a possible explanation for the short calf interval. In addition, the estimate of the mean age at first conception would be biased if the bull calf of one of the oldest females reached the puberty and left the family unit before the survey (Jachmann, 1986). Available knowledge on the social organization and behaviour of the Waza elephants is insufficient to confirm at what age the bulls leave the family unit.

The sex ratio in favour of females in mature elephants may be because mostly males have been killed by professional hunters as well as during crop damage control operations.

The determination of the reproductive parameters to be used in constructing elephant population models presents less problems than the selection of realistic mortality schedules (Hanks & McIntosh, 1973). The frequency of ages at death can provide life-table information and hence survivorship curves, but only when they are drawn from a population with a stationary age distribution (Caughley, 1966). The stationary age distribution is a special case of the stable age distribution. It results when a population does not change in size and where the age structure of the population is constant with time. The estimated mortality rate of 9.2% is higher than the mean mortality rate of the Kasungu National Park (Malawi) elephant population, estimated in three different ways (8.2 ± 0.7% per year) (Jachmann, 1986). There is no evidence that the samples used to construct the elephant survival curve were drawn from a population with a stationary age distribution and the life-table information presented here is therefore not unequivocally reliable. The lower jaws were collected *ad hoc* and do not probably represent a random sample. The very high survival probability between 0 and 1 might be an artefact of the techniques used. The fact that young animals decay faster than adults and small jaws of young calves are liable to be removed by scavengers result in an under-representation of young animals in a collection of found jaws. In addition, poaching, professional hunting and control shooting is selective by age class.

The theoretical maximum intrinsic rate of increase for the African elephant was estimated at 7% by Calef(1988) but is disputed as too high by Moss (1992). The estimated annual growth rate of 5.9% agrees closely with the rate of increase observed at Addo Elephant Park, the highest rate of increase reported for elephants living under natural conditions (Hall-Martin, 1980). Moss (1992) indicated that the estimate for Addo Elephant Park should be revised downward. By constructing elephant population models, Hanks & McIntosh (1973) show that an annual elephant population increase of 4% would be close to the maximum rate of increase that an elephant population could be expected to attain under 'ideal' biological conditions. It is possible that Esser & van Lavieren (1979) underestimated the elephant population if they missed the sub-population which migrates seasonally to Kalamaloué National Park. In that case the annual growth rate of 5.9% would be overestimated. If one third of the Waza elephant population migrates to Kalamaloué during the dry season (Mahamat, 1991), then Esser and van Lavieren (1979) could have missed about 155 individuals and the 1977 elephant population would have been approximately 620 individuals. The annual growth rate between 1977 and 1991 then would be 3.9%, a more realistic figure.

Still, the comparison between the mortality rate (9.2%) and the recruitment rate (10%) results only in a net annual increment of approximately 1%. This would be in agreement with a static population as suggested by the age structure presented in Fig. 2.8. The discrepancies between the age structure, the reproductive parameters and the annual growth rate might stem from:

(i) A sampling bias in the estimation of the reproductive parameters;
(ii) An underestimation of the 1977 elephant population; and, furthermore,
(iii) An undocumented immigration of elephants from Chad.

Flizot (1969) and Fry (1970) noted that most of the Waza elephant population increase between 1961 and 1969 was due to immigration from Chad, resulting from disturbances there. It is alleged that in the 80's the Waza elephants which migrated seasonally to Kalamaloué National Park (Tchamba *et al.*, 1994) came into contact with Chadian elephants around Lake Chad, and that they usually returned to Waza in greater numbers (Badjoda Daouda, Former Conservator, Pers. comm.). Although the scale of the immigration from Chad can not be established, it is likely that the increase in the Waza elephant population between 1977 and 1991 can not soly be explained by natural recruitment.

Conclusions

We can infer from the age structures, the mortality and recruitment rates that the Waza elephant population is static. The results of this study are somewhat limited by the techniques used. For another, the immigration factor remains largely unquantified, as do the information on elephant carcass disappearance and decay processes. However, some useful information has emerged, suggesting that the elephant population size should be continually monitored.

It is not likely that the Waza National Park and its surroundings will sustain a continued elephant population growth whether this is due to immigration from Chad or to natural recruitment. It must be expected that, in the long run, there will be density-dependent effects of food supply on reproduction, and consequently a reduction of the annual growth rate. Before that happens, however, the elephant damage to the natural vegetation may be very serious, as will be the human/elephant conflict.

Tchamba and Mahamat (1992) noted that elephant damage to the vegetation in Kalamaloué National Park, was serious enough to warrant management intervention. Tchamba (1995) indicated that the number of *Acacia seyal* trees killed by elephants in Waza National Park doubled in 15 years. If this trend continues, elephants might have considerable effects on the woodland dynamics and structure in future.

The annual human population growth rate in the Waza-Logone region is estimated as 3.7% (MINPAT, 1990). As human population increases rapidly and consequently agricultural lands are expanded, the pressure on Waza and Kalamaloué National Parks will mount. It can be expected that the human/elephant conflict will escalate in future years, unless an overall policy and management plan integrating both people and elephants is developed in the region. Tchamba (1996) noted that an increasing number of elephants were expanding crop damage to areas where no damage had occurred previously. In 1993, total crop damages in the Waza-Logone region were estimated at more than US$ 767,000 and the elephants responsible for this mainly came from the Waza population (MINAGRI, 1993).

In 1968, wildlife authorities decided to limit elephant numbers in the immediate vicinity of Waza by killing 62 elephants in 1969 and 80 elephants in 1970 (Flizot, 1969). They expected that an annual offtake of this order repeated for several years would limit elephant numbers sufficiently. However, a scheme of this nature (13% offtake) is unsustainable and would probably exterminate the Waza population. It is more likely that the future policy will aim at reversing the trends in woodland deterioration and at reducing human-elephant conflicts by controlling elephant populations. The present hunting quota of 10 elephants per year and the control shooting of about 10 elephants per year (2% offtake) may well be kept up without seriously impacting the elephant population if poaching remains at low level and if a severe drought does not occur. Estimating sustainable hunting quota and culling limits would be unjustified without the backup of further research to investigate and attempt to understand the elephant population dynamics in Waza National Park. Finally, it is recommended that with or without intervention, periodic monitoring of elephant age structures, mortality and recruitment rates, as well as their numbers, distribution and migration patterns, and the human activities around Waza be carried out.

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2.4

Some Observations on the Movements and Home Range of Elephants in Waza National Park, Cameroon

Summary

The movement patterns and home range of elephants in the Waza National Park are discussed. Home range size varied from 785 to 2534 km². One elephant moved up to 80 km away from Waza N.P., towards Kalamaloué National Park. The second elephant stayed in Waza N.P. throughout the study period. This study supports the hypothesis that the Waza elephant population is divided into at least two sub-populations or clans: the resident sub-population and the northern sub-population which migrates between Kalamaloué and Waza N.P.

Introduction

In historical times, Waza National Park was devoid of elephants until 1947 when the first groups crossed the Logone River from Chad, stopped in Kalamaloué and later on travelled to Waza where they took up residence (Flizot, 1948). Since then their numbers have grown steadily due to not only natural growth but also subsequent immigration from Chad and Nigeria (Flizot, 1968).

Tchamba (1993) hypothesized that there are three elephant sub-populations in Waza Park. The first sub-population resides in the northern part of the park and migrates to Kalamaloué National Park at the beginning of the dry season (December-January). They return at the beginning of the wet season (May-June). Tchamba & Mahamat (1992) noted that the prolonged stay of an increased number of elephants in Kalamaloué was causing considerable damages to the natural vegetation. The second sub-population resides year-round inside Waza Park. The third sub-population uses the central and southern part of the park and spills out to the south of the park at the onset of the rains (June-July). They cause extensive damages to crops throughout the wet season and return to Waza only in November-December. Tchamba's (1993) conclusions were based on extensive ground surveys by reference to visually identifiable animals and on enquiries in the villages of the region.

To allow the coexistence of agricultural development and elephant conservation in the Waza region a good understanding of elephant movements and home ranges is required. The purpose of the present study was to use telemetry to confirm or revise the hypotheses of Tchamba (1993) and to estimate elephant home ranges for this area.

The study area has been described in Chapter 1.2. A detailed description of the vegetation is given by Wit (1975) and Esser & Van Lavieren (1979). Details on wildlife are found in Vanpraet (1977).

Methods

Two elephant cows from seperate herds were fitted with transmitter-collars in January 1993. The first elephant cow (No. 1) was collared with a combination VHF radio-transmitter and UHF satellite-transmitter and the second cow (No. 2) with only a VHF radio-transmitter both produced by Telonics, Arizona, USA. The satellite-transmitter was pre-programmed to transmit on a 24 h-on/72 h-off duty-cycle to extend battery-life. Satellite-transmitter components were within the specifications set by CLS Argos, Toulouse, France (Argos, 1987). The satellites NOAA-11 and -12, managed jointly by space-agencies in the USA and France were operational during this study. Full technical details for position-finding and data-acquisition are discussed by Argos (1987) and Fancy *et al.* (1988).

Radio-tracking was done with a Telonics TR-4 receiver attached to a hand-held yagi-antenna. Bearings were taken on ground-level and from elevated points in the Park. When a signal was detected, the tagged animal was approached and its position was determined with a GPS (Geographical Positioning System, Garmin GPS-50). On 38 occasions (Table 1) cow No. 2 was located by means of 'triangulation', calculating its position from the bearings taken at three or more places (with known coordinates). The range of the VHF-transmitter was approximately 20km for bearings taken at 200m above groundlevel. Such heights could only be reached on the hills near the entrance of the Park. In the field the highest points were the roof of the car or the artificial sand-heaps abutting some water-holes. This resulted in a reduced signal-range of about ten km. In addition to this, after the start of the rainy season (end of April) the accessibility of the Park decreased rapidly, and by July only about 30% could still be visited.

Home-range was estimated by drawing the minimum area convex polygon which encompassed all location data of that elephant (White & Garrott, 1990; Dunham, 1986) for the period January to August 1993.

Results

Table 2.5 presents the home ranges for both collared cows. Figs 2.11 and 2.12 show the locations and shapes of this home ranges. The two home ranges were different in location and shape. Cow No. 1 had a larger home range than cow No. 2 (2534 km² and 785 km² respectively). Cow No. 2 stayed inside the park or in its vicinity throughout the study period. From March 8 to April 22, cow No. 1 made a long-distance movement of about 80 km towards Kalamaloué National Park. She stayed in the vicinity of Kalamaloué for 40 days, then returned to Waza National Park.

Table 2.5

Estimated home ranges (km²) for two collared elephant cows in Waza National Park (January-August 1993)

Elephant No.	Number of locations				Home range (km²)
	Satellite	VHF	Visual	Total	
1	309	0	12	321	2534
2	0	38	14	52	785

Discussion

A disadvantage of the minimum area convex polygon method of estimating home ranges is that the estimate is dependent upon sample size (Don, 1983). Although the set of data for cow No. 1 (satellite-tracked) was bigger than the one for cow No. 2 (VHF-tracked), the difference in home range size was not due to the difference in sample size (321 for cow No. 1 and 52 for cow No. 2). The trip to the Kalamaloué area of cow No. 1 increased considerably its home range. The home range of cow No. 1 excluding the excursion towards Kalamaloué National Park was estimated at 930 km². Cow No. 2 was observed inside the Waza National Park and her position was assessed when cow No. 1 was moving northward.

The long-distance movement of cow No. 1 followed the migration route of a northern sub-population described by Tchamba (1993). However, the timing was not as predicted. Cow No. 1 migrated to the north in March instead of December as predicted by Tchamba (1993). Anomalous timing might have been caused by human disturbances. In January 1993, a herd of about 300 elephants that had migrated to Kalamaloué were chased out of the park by local farmers. Consequently, Kalamaloué elephants resided in the area south of the Park until April. Kalamaloué National Park seems to be losing its function as dry season refuge for part of the Waza elephants. This is not only due to the negative

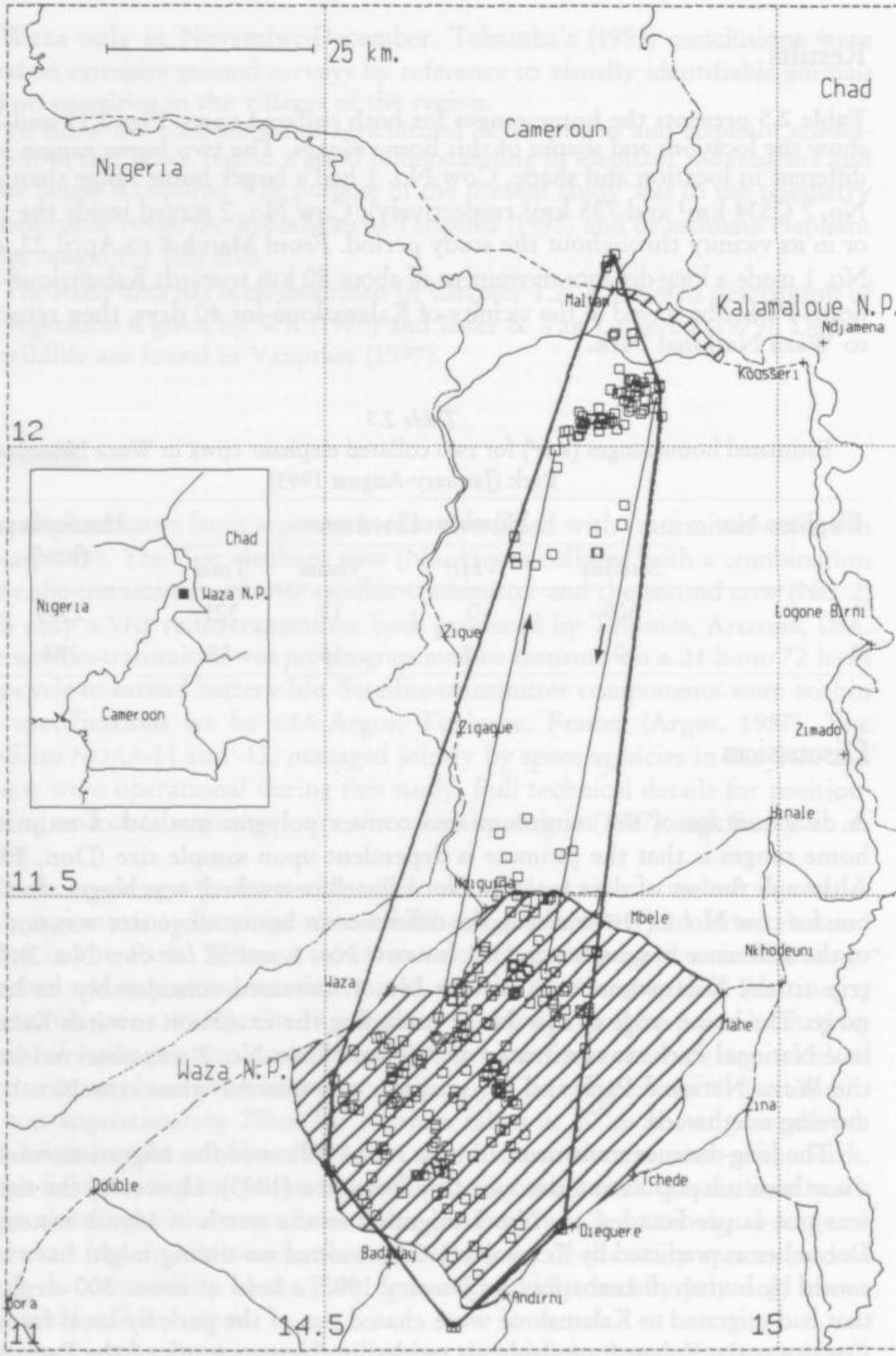

Figure 2.11

Satellite locations of elephant No. 1 ( ), her migration to (↑) and from (↓) Kalamaloué National Park and her home range (minimum convex polygon)

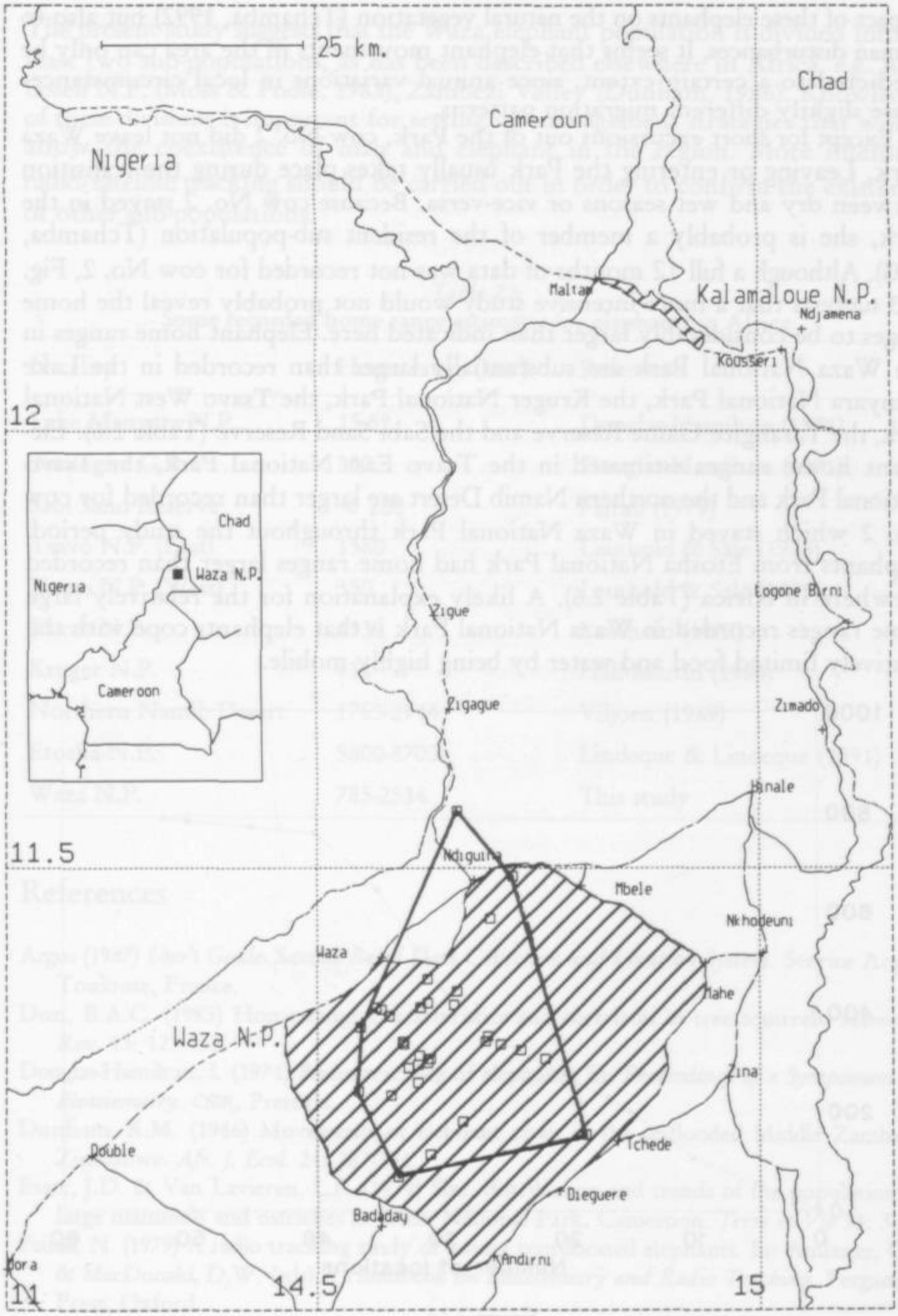

Figure 2.12
Radio locations of elephant No. 2 ( ), and her home range
(minimum convex polygon)

impact of these elephants on the natural vegetation (Tchamba, 1992) but also to human disturbances. It seems that elephant movements in the area can only be predicted to a certain extent, since annual variations in local circumstances cause slightly different migration patterns.

Except for short excursions out of the Park, cow No. 2 did not leave Waza Park. Leaving or entering the Park usually takes place during the transition between dry and wet seasons or vice-versa. Because cow No. 2 stayed in the Park, she is probably a member of the resident sub-population (Tchamba, 1993). Although a full 12 months of data was not recorded for cow No. 2, Fig. 2.13 suggests that a more intensive study would not probably reveal the home ranges to be considerably larger than indicated here. Elephant home ranges in the Waza National Park are substantially larger than recorded in the Lake Manyara National Park, the Kruger National Park, the Tsavo West National Park, the Tarangire Game Reserve and the Sabi Sand Reserve (Table 2.6). Elephant home ranges estimated in the Tsavo East National Park, the Tsavo National Park and the northern Namib Desert are larger than recorded for cow No. 2 which stayed in Waza National Park throughout the study period. Elephants from Etosha National Park had home ranges larger than recorded elsewhere in Africa (Table 2.6). A likely explanation for the relatively large home ranges recorded in Waza National Park is that elephants cope with the relatively limited food and water by being highly mobile.

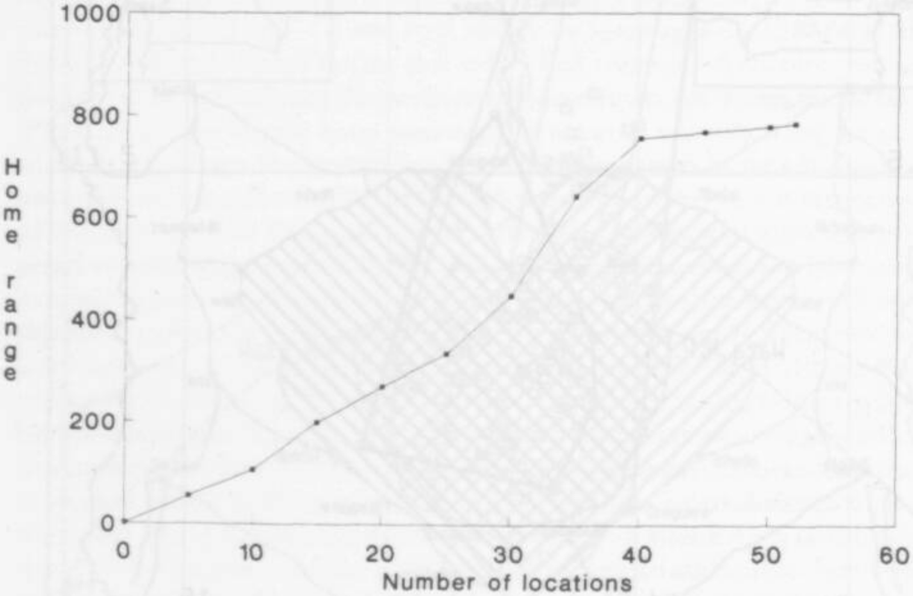

Figure 2.13

Curve of home range (km^2) versus number of locations for elephant cow No. 2 in Waza National Park

The present study suggests that the Waza elephant population is divided into at least two sub-populations, as has been described elsewhere in Africa, *e.g.* Amboseli N.P. (Moss & Poole, 1983), Zambezi Valley (Dunham, 1986). Knowledge of these divisions is important for setting up management strategies that would allow the coexistence of man and elephant in the region. More intensive radio/satellite tracking should be carried out in order to confirm the existence of other sub-populations.

Table 2.6
Some recorded home range estimates for elephants in Africa

Locality	Home range (km^2)	Reference
Lake Manyara N.P.	15-52	Douglas-Hamilton (1971)
Tarangire G.R.	330	Douglas-Hamilton (1971)
Sabi Sand Reserve	< 200	Fairall (1979)
Tsavo N.P. (East)	1580	Leuthold & Sale (1973)
Tsavo N.P. (West)	350	Leuthold & Sale (1973)
Tsavo N.P.	1532	Leuthold (1977)
Kruger N.P.	436	Hall-Martin (1984)
Northern Namib Desert	1763-2944	Viljoen (1989)
Etosha N.P.	5800-8700	Lindeque & Lindeque (1991)
Waza N.P.	785-2534	This study

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2.5

Application of VHF-radio and Satellite Telemetry Techniques on Elephants in Waza National Park, Cameroon

Summary

Two young adult elephant cows, belonging to the population of the Waza National Park in northern Cameroon were tracked for twenty-one and ten months respectively, using collars with VHF-radio and satellite transmitters. One cow used mainly the central and northwestern parts of the park, but migrated as far as 80 km north of the park during the dry season. The other cow used mainly the southeastern parts of the park, but migrated as far as 100 km south of the park in the wet season. Home ranges (Minimum Convex Polygon) were 3066 and 2484 km^2, respectively. Movement and activity patterns are discussed in relation to local conditions.

Introduction

VHF-radio telemetry has been used in several parts of Africa for studying elephants (*Loxodonta africana*, Blumenbach 1797) (Douglas-Hamilton, 1971; Fairall, 1980; Western & Lindsay, 1984). Satellite telemetry has been used in a wide range of wildlife studies (Fancy *et al.*, 1988; Keating, Brewster & Key, 1991), it has been applied in research on elephants since 1987 (Lindeque & Lindeque, 1991). The methodology and equipment involved in telemetry have continued to evolve. Telemetry and other techniques have revealed elephant home ranges (Minimum Convex Polygon) ranging from under 200 to 10,738 km^2 (Douglas-Hamilton, 1973; Fairall, 1980; Viljoen, 1989; Lindeque & Lindeque, 1991).

The elephants in Waza National Park are known to migrate out of the park, causing damage to croplands (Tchamba, 1993). Tchamba (1993) hypothesized three sub-populations within the elephant population: one resident, one migrating north in the dry season and one migrating south in the rainy season. This division into sub-populations was partly validated by previously published telemetry data (Tchamba *et al.*, 1994). The aim of this chapter is to present the results of nearly two years of radio and satellite tracking of elephants in Northern Cameroon and to verify preliminary findings on elephant movements in the area.

The study area has been described in Chapter 1.2. Details on the vegetation and wildlife of Waza National Park are found in Wit (1975) and Vanpraet (1977), respectively.

Materials and methods

Equipment

Two collars were used in this study, both with a ST-3 Platform Transmitter Terminal (PTT) for satellite transmission and a VHF transmitter (purchased from Telonics, Mesa, Arizona, USA). The two PTT's had different identification numbers and identifier signals and the VHF transmitters were transmitting on different frequencies. The collars were of four layered black plastic belting, secured with eight bolts. VHF and PTT transmitter boxes and dipole antennas were sandwiched between the belting layers on opposite sides of the collar. Extra weight was incorporated in the VHF transmitter box, to ensure that the opposite side of the collar, with the PTT transmitter box, would be on top for improved transmission. The transmitters in the first collar were in operation from January 1993 to 24 October 1994, when the battery ran down. The transmitters in the second collar have been in operation since January 1994. All data obtained before the end of October 1994 are included in this article.

The PTT's used a frequency of 401.650 MHz with a 24/72 hour on/off duty schedule to extend battery life; one 24 h on-duty period will be referred to as one 'cycle'. A mercury switch was incorporated in the PTT to register activity. Short-term activity is defined as the number of seconds in motion during the preceding 60 seconds, long-term activity as the number of seconds in motion during the preceding 24 hours divided by a scaling factor of 85.

The VHF transmitters were continually transmitting a 15 ms pulse with 1 s intervals on the 150.458 MHz and 150.469 MHz frequencies, respectively. For reception, a Telonics TR-4 receiver was used, in combination with a three element Yagi antenna. The antenna was usually hand-held but could also be attached to a telescopic antenna pole of five m. One and five m antenna cables with 50 Ω impedance were used to connect the antenna to the receiver.

Capture

Two elephants in Waza N.P. were equipped with collars, one in January 1993 (E1) and one in January 1994 (E2). Selection was aimed at identifying sub-adult females to test the hypothesis that there are different migrating sub-populations. The selected cows were immobilised with the anaesthetic M99 (Etorphine hydrochloride) after which the collars were fitted and various body measurements were taken; the whole process lasted about 45 minutes. during this time the animals were kept cool by spraying them with water. After completing all procedures antidotes were injected and the revived animals were followed until they rejoined their herds.

VHF-radio telemetry

Triangulation and homing techniques were used to locate the VHF transmitters (Kenward, 1987). The range of the VHF transmitter was 20 km for bearings taken at 200 m above ground level, a height that was attainable only on top of the hills near the entrance of the Park. The range was reduced to about 10 km when attempting to track from a vehicle or on foot. Due to this limited range, and to the decrease in accessibility of the Park during the rainy season, VHF-radio telemetry could be used only infrequently and under favourable conditions.

Satellite telemetry

The locations of the PTT's were calculated by CLS Service Argos, Toulouse, France, when identifier signals were received by the NOAA 10 and 11 Tiros-N weather satellites. One successfully received identifier signal is called an uplink. Multiple uplinks are combined to calculate one location, based on the angle of reception. This is calculated from the Doppler shift in the PTT carrier signal frequency, caused by the speed (28,000 km/h) with which the satellites orbit at 820 km above the earth's surface (Argos, 1987; Fancy *et al.*, 1988). Data from the incorporated sensors were encoded in 16 bits and transmitted after the individual PTT identifier signal, the location and these data together form a location message. Activity sensor information was still received by the satellites on some passes when insufficient uplinks were established to calculate a location; these messages are referred to as non-location messages. The messages were available for downloading from the ARGOS computer by modem connection within six hours after the uplinks. Data were downloaded in The Netherlands because of requirements on telephone line quality and weekly updates were sent to Cameroon by fax.

Since the satellites are on a polar orbit, satellite passes are fewer near the equator, in our study area it averaged eight passes per 24 h. ARGOS divides the data into accuracy classes depending on the duration of reception and the number of uplinks. Class definition changed in June 1994, as listed in Table 2.7, where accuracy is presented as the standard deviation (σ) of the bivariate normal distribution with $\mu x = \mu y = 0$ and $\sigma x = \sigma y$. After transformation to the normal distribution circles with listed radii include about 39% of the locations (Keating, Brewster & Key, 1991).

Table 2.7

Criteria for assigning satellite telemetry accuracy classes to messages with elephant locations (Argos, 1987)

Accuracy before June 1994	Accuracy since June 1994
Class 3: ≥ 5 uplinks over ≥ 420 s, good internal consistency and geometric conditions; $\sigma = 150$ m.	New class 3: ≥ 4 uplinks, location passes at least 2 of the four plausibility tests; Argos estimates $\sigma \leq 150$ m.
Class 2: ≥ 5 uplinks over ≥ 420 s, control on frequency drift; $\sigma = 350$ m.	New class 2: same as new class 3; Argos estimates $\sigma \leq 350$ m.
Class 1: ≥ 4 uplinks over ≥ 240 s, no control on frequency drift; $\sigma = 1000$ m.	New class 1: same as new class 3; Argos estimates $\sigma \leq 1000$ m.
Class 0: < 4 uplinks and any message rejected by other classes; non-location.	New class 0: same as new class 3; Argos estimates $\sigma > 1000$ m.
	Class A: 3 uplinks, 2 plausibility tests done, frequency calculated; accuracy not estimated.
	Class B: 2 uplinks, 2 plausibility tests done, frequency not calculated; accuracy not estimated.
	Class Z: Rejected by other classes; non-location.

Locations with a quality lower than class one were excluded from calculations on home ranges, migration patterns and PTT performance. Sensor data from non-locations messages were excluded from calculations where a distinction is made between inside and outside the Park, because this distinction is based on the location.

Calculations

A spreadsheet computer program was used to calculate straight line distances between locations in subsequent messages. Distances were divided by the time in which they were bridged to give the approximate minimum speed of the elephant. This calculated speed was categorised by day and night if both locations were assessed in one category during one cycle. The two-sample t-test (Guttman, Wilks & Hunter, 1982) was used to compare calculated speed during the day with calculated speed during the night. The two-tailed Mann-Whitney U-test with 95% confidence level was used to compare the quality of the two PTT's, defined by the number of locations per cycle and the average quality, and to compare activity patterns. Minimum Convex Polygon home ranges were calculated using the McPaal computer program and mapped using the Geographical Information System IDRISI. The Minimum Convex Polygon has been used in most other studies on elephant home ranges (Lindeque & Lindeque, 1991). The polygon is determined by the extreme locations ,which makes it useful for discrimination between differently migrating populations (White & Garrott, 1990).

Results

Efficiency of the PTT's

The mean number of messages per cycle divided into accuracy classes is listed together with some biological data in Table 2.8. The PTT on E2 performed considerably better than E1 in terms of the number of locations per cycle ($U_{160/74}$ = 2.96, $P<0.01$). PTT performance did not vary in terms of accuracy, the average quality class of E1 is 1.6 and that of E2 is 1.7, but the medians are not significantly different ($U_{645/355}=1.27$, $P=0.20$).

Activity patterns

Table 2.9 lists the results of location and sensor data, categorised by day and night. The median short term activity sensor value was significantly higher during the day than it was during the night with both cows (E1: $U_{572/635}$ = 7.12, $P<0.001$; E2: $U_{281/300}$ = 5.41, $P<0.001$). Calculated speed shows a more detailed pattern: when the animals were inside the Park it was higher at daytime than at night only with E1 ($t_{291}=3.56$, $P<0.001$), with E2 it was equal (t_{147} = 0.33, P = 0.74). Outside the Park, however, for E2 calculated speed during the daytime exceeded speed during the night (t_{92} = 2.11, $P<0.05$) but was not significantly different between day and night for E1 (t_{128} = 0.28, P = 0.78).

Table 2.8

Biological information on two elephants equipped with transmitter collars and performance of satellite transmission

Elephant number	E1	E2
Name	Helias	Marie Louise II
Sex	Female	Female
Overall body length	637	646
Shoulder height	258	254
Neck circumference	236	240
Estimated age	15-20	20-35
Date of capture	25-01-1993	09-01-1994
Location of capture	Waterhole Anane 11°21'/14°37'	Waterhole Tchikam 11°45'/14°48'
Transmitter id.	03273	05352
Maximum distance from capture site (km)	98	129
Maximum distance from Waza N.P. (km)	80	97
Total minimum distance travelled (km)	2973	1451
Average calculated speed (km/h; ±sd)	0.6 (0.65)	0.76 (1.5)
Home range (km^2)	3066	2484
Tagged period (days)	633	296
Number of 24 h cycles	160	74
Mean locations per 24 h cycle (±sd)	4.6 (1.8)	6.3 (1.4)
Number of locations	741	467
Locations per accuracy class (% of total locations)		
class 3	78 (10.5%)	64 (13.7%)
class 2	242 (32.7%)	118 (25.3%)
class 1	325 (43.9%)	173 (37.0%)
new class 0[1]	50 (6.7%)	54 (11.5%)
new class A[1]	22 (3.0%)	32 (6.9%)
new class B[1]	24 (3.2%)	26 (5.6%)
Number of non-locations[2] (% of all messages)	466 (38.6%)	114 (19.6%)

[1] These locations were not included in calculations on home-range and PTT-performance.

[2] These were not included in calculations differentiating between in- and outside of the park.

Table 2.9
Summary of information from PTT's on two elephants, categorised by day and night

Elephant number	E1		E2	
	day	night	day	night
Total number locations (% of all messages)	387 (31.9%)	354 (29.2%)	246 (42.3%)	221 (38.0%)
Total number non-locations (% of all messages)	250 (20.6%)	221 (18.2%)	54 (9.3%)	60 (10.3%)
Average distance between locations (km; ±sd)	2.95 (2.6)	2.35 (2.5)	2.20 (2.0)	1.41 (1.2)
Average calculated speed (km/h; ±sd)	0.89 (0.77)	0.67 (0.62)	0.93 (2.0)	0.93 (1.0)
Sensordata (±sd):				
- Average short term activity (min^{-1})	26.9 (14.8)	20.6 (15.6)	27.8 (14.9)	21.0 (15.8)
- Range of short term activity (min^{-1})	0 - 60	0 - 60	0 - 60	0 - 60
- Average long term activity (day^{-1})	340.1 (161)	346.5 (165)	386.8 (137)	394.8 (144)
- Range of long term activity (day^{-1})	0 - 642	0 - 972	1 - 728	1 - 921

Both cows were more active in the wet season (July-October) than in the dry season (November-June) as measured by the long term activity sensor (E1: $U_{266/204} = 3.86$, $P<0.001$; E2: $U_{313/268} = 9.42$, $P<0.001$). This sensor gives higher median values with E1 than with E2 in the dry season, when E1 undertook long distance movement north, and higher values with E2 in the rainy season, when E2 undertook long distance movement south (dry season: $U_{313/266} = 3.24$, $P<0.01$; wet season: $U_{204/268} = 3.13$, $P<0.01$). Calculated speed partly supports these observations on activity: both cows had the same median calculated speed when they were inside the Park ($U_{644/353} = 1.04$, $P = 0.30$), it did not change with E1 when she was outside the park ($U_{467/174} = 0.45$, $P = 0.66$), but rose with E2 when she is outside the park ($U_{218/135} = 2.46$, $P<0.05$).

Movements

The home range polygons are shown in Figs 2.14 and 2.15, the Minimum Area Convex Polygon is 3066 km^2 for E1 and 2484 km^2 for E2. Fig. 2.16 shows the actual movement patterns. E1 undertook a northward migration in both years of PTT operation, in 1993 as far as 80 km and in 1994 up to 20 km north of the park. E2 undertook a southward migration twice in one year to as far as 97 km south of the Park in the ten months of PTT operation reported here, using identical routes.

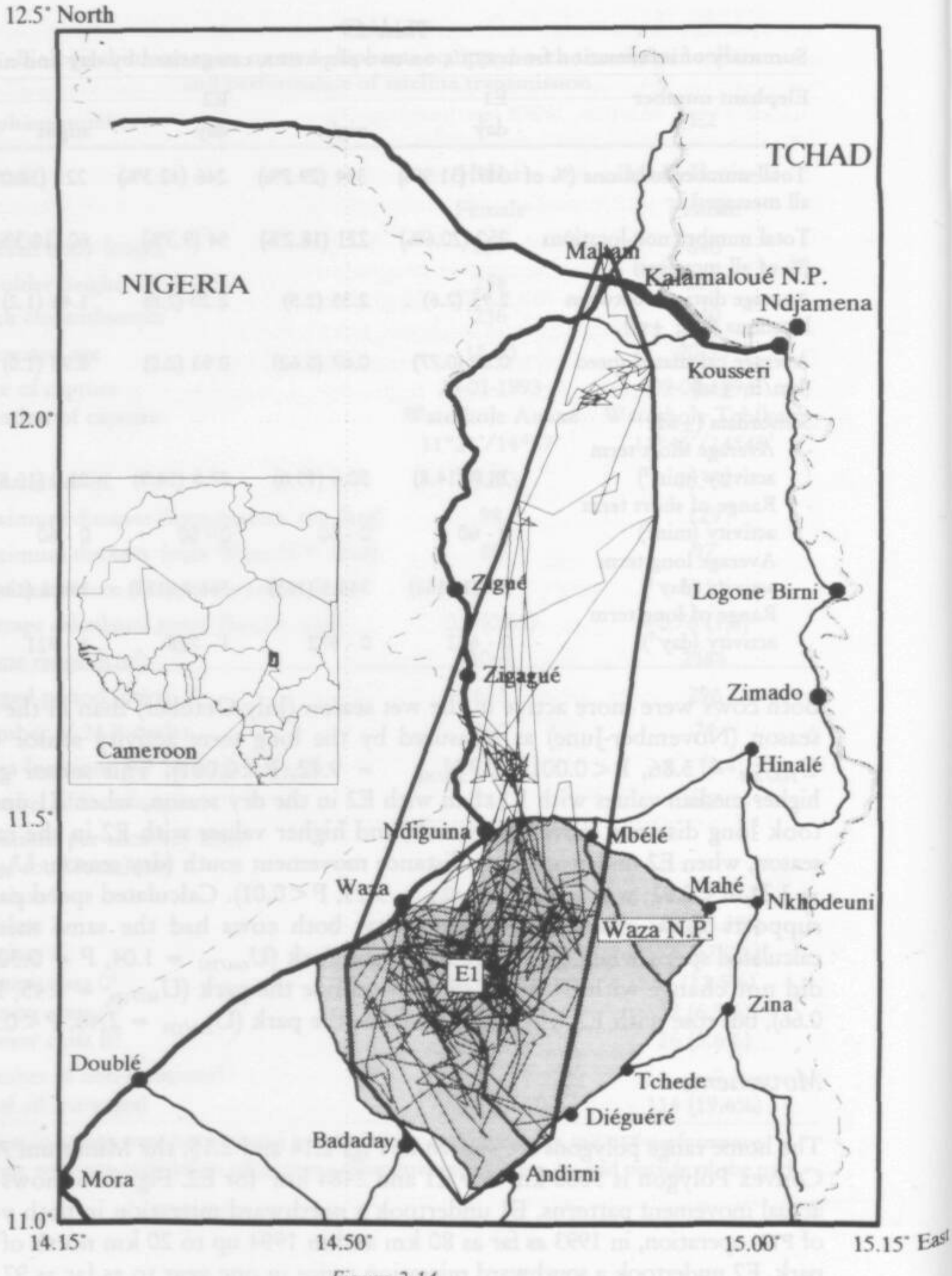

Figure 2.14

Locations of tagged elephant E1 interconnected by straight lines, fat line represents the Minimum Convex Polygon home range. Inset shows the location of the study area

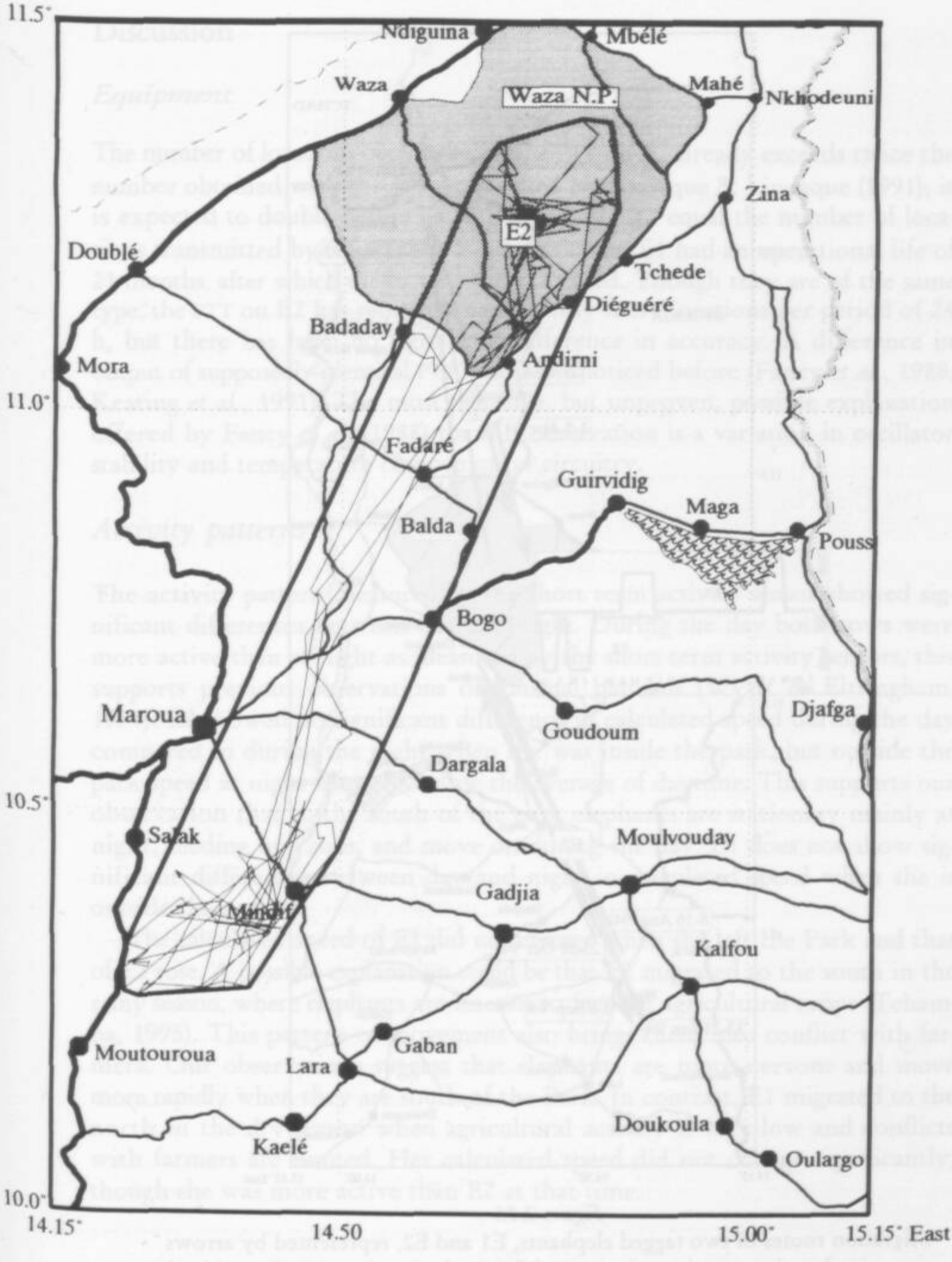

Figure 2.15

Locations of tagged elephant E2 interconnected by straight lines, fat line represents the Minimum Convex Polygon home range

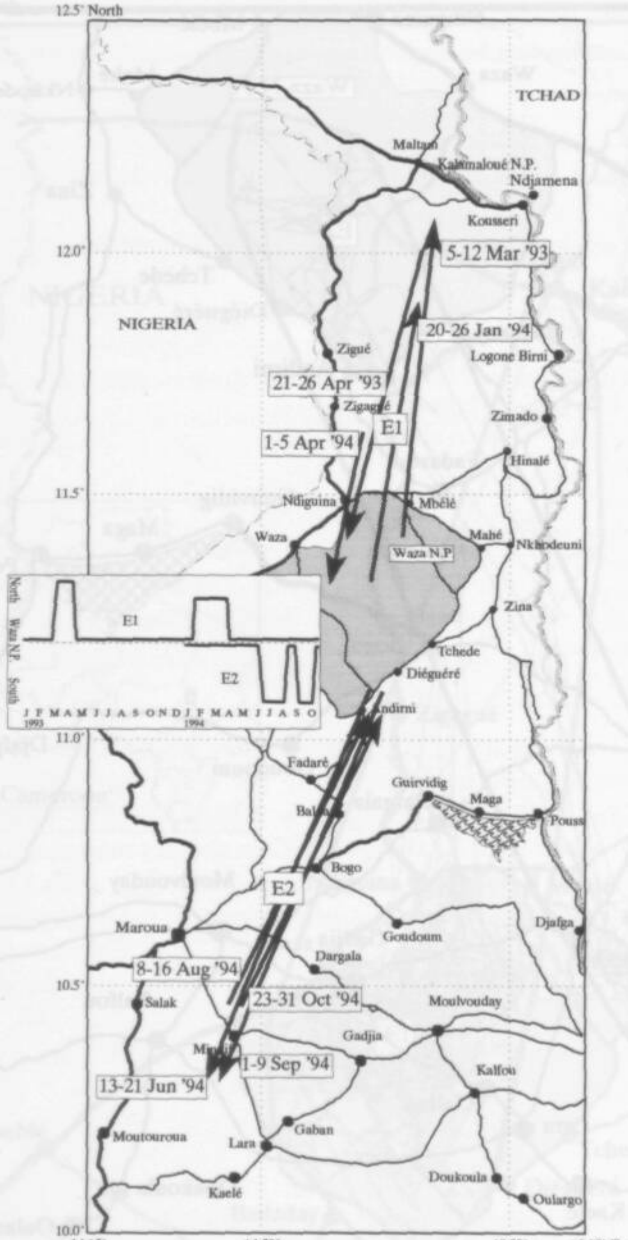

Figure 2.16

Migration routes of two tagged elephants, E1 and E2, represented by arrows connecting locations on days of start and finish of migration as indicated in the boxes. Inset shows when E1 is in or north of the park and when E2 is in or south of the park, during their respective periods of operational satellite tracking

Discussion

Equipment

The number of locations obtained with the PTT on E2 already exceeds twice the number obtained with the best collar used by Lindeque & Lindeque (1991); it is expected to double before battery exhaustion to equal the number of locations transmitted by the PTT on E1. The PTT on E1 had an operational life of 21 months, after which the battery was exhausted. Though they are of the same type, the PTT on E2 has rendered significantly more locations per period of 24 h, but there has been no significant difference in accuracy. A difference in output of supposedly identical PTT's has been noticed before (Fancy *et al.*, 1988; Keating *et al.*, 1991). The most plausible, but unproven, possible explanation offered by Fancy *et al.* (1988) for this observation is a variation in oscillator stability and temperature compensation circuitry.

Activity patterns

The activity pattern measured by the short term activity sensor showed significant differences between day and night. During the day both cows were more active than at night as measured by the short term activity sensors, this supports previous observations on diurnal patterns (Wyatt & Eltringham, 1974). E2 showed no significant difference in calculated speed during the day compared to during the night when she was inside the park, but outside the park speed at night dropped below the average of daytime. This supports our observation that to the south of the park elephants are stationary mainly at night, feeding on crops, and move on during the day. E1 does not show significant differences between day and night in calculated speed when she is outside the park.

The calculated speed of E1 did not change when she left the Park and that of E2 rose. A possible explanation could be that E2 migrated to the south in the rainy season, where elephants are known to feed on agricultural crops (Tchamba, 1995). This pattern of movement also brings them into conflict with farmers. Our observations suggest that elephants are more nervous and move more rapidly when they are south of the Park. In contrast, E1 migrated to the north in the dry season when agricultural activity is very low and conflicts with farmers are limited. Her calculated speed did not change significantly, though she was more active than E2 at that time.

Movements

A cow of the resident sub-population was studied from January through August 1993 (Tchamba *et al.*, 1994). She was reported to have a 785 km² home range, remained in the park and used almost the entire Park. In contrast, our results show that the migrating sub-populations have considerably larger home ranges (3066 and 2484 km², respectively). E1 migrated northwards at the start of both dry seasons and returned both times just before the start of the rains, she used mainly the northern and western parts of the Park (Fig. 2.14). E2 migrated southwards during the rainy season, she returned temporarily to the Park for three weeks in August, and returned again at the end of the rainy season (Fig. 2.15). When present in Waza, E2 used mainly the southern and eastern parts of the Park. These results support Tchamba's (1993) hypothesized division of the elephants in Waza National Park into sub-populations that have differentiated spatial distributions.

The routes and timing of migration of E1 were slightly different from those of a northern sub-population described by Tchamba (1993). The difference was most apparent in 1994, when her movements were limited to only twenty km north of the park. The migration routes of E2 were not different from those of a southern sub-population described by Tchamba (1993), but the temporary return to the park in September was, perhaps, unusual.

Timing and routes of migration ultimately depend on the specific circumstances at a specific time. Human interference is one of the obvious factors influencing migrational behaviour (Whyte, 1993). In January 1993 the northern sub-population was chased out of the Kalamaloué National Park by surrounding farmers, which forced the elephants to remain south of this Park. In 1994, political instability in the north was responsible for much shooting north of the line Zigague - Zimado (Fig. 2.14). Furthermore, three elephant bulls accompanying E1's herd were shot by professional hunters during the start of their northward movement in 1994. In the south, the Wildlife and Protected Areas Service killed 21 elephants during a crop damage control operation. The unexpected temporary return of E2 and the associated herd to Waza N.P. in August 1994 may well be explained by the intensive disturbance caused by shooting and killing carried out by the Wildlife and Protected Areas Service. In Kruger National Park, Whyte (1993) noted that significant elephant movements may be induced by culling.

The results of this study indicate that elephant ecology is affected by conflicts between man and elephant in the region. To the north, we observed that conflicts only arise on a limited scale with the first northward elephant movements, early in the dry season when there is still some agricultural activity (Tchamba, 1996). The limited extent of conflicts is reflected in lower calculated speed during migration. Conflicts are more serious in the south, partly because elephants move into this area in the rainy season when the area is intensively used by farmers (Tchamba, 1995). This is reflected in increased activity sensor values and calculated speed. It is strongly recommended that future actions of the Waza National Park management towards mitigation of the conflicts take the separation of the elephant population into differentiated sub-populations into account.

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Part III

Impact of Elephants on the Natural Vegetation and the Local Agriculture

The study resulted in information on habitat use of elephants inside Waza National Park

3.1

Effects of Elephant Browsing on the Vegetation in Kalamaloué National Park, Cameroon

Summary

The Kalamaloué National Park was sampled by means of line transects to assess damage to trees caused by elephants in the dry season. A total of 2602 trees was examined of which 53% were browsed (less than three-quarters browsed) and 44% were seriously browsed (three-quarters browsed or more). Most mature trees were seriously browsed (77%). Ninety-five per cent of trees in the regeneration class were browsed. Of all trees browsed the majority (57%) come from the recruitment class. It is concluded that elephant damage to vegetation is serious enough to warrant management intervention.

Introduction

The Waza-Logone floodplain of Northern Cameroon in which the Kalamaloué National Park is situated contains one of the largest elephant population of the soudano-sahelian region. The expansion of agricultural land and wood cutting activities has resulted in an apparent maldistribution of people with respect to elephant herds, and changes of elephant migration patterns. Since elephants are free to move, they migrate between Waza National Park and Kalamaloué National Park (Fig. 1.1). On the one hand farmers continually face the threat of extensive elephant crop damages, and on the other the Kalamaloué National Park is threatened by elephant overpopulation in the dry season.

As part of a larger study of the factors affecting elephant migration patterns in Northern Cameroon and the impact of these migration on the environment, the data presented here investigate the effects of elephant browsing on the vegetation of Kalamaloué National Park. Since 1986, destruction of the woody vegetation by elephant has become a cause for concern for park officials from the Ministry of Tourism. The principal objective was to determine if elephant browsing significantly interferes with the systematic progression of seedlings growing to mature trees. This information should lead to the designing of suitable management strategies.

Study Area

Kalamaloué National Park is located in Northern Cameroon (Fig. 1.1) between 12°05' N and 12°11' N and 14°49' E and 14°90' E. Founded in 1948, the park covers approximately 4,500 ha and falls into the soudano-sahelian ecological zone. Annual rainfall varies between 500 mm and 700 mm (Mahamat 1990). The hot and dry climate is characterized by one long dry season (October to May) and one short wet season (June to September). Temperature varies extremely between the December minimum of 12°C and the May maximum of 42°C.

The woody vegetation of the park is dominated by *Combretum aculeatum, Balanites aegyptiaca* and *Acacia seyal* (Mahamat 1991). Dominant trees in the alluvial valley areas are *Morelia senegalensis* and *Mitragyna inermis*. The herbaceous vegetation comprises primarily *Pennisetum purpurum* and *Imperata cylindrica*. As far as wildlife is concerned, Kalamaloué National Park is not diversified. Wildlife consists primarily of green monkeys (*Cercopithecus aethiops*), red monkeys (*Erythrocebus patas*), red fronted gazelles (*Gazella rufifrons*), Kobs (*Kobus kob*), jacals (*Canis aureus*) and elephants (*Loxodonta africana africana*). Drought, poaching and deforestation have led to the disappearance of several species among which are the waterbuck (*Kobus defassa*), the drill (*Papio leucophaeus*) and the topi (*Damaliscus korrigum*). Added to these factors, the prolonged stay of an increasing number of elephants in the park might cause the end of the park's richness (SPTEN 1986).

Methods

Ten transects of about 2 km long and 20 m wide were walked by two observers from the 10-20 April 1991, to determine the impact of elephant browsing on the vegetation. The transects were at right angles to the Maltam-Kousseri paved road which forms the southern border of the park. They were spaced 0,8 km apart.

The following size classes of trees were recognized by the observers (Okula & Size, 1986):

a. regeneration trees, < 1 m height;
b. recruitment trees ("immature trees"), 1-3 m;
c. mature trees, > 3 m.

By designating different height classes, it was possible to determine whether elephants were selecting browse according to height and if so, to assess possible effects.

Six classes of utilization were assigned:

1. no use or very light use;
2. a quarter of the tree browsed;
3. half of the tree browsed;
4. three-quarters of the tree browsed;
5. all the tree browsed; and
6. tree uprooted.

This classification was adapted from Croze (1974). The term "not browsed" refers to category (i). Trees in categories (ii) and (iii) were considered browsed, and trees in categories (iv) to (vi) were considered to be seriously browsed.

The equality of the number of trees in the three categories of utilization was determined by a Kruskal-Wallis test (Ott, 1984). The same test was used to determine significant differences in the number of trees not browsed, browsed and seriously browsed, respectively, in the three size classes of trees. A chi-square test (Ott, 1984) was used to determine whether elephants selected by height class. Tree species selection by elephant was examined by determining the percentage utilization for each species. A chi-square test was used to assess deviation of observed utilization of the recorded species (percentage utilization) from expected utilization (percentage availability) of these species.

Results and Discussion

Of the 2602 trees examined, 53% were browsed, 44% were seriously browsed and only 3% were not browsed (Table 3.1). The total sample consisted of 17% regeneration trees, 57% recruitment and 26% mature trees (Table 3.1). Of the trees that were browsed, 30% were regeneration, 60% were recruitment and 10% were mature trees. Of the seriously browsed trees, 1% was regeneration, 53% were recruitment and 46% were mature trees.

Results of browsing within height classes show that 95% of regeneration, 57% of recruitment and 20% of mature trees were browsed while 3% of regeneration, 41% of recruitment and 77% of mature trees were seriously browsed.

Killing of mature trees, together with heavy browsing of regeneration trees have created a situation where most of the trees found were in the recruitment class, with mature trees being the next most numerous (29%) and regeneration trees the least numerous (11%).

Table 3.1
Effects of elephant browsing on the vegetation of Kalamaloué National Park, Cameroon

	Regeneration	Recruitment	Mature	Total
No. of trees	438 (17%)	1484 (57%)	681 (26%)	2602
No. not browsed	9 (2%)	35 (2%)	24 (3%)	68 (3%)
No. browsed	414 (95%)	841 (57%)	133 (20%)	1388 (53%)
No. seriously browsed	15 (3%)	607 (41%)	524 (77%)	1146 (44%)

The total sample of 2602 trees consisted primarily of *Combretum aculeatum* (22%), *Acacia seyal* (21%), *Balanites aegyptiaca* (17%), *Piliostigma reticulatum* (16%) and *Bauhinia rufescens* (13%) (Table 3.2). Results of browsing within

Table 3.2
Distribution of sampled trees by height classes and by species

Species	Regeneration	Recruitment	Mature	Total
Balanites aegyptiaca	202	152	94	448 (17%)
Combretum aculeatum	66	333	166	565 (22%)
Acacia seyal	21	323	180	523 (21%)
Faidherbia albida	0	1	0	1
Mitragyna inermis	2	23	31	56
Piliostigma reticulatum	54	274	102	430 (16%)
Ziziphus mauritiana	4	81	19	104
Bauhinia rufescens	83	200	44	327 (13%)
Tamarindus indica	1	2	15	18
Guiera senegalensis	5	90	0	95
Anogeissus leicarpus	0	0	11	11
Combretum glutinosum	0	1	1	2
Diospyros mespiloformis	0	0	7	7
Crateva adansonii	0	4	11	15
Total	438	1483	681	2602

species indicate that most trees of all species were utilized. The highest percentages utilization from the total sample of trees were found for *Combretum aculeatum* (22%), *Acacia seyal* (20%), *Pilostigma reticulatum* (17%), *Balanites aegyptiaca* (16%) and *Bauhinia rufescens* (12%) (Table 3.3). These five species could be considered the most preferred foods.

From these results three observations may be made:

1. most trees were browsed;
2. of those browsed and those seriously browsed there were significantly more recruitment trees than there regeneration and mature trees ($H=24.65$ and $H=34.63$ respectively, $df=9$, $P<0.001$);
3. elephants use was selective by height class. They browsed and seriously browsed recruitment trees more than expected ($X^2=19.94$ and $X^2=30.72$ respectively, $df=2$; $P<0.001$);
4. elephants use was not selective by tree species ($X^2=9.95$, $P>0.05$; $df=6$).

Table 3.3
Distribution of sampled trees by classes of utilization and by species

Species	Classes of utilization			
	Not browsed	Browsed	Seriously browsed	Total
Balanites aegyptiaca	33 (7%)	201 (45%)	214 (48%)	448
Combretum aculeatum	3 (0%)	224 (40%)	338 (60%)	565
Acacia seyal	5 (1%)	250 (48%)	268 (51%)	523
Faidherbia albida	1	0	0	1
Mitragyna inermis	0	32	24	56
Piliostigma reticulatum	2(0%)	261 (61%)	167 (39%)	430
Ziziphus mauritiana	1	77	26	104
Bauhinia rufescens	11 (3%)	236 (72%)	80 (25%)	327
Tamarindus indica	12	4	3	18
Guiera senegalensis	0	93	2	95
Anogeissus leicarpus	0	7	4	11
Combretum glutinosum	0	2	0	2
Diospyros mespiloformis	0	0	7	7
Crateva adansonii	0	2	13	15
Total	68	1388	1146	2602

Table 3.4
Tree species selection by elephants in Kalamaloué National Park

Species	Percentage of the trees of the species used	Percentage availability from the total sample	Percentage utilization from the total sample
Balanites aegyptiaca	93	17	16
Combretum aculeatum	99	22	22
Acacia seyal	99	21	20
Faidherbia albida	0	0	0
Mitragyna inermis	100	2	2
Piliostigma reticulatum	99	16	17
Ziziphus mauritiana	99	16	4
Bauhinia rufescens	97	13	12
Tamarindus indica	39	0.7	0
Guiera senegalensis	100	4	4
Anogeissus leicarpus	100	0.4	0
Combretum glutinosum	100	0.08	0
Diospyros mespiloformis	100	0.3	0
Crateva adansonii	100	0.6	0

Conclusion

In 1986, Park officials estimated that the elephant population of Kalamaloué National Park varied from 450 to 500 individuals (SPTEN 1986). Results of waterhole counts conducted in April 1991 indicated that there were 384 elephants in Kalamaloué (Mahamat 1991). With a density of 8.5 elephants/km² this park can be considered as overpopulated. The overpopulation lasts 6 to 7 months. At the beginning of the wet season (May), elephants migrate back to Waza National Park.

Fowler & Smith (1973) noted that when elephant density was over 0.5 elephant/km² in dry savannas, the habitat could be fatally damaged. Conditions at the time of this study suggest that an 'elephant problem' in Kalamaloue National Park was significant. Data reveal large scale killing of mature trees and serious damages on the regeneration vegetation. If elephants continue to use this park on the same scale, the habitat would not remain in equilibrium, with regeneration not balancing the losses.

Beginning in 1979-1980, upstream use of the Logone River flood waters for a rice project deprived Waza National Park of its annual flooding. The reduction of the flooded area has led to the replacement of perennial grasses (*i.e Vetiveria nigritana*) major elephant flood in the dry season (Van der Zon 1986), by annual grasses which can not procedure nutritive regrowth for wildlife and cattle (Oijen & Kemdo 1986). The change in hydrological conditions has increased the number of elephants migrating from Waza National Park to Kalamaloué National Park and increased their stay in Kalamaloué (SPTEN 1986).

The high density of elephants in Kalamaloué is a seasonal phenomenon. Culling operations as suggested by park officials should be delayed until such time that adequate monitoring of the vegetation has been established and until radiotracking studies on the elephants has progressed sufficiently to support an experimental culling operation. An attempt should be made to reduce the dry season movement of elephants into the park. The Waza Logone Project is designing an operational plan for hydrological rehabilitation of the floodplain. This rehabilitation might have short-term effects on elephant numbers migrating out of Waza national Park.

An international ecological infrastructure for elephants is needed in this region. Former migration corridors to Chad should be restore and enriched. The existing corridor to Nigeria should be protected against deforestation and reclamation. The present approach is to develop an overall policy and management plan for the Northern Cameroon elephant population, one which will promote the long-term value and conservation of the elephant throughout its present range rather than just within the parks.

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3.2

The Impact of Elephants on the Vegetation in Waza National Park, Cameroon

Summary

The *Acacia seyal* zone and the woodland zone of Waza National Park were sampled by means of line transects to assess damage to trees caused by elephants. In *the Acacia seyal* zone a total of 1503 trees were examined of which 65% were not browsed, 15% were browsed and 20% were seriously browsed. Of all trees browsed and trees seriously browsed the majority (60% and 70% respectively) were in the mature class. The mortality of *Acacia* trees (20%) exceeded their regeneration potential (16%). It is concluded that elephant damage to *Acacia* trees is serious and if the trends continue (a doubling of the number of trees killed in 15 years), elephant might have considerable effects on *Acacia* dynamics and structure. The size class distribution of trees indicated a declining population of *Acacia seyal*.

In the woodland zone a total of 1431 trees was examined of which 55% were not browsed, 36% were browsed and 9% were seriously browsed. Of all trees browsed and trees seriously browsed the majority (64% and 74% respectively) were in the mature class. The woodland zone of Waza is under far less pressure than that of Kalamaloué National Park, a dry season habitat for Waza elephants. In both parks *Acacia seyal*, *Piliostigma reticulatum*, *Combretum spp.* and *Balanites aegyptiaca* were sought out as preferred foods.

The study concludes with a recommendation for further research on possible outcomes of the elephant-habitat interaction in the Waza-Logone region. This paper stresses the importance of continued monitoring of the impacts of the hydrological restoration of the Waza-Logone floodplain on woodland.

Introduction

The ecological importance of the African elephant (*Loxodonta africana* Blumenbach, 1797) has led to its description as a keystone species (Western, 1989).

Wherever they occur, elephants greatly affect the structure and dynamics of the vegetation, and where their densities are high they can bring about changes to the habitat (Laws, 1970; Kabigumila, 1993; Ruggiero, 1993).

Since 1986 the effect of increased elephant densities on the vegetation of Waza and Kalamaloué National Parks had become a cause of concern to the Wildlife and Protected Areas Service (SPTEN, 1986). In particular, attention is drawn to the impact of elephants on *Acacia seyal* which is a very characteristic component of the region's landscape and the primary food item for giraffes (Ngog, 1983). Tchamba & Mahamat (1992) observed a large scale killing of mature trees and serious damage on the regeneration vegetation in Kalamaloué National Park, a dry season habitat for Waza elephants (Tchamba, 1993). They expresses concern that such a trend could cause complete failure of regeneration and thus extinction of some species in the Park.

Okula & Sise (1986) sampled the *Acacia seyal* zone of Waza Park in 1978 and concluded that elephant damage was not serious enough to warrant management action. Steehouwer & Kouahou (1988) observed an increase in elephant damage to *Acacia* trees in 1987. Rates of woodland decline estimated from measurements made at one point in time must be viewed with caution, and should be checked with data collected in subsequent years. The purpose of the present study, therefore, was to repeat the surveys conducted in 1978 (Okula & Sise, 1986) and 1987 (Steehouwer & Kouahou, 1988). The present survey included the woodland zone of Waza, not sampled by previous researchers, for comparisons with Kalamaloué Park (Tchamba & Mahamat, 1992).

Study Area and Methods

The study area has been described in detail in Chapter 1.2. Waza National Park is located in northern Cameroon (Fig. 3.1) between 11°03' N and 11°30' N and 14°28' E and 14°56' E. The park has an area of about 1700 km² and consists of three main vegetation types (Fig. 3.1) (Wit, 1975: i) a western woodland zone dominated by *Sclerocarya birrea, Anogeissus leiocarpus* and *Lannea humilis*; ii) a central *Acacia seyal* zone in which practically no other trees is encountered; iii) an eastern zone consisting of annually flooded grasslands locally called 'yaérés'. The sample areas were located in the woodland zone, habitat used by elephants during the wet season, and in the *Acacia seyal* zone, principal elephant habitat throughout the year.

Data were gathered at intervals between December 1992 and February 1993. In the event it proved impossible to repeat the earlier surveys exactly because of the difficulties in finding all the sample transects of the previous researchers. The *Acacia* zone was sampled in five areas (Fig. 3.1) with noticeably different elephant use. Elephant use was judged from sightings from the park's road system and observations during aerial surveys. Area 1 covered the area between

Kingueroua and Goubouremaram; Area 2 between Kalia and Ouakandouri; Area 3 between Mourgouma and Magala; Area 4 between Mourgouma and Anane; and Area 5 between Hoya and Gasasangua. Areas 1, 2, 3, 4, and 5 covered approximately 20%, 10%, 25%, 15% and 30%, respectively, of the *Acacia* zone. In each area the road was used as a baseline and four transects were distributed at random along the baseline. The transects were 1 km long and 5 m wide and at right angles to the road.

In the woodland zone the baseline was the Waza-Tagawa-Andirni road (Fig. 3.1) which is the south-western border of the park. Twenty transects 1 km long and 10 m wide were distributed at random along the baseline and were at right angles to the road.

The following size classes of trees were recognized by observers (Okula & Sise, 1986; Tchamba & Mahamat, 1992):

i regeneration trees, < 1 m height;
ii recruitment trees ("immature trees"), 1-3 m;
iii mature class, > 3m.

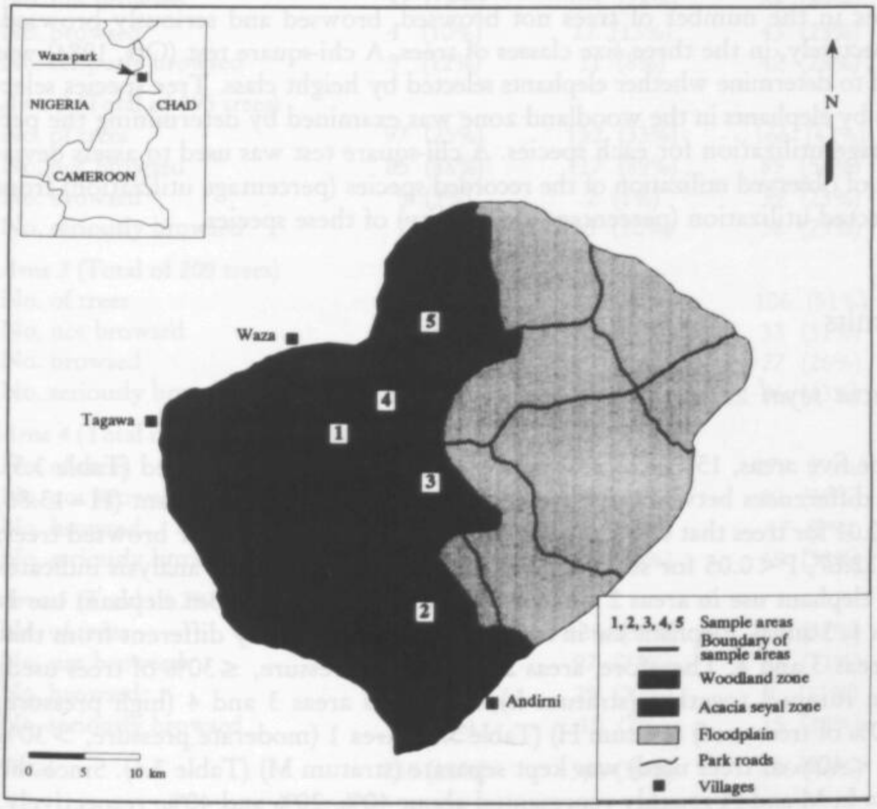

Figure 3.1

Waza National Park, Cameroon, showing major vegetative and sample areas

By designating different height classes, it was possible to determine whether elephants were selecting according to height and if so, to assess possible effects. Six classes of utilization were assigned (Croze, 1974):

i no use or very light use;
ii a quarter of the tree browsed;
iii half of the tree browsed;
iv three-quarters of the tree browsed;
v all the tree browsed; and
vi tree uprooted.

The term 'not browsed' refers to category (i). Trees in categories (ii) and (iii) were considered browsed, and trees in categories (iv) to (vi) were considered to be seriously browsed.

A Kruskal-Wallis test (Ott, 1984) was used to determine whether the five sample areas were significantly different in elephant use (browsing and seriously browsing) and also to test the equality of the number of trees in the three categories of utilization. The same test was used to determine significant differences in the number of trees not browsed, browsed and seriously browsed, respectively, in the three size classes of trees. A chi-square test (Ott, 1984) was used to determine whether elephants selected by height class. Tree species selection by elephants in the woodland zone was examined by determining the percentage utilization for each species. A chi-square test was used to assess deviation of observed utilization of the recorded species (percentage utilization) from expected utilization (percentage availability) of these species.

Results

Acacia seyal zone

In the five areas, 1503 *Acacia seyal* trees were found and examined (Table 3.5). The differences between the five areas were statistically significant ($H=13.86$, $P<0.01$ for trees that were not browsed; $H=11.66$, $P<0.05$ for browsed trees; $H=12.67$, $P<0.05$ for seriously browsed trees; $df=19$). The analysis indicates that elephant use in areas 2 and 5 was significantly lower from elephant use in areas 1, 3 and 4. Elephant use in area 1 was also significantly different from that of areas 3 and 4. Therefore, areas 2 and 5 (low pressure, $\leq 30\%$ of trees used) were lumped together (stratum L), as well as areas 3 and 4 (high pressure, $\geq 40\%$ of trees used) (stratum H) (Table 3.6). Area 1 (moderate pressure, $>30\%$ and $<40\%$ of trees used) was kept separate (stratum M) (Table 3.6). Since the strata L, M and H roughly represented about 40%, 20% and 40%, respectively, of the *Acacia* zone and it appeared that they were sampled in direct proportion to their occurrence (8, 4 and 8 transects, respectively) the total sample of 1503 trees was sufficiently representative of the whole *Acacia* zone.

Of the total sample of trees, 65% were not browsed, 15% were browsed while 20% were seriously browsed (Table 3.6). Of the trees that were not browsed, 19% were regeneration, 46% were recruitment and 35% were mature trees. Of those browsed, 11% were regeneration, 29% were recruitment and 60% were mature trees. Of those seriously browsed, 20% were regeneration, 10% were recruitment, and 70% were mature trees.

Table 3.5

Effects of elephant browsing on *Acacia seyal* in five sampled areas of the *Acacia* zone in Waza National Park, Cameroon

	Regeneration	Recruitment	Mature
Area 1 (Total of 323 trees)			
No. of trees	41 (13%)	129 (40%)	153 (47%)
No. not browsed	32 (78%)	101 (78%)	68 (44%)
No. browsed	4 (10%)	17 (13%)	43 (28%)
No. seriously browsed	5 (12%)	11 (8%)	42 (28%)
Area 2 (Total of 395 trees)			
No. of trees	97 (25%)	132 (33%)	166 (42%)
No. not browsed	85 (88%)	117 (89%)	89 (54%)
No. browsed	5 (5%)	2 (1%)	39 (23%)
No. seriously browsed	7 (7%)	13 (10%)	38 (23%)
Area 3 (Total of 209 trees)			
No. of trees	22 (10%)	81 (39%)	106 (51%)
No. not browsed	13 (59%)	65 (80%)	33 (31%)
No. browsed	3 (14%)	3 (4%)	27 (26%)
No. seriously browsed	6 (27%)	13 (16%)	46 (43%)
Area 4 (Total of 319 trees)			
No. of trees	37 (12%)	103 (32%)	179 (56%)
No. not browsed	25 (67%)	74 (72%)	93 (52%)
No. browsed	4 (11%)	14 (13%)	17 (9%)
No. seriously browsed	8 (22%)	15 (15%)	69 (38%)
Area 5 (Total of 257 trees)			
No. of trees	39 (15%)	136 (53%)	82 (32%)
No. not browsed	27 (69%)	97 (71%)	58 (71%)
No. browsed	9 (23%)	29 (22%)	9 (11%)
No. seriously browsed	3 (8%)	10 (7%)	15 (18%)
Total	236 (16%)	581 (39%)	686 (46%)

The total sample of 1503 trees consisted of 16% regeneration trees, 39% recruitment trees and 45% mature trees (Table 3.6). Results of elephant use within height classes show that 11% of regeneration, 11% of recruitment and 19% of mature trees were browsed while 12% of regeneration, 11% of recruitment and 31% of mature trees were seriously browsed.

Table 3.6

Effects of elephant browsing on *Acacia seyal* in the three identified strata of the *Acacia* zone in Waza National Park, Cameroon

	Regeneration	Recruitment	Mature
Stratum L			
(Low pressure)			
(Total of 652 trees)			
No. of trees	136 (21%)	268 (41%)	248 (38%)
No. not browsed	112 (82%)	214 (80%)	147 (59%)
No. browsed	14 (10%)	31 (11%)	48 (19%)
No. seriously browsed	10 (8%)	23 (9%)	53 (22%)
Stratum M			
(Moderate pressure)			
(Total of 323 trees)			
No. of trees	41 (13%)	129 (40%)	153 (47%)
No. not browsed	32 (78%)	101 (78%)	68 (44%)
No. browsed	4 (10%)	17 (13%)	43 (28%)
No. seriously browsed	5 (12%)	11 (8%)	42 (28%)
Stratum H			
(High pressure)			
(Total of 528 trees)			
No. of trees	59 (11%)	184 (35%)	285 (54%)
No. not browsed	38 (64%)	139 (76%)	126 (44%)
No. browsed	7 (12%)	17 (9%)	44 (16%)
No. seriously browsed	14 (24%)	28 (15%)	115 (40%)
All strata by classes			
(Total of 1503 of trees)			
No. of trees	236 (16%)	581 (39%)	686 (45%)
No. not browsed	182 (77%)	454 (78%)	341 (50%)
No. browsed	25 (11%)	65 (11%)	135 (19%) 210
No. seriously browsed	29 (12%)	62 (11%)	(31%)
All strata, no class distinction			
(Total of 1503 trees)			
No. not browsed	977 (65%)		
No. browsed	225 (15%)		
No. seriously browsed	301 (20%)		

From these results three observations can be made:

a. most trees were not browsed;
b. of those trees that were browsed and those seriously browsed there were significantly more mature trees than there were regeneration and recruitment trees ($H=7.26$, $P<0.05$ and $H=6.49$, $P<0.05$, respectively, $df=2$);
c. elephant use of *Acacia seyal* was selective by height class. Elephants browsed and seriously browsed mature trees more than expected ($X^2=9.13$, $P<0.05$ and $X^2=25.39$, $P<0.001$, respectively, $df=2$).

Woodland zone

Whereas the *Acacia seyal* zone is dominated almost exclusively by this species, the woodland zone harbours many species. This offers an opportunity to investigate possible preferences for tree species.

Eight species encountered with less than 10 individual trees examined were not considered in subsequent analyses: *Acacia albida, Annona senegalensis, Bauhinia rufescens, Boscia senegalensis, Combretum collinum, Mitragyna inermis, Stereospermum kunthianum*, and *Tamarindus indica*. Of the remaining 1431 trees examined, 55% were not browsed, 36% were browsed and only 9% were seriously browsed (three-quarters browsed or more) (Table 3.7).

The sample of 1431 trees comprised 15% regeneration, 35% recruitment and 50% mature trees (Table 3.7). Of the trees that were not browsed, 21% were regeneration, 42% recruitment and 37% mature trees. Of the browsed trees, 7% were regeneration, 29% recruitment and 64% were mature trees. Of the seriously browsed trees, 7% were regeneration, 19% recruitment and 74% mature trees.

Results of elephant use within height classes indicate that 18% of regeneration, 29% of recruitment and 46% of mature trees were browsed while 4% of regeneration, 5% of recruitment and 13% of mature trees were seriously browsed.

Table 3.7

Effects of elephant browsing on the woodland zone of Waza National Park, Cameroon

	Regeneration	Recruitment	Mature	Total
No. of trees	215 (15%)	503 (35%)	713 (50%)	1431
No. not browsed	168 (78%)	332 (66%)	293 (41%)	793 (55%)
No. browsed	38 (18%)	147 (29%)	326 (46%)	511 (36%)
No. seriously browsed	9 (4%)	24 (5%)	94 (13%)	127 (9%)

Table 3.8

Distribution of sampled trees by height and by species in the woodland zone

Species	Regeneration	Recruitment	Mature	Total
Acacia seyal	11	39	25	75
Anogeissus leiocarpus	0	16	174	190
Combretum aculeatum	87	66	41	195
Lannea humilis	26	102	43	171
Balanites aegyptiaca	63	60	99	222
Sclerocarya birrea	2	44	157	203
Cadaba farinosa	9	38	17	64
Combretum glutinosum	0	11	45	56
Piliostigma reticulatum	16	17	55	88
Feretia apodanthera	0	8	7	15
Guiera senegalensis	0	93	34	127
Hyphaena thebaica	1	4	9	14
Securinega virosa	0	5	6	11
Total	215	503	713	1431

The total sample of 1431 trees consisted primarily of *Balanites aegyptiaca* (15%), *Combretum aculeatum* (14%), *Sclerocarya birrea* (14%), *Anogeissus leiocarpus* (13%) and *Lannea humilis* (12%) (Table 3.8). Three species were not browsed: *Feretia apodanthera*, *Hyphaena thebaica* and *Securinega virosa* (Table 3.9). For five species more than 50% of the trees were browsed: *Piliostigma reticulatum* (93%), *Acacia seyal* (83%), *Balanites aegyptiaca* (79%), *Combretum aculeatum* (69%) and *Combretum glutinosum* (52%). These five species could be considered the most preferred foods (Table 3.10).

From these results five observations can be made:

a. most trees were not browsed;
b. of those trees that were not browsed there were significantly more regeneration trees than there were recruitment and mature trees ($H=16.64$, $df=19$, $P<0.001$);
c. of those browsed and those seriously browsed there were significantly more mature trees than there were regeneration and recruitment trees ($H=46.89$ and $H=27.64$ respectively, $df=19$, $P<0.001$);
d. elephants use of the woodland zone was selective by height class. Elephants browsed and seriously browsed mature trees more than expected ($X^2=9.21$, $P<0.05$ and $X^2=23.10$, $P<0.001$ respectively, $df=2$);
e. elephants use was selective by tree species ($X^2=56.67$, $P<0.001$, $df=8$).

Table 3.9
Distribution of sampled trees by classes of utilization and by species in the woodland zone

Species	Classes of utilization			Total
	Not browsed	Browsed	Seriously browsed	
Acacia seyal	13 (17%)	50 (67%)	12 (16%)	75
Anogeissus leiocarpus	97 (51%)	86 (45%)	7 (4%)	190
Combretum aculeatum	59 (31%)	73 (37%)	63 (32%)	195
Lannea humilis	155 (91%)	16 (9%)	0	171
Balanites aegyptiaca	47 (21%)	142 (64%)	33 (15%)	222
Sclerocarya birrea	174 (86%)	29 (14%)	0	203
Cadaba farinosa	61 (95%)	3 (5%)	0	64
Combretum glutinosum	27 (48%)	21 (38%)	8 (14%)	56
Piliostigma reticulatum	6 (7%)	78 (89%)	4 (4%)	88
Feretia apodanthera	15	0	0	15
Gueria senegalensis	114 (90%)	13 (10%)	0	127
Hyphaena thebaica	14	0	0	14
Securinega virosa	11	0	0	11
Total	793	511	127	1431

Discussion

Although elephants used mature trees more intensively than regeneration and recruitment trees, this does not imply that there was a specific preference. The difference in use may be simply due to the fact that mature trees with their larger biomass were encountered much more easily than small trees.

Trend in the Acacia seyal population

Okula & Sise (1986) reported of the tree census they made in Waza National Park in 1978. Although the results from the present study and their 1978 are not strictly comparable (sample transects were different), some observations may be made:

Table 3.10

Tree species selection by elephants in the woodland zone of Waza National Park, Cameroon

Species	Percentage of the trees of the species used	Percentage availability from the total sample	Percentage utilization from the total sample
Acacia seyal	83	5	10
Piliostigma reticulatum	93	6	15
Combretum glutinosum	52	4	21
Balanites aegyptiaca	79	15	2
Combretum aculeatum	70	14	27
Anogeissus leicarpus	49	13	5
Guiera senegalensis	10	9	0
Cadaba farinosa	5	5	5
Sclerocarya birrea	14	14	13
Lannea humilis	9	12	0
Hyphaena thebaica	0	1	2
Feretia apodanthera	0	1	0
Securinega virosa	0	1	0

1. Of the 1742 trees examined in 1978, 22% were regeneration, 39% were recruitment and 39% were mature trees. Of the total sample, 72% were not browsed, 17% browsed and 11% seriously browsed. This is very different from the distribution found in this study (65%, 15%, 20%, table 3.6) in that the percentage of seriously browsed has increased relative to the two categories ($X^2=124.60$; $P<0.001$; df=2). Okula & Sise found that, of the seriously browsed 10% were regeneration, 13% recruitment and 77% were mature trees. A comparison with the present data of 20%, 10% and 70% reveals a significantly different distribution ($X^2=47.66$; $P<0.001$; df=2). In other words: not only has the amount of seriously browsed trees increased, but there is also a relative increase in the damage inflicted on the youngest age class;
2. the regeneration class was under-represented in 1978, and even less represented in the present study. It is possible that this under-representation be an artefact of the method of sampling which cannot account for the mortality of the regeneration trees that are totally removed by elephants. However, it is important to note that in 1978 it was concluded that the *Acacia seyal* habitat would continue to remain in balance, with recruitment balancing the losses (22% regeneration, 11% mortality) while the present study suggests that the mortality of *Acacia seyal* trees (20%) is exceeding their regeneration

potential (16%). As the regeneration class declines and the population gets older (mature class increases), the *Acacia seyal* population will begin to decline;

3. elephant use of the *Acacia* zone has significantly increased, with almost a doubling in 15 years of the number of trees seriously browsed by elephants (from 11% to 20%).

Steehouwer & Kouahou (1988) noted that elephants spent more time in the *Acacia* zone than in the woodland and floodplain zones where more than 25% of the trees were seriously browsed. Their results probably reflect a heavier use of *Acacia seyal* than normally occurs throughout the habitat type as they only sampled areas intensively used by elephants (Areas 3 and 4).

Results of an aerial census conducted in 1977 showed that elephants numbered about 500 in Waza (Esser & Van Lavieren, 1979). At the time of the present study elephants were estimated at about 1100 (Tchamba, 1993), a doubling compared to 1978 when Okula & Sise (1986) carried out their investigations. The increase in elephant numbers has certainly had an impact on the elephant use of *Acacia seyal*.

Since 1980, the upstream use of the Logone River's floodwaters for a rice project has deprived Waza Park of its annual flooding. Steehouwer & Kouahou (1988) indicated that the elephants have consequently changed their movement patterns inside the Park, spending more time in the *Acacia seyal* zone than previously. The change in hydrological conditions may have increased the elephant use of *Acacia seyal*.

The sample areas of the greatest concern for Acacia seyal survival are Areas 3 and 4 within which 30% of the sample trees were destroyed. Most of these came from the mature class (40%), but the remainder represent 24% of regeneration trees and 15% of the recruitment trees. In these areas the regeneration trees made up the smallest percentage (11%) of the sampled trees in the areas. Elephants feed intensively in Areas 3 and 4 where the two major waterholes (Magala and Mourgouma), the only places within the park where water is available at the peak of the dry season, are located.

Elephant impact on woodland can be manipulated to some extent by burning (Bell & Mphande, 1980; Lewis, 1982). The present fire management policy is to burn most parts of the park at the beginning of the dry season in order to improve grass production, while retaining open understorey which is aesthetically attractive for wildlife viewing by tourists. Unfortunately, the burning is often done late due to inadequate organization. In heavily used areas where late fire had occurred, fire stress may have been so severe that many elephant-damaged trees may succumb to fire.

Comparisons with the woodland zone of Kalamaloué National Park

Kalamaloué National Park, located about 100 km north of Waza, is home for about 400 Waza elephants in the dry season (Mahamat, 1991). Tchamba & Mahamat (1992) noted large scale killing of mature trees and serious damage to the regeneration vegetation. They concluded that there was an 'elephant problem' in Kalamaloué. The situation of the woodland zone of Waza was better. Most trees were not browsed and of those browsed the majority came from the mature class. Only 9% of the trees were seriously browsed in Waza compared to 44% in Kalamaloué.

The difference in the intensity of use of the woodland zones of Waza and Kalamaloué could be explained by the fact that Kalamaloué is used at a critical period of the year (dry season), for a relatively long time (5 to 7 months) and by a high number of elephants (8.5 elephants/km²) (Mahamat, 1991). Fowler & Smith (1973) noted that when elephant density was over 0.5 elephant/km² in the dry savannas, there could be serious damage to the habitat. The woodland zone of Waza is used by part of the elephant population throughout the wet season and beginning of the dry season, a less critical period. Therefore, elephant damage to the natural vegetation is less severe than in Kalamaloué National Park.

There was a clear selectivity in the use by elephants of the tree species. Two factors may be involved: (i) trees appearing rarely seem to be neglected by elephants altogether, and (ii) trees appearing comparatively frequently are differentially used on the basis of some preference factors. *Acacia seyal, Piliostigma reticulatum, Combretum spp.* and *Balanites aegyptiaca* were all sought out as preferred foods in both Kalamaloué and Waza. The maintenance of this preference suggests that the elephant migration from Waza to Kalamaloué in the dry season may not be determined primarily by the need for food but rather by the search for sufficient water. This means that they are 'pushed out' of Waza by the limited water supply. Indeed, the water supply in Waza has decreased in recent years. In the early 1980's seventeen large waterholes were dug in Waza to supplement the about 50-odd smaller, natural pools, which are left behind after the floods. However, erosion, from rain and from animals' hooves, has caused these waterholes to fill up with soil, thus reducing their effective volume and their capacity to last through the dry season. Natural pools no longer provide drinking and bathing water long into the dry season because of the drought which stems first from climatic fluctuations and secondly from the dam of the SEMRY rice project which has severely reduced the seasonal flooding of the plain. Elephants most likely leave Waza to seek water in Kalamaloué, which is bordered by the permanent Chari river. A good understanding of elephant migration patterns is essential for developing an overall management policy for elephant conservation in the Waza-Logone region.

In the 1960's, 'the elephant problem' was the concern over habitat change due to elephant 'overpopulation' (Laws, 1970). Then in the 1970's and 1980's, the uncontrolled ivory trade changed 'the elephant problem' to one of decline and local extinction of elephant populations through poaching (Douglas-Hamilton, 1987). In recent times, the attention has turned from a grave concern with the number of elephants that were being poached to the numbers of people being killed by elephants and the damage to human property (Kangwana, 1995). The discussions and the decisions on how to deal with elephant impacts on vegetation and the risk of irreversible habitat change have moved to the background. However, it is recognised that the issue must be faced in the future (Poole *et al.*, 1992; Lindsay, 1993).

Some models have been developed to explore the consequences of different elephant management regimes on tree population dynamics (Norton-Griffiths, 1979; Barnes, 1983; Owen-Smith, 1983; Pellew, 1983; Dublin *et al.*, 1990; Craig, 1992). Relatively few attempts have been made to analyze the dynamics of freely interacting elephant and tree populations (Caughley, 1976; Van Wijngaarden, 1985). The Waza-Logone region of northern Cameroon is one of the key areas where information from research could provide insight into possible outcomes of the elephant-habitat interaction. Data could be collected to test, refine, or develop conceptual and numerical models of the regulation of elephant and tree populations, and the influence of other environmental factors.

The knowledge available till now leads to the recommendation to relieve the pressure from the *Acacia seyal* zone. The IUCN Waza-Logone Project may be an important step in this respect. It involves activities such as: the evaluation of the existing area reflooded by local people, hydrological studies to investigate the technical and financial feasibility of various reflooding options, and the monitoring of reflooded areas. This approach for hydrological restoration of the floodplain might have a number of possible effects on the *Acacia seyal* zone including:

1. an improvement in perennial grasses may encourage elephants to use the floodplain more during the dry season and consequently reduce the pressure on the *Acacia seyal* zone;
2. there may be changes in the quality and composition of the Acacia seyal zone in the area affected by flooding;
3. an increase in the dry season water availability within the Waza National Park might delay the movements out of the Park to the north and reduce the number of elephants moving out, and consequently increase the pressure on the Acacia seyal zone.

Conclusions

Conditions at the time of this study indicate that elephants represent a problem to *Acacia seyal* survival in Waza National Park. They contribute to *Acacia seyal* mortality and if present trends continue the *Acacia seyal* woodland might be seriously opened up in coming years. The severity and the rapidity of the changes will depend on elephant densities, change in elephant home ranges caused by human activities around the Park and the implementation of the hydrological rehabilitation plan developed by the IUCN's Waza-Logone Project. Available information is insufficient to conclude on whether or not the changes in hydrological conditions might have positive effects on woodland dynamics in the study area. It is recommended that the *Acacia seyal* woodland be monitored regularly to evaluate the impact of elephants. Monitoring of the Park's habitat in relation to the fire management policy may also be in order.

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3.3
History and Present Status of the Human-Elephant Conflict in the Waza-Logone Region, Cameroon, West Africa

Summary

Increasing elephant population coupled with the rapid human population growth and the expansion of agricultural land have escalated human/elephant conflict in the Waza-Logone region. This paper analyses the magnitude of the conflict and examines its development in time. Elephant damage to crops has doubled between 1992 and 1993 in the Kaélé and Mindif areas and caused increasing loss of human life. The present situation is likely to worsen unless the control of 'problem animals' is ameliorated, the management of Waza National Park is improved, a conservation education program is developed and an adequate compensation scheme is designed. It is also essential to determine elephant movements and home ranges and to identify causes of their movements.

Introduction and Study Area

In recent years the most serious issue in elephant conservation across Africa has been the decline in populations caused by illegal hunting for ivory. On a continental scale elephants had declined from some 1.3 million in 1979 to approximately 609,000 in 1989 (Hamilton *et al.*, 1992). However, the growing human population and the expansion of cropland are now a major threat and human/elephant conflict has developed from being perceived as a nuisance to being considered a major conservation concern.

Few studies of human/elephant conflict have been conducted in Africa. In Niger, Taylor (1987) noted that elephants destroyed only 0.2% of the crops but that a farmer could lose his entire annual harvest during a single night incursion of elephants. Damiba & Ables (1993) observed that elephant impact in the villages around the Nazinga ranch (Burkina Faso) peaked in the rainy season and that in the dry season elephants attempted to knock down millet granaries. In Zimbabwe, over 70% of wildlife complaints are elephant-related (Hoare & Mackie, 1993; Taylor, 1993). Such problems must be minimized if elephant conservation is to succeed in African countries facing harsh socio-economic realities.

The present study was undertaken in the Waza-Logone region of Northern Cameroon to analyze the magnitude of the human/elephant conflict and to examine its development in time. The specific objectives were to: (1) investigate the historical nature and extent of the crop losses that have been incurred; (2) document the current type and level of elephant impacts; (3) establish elephant crop raiding regimes; (4) identify the traditional methods being used by local people to mitigate elephant impacts, and (5) examine local opinions and perceptions about elephants.

The Waza-Logone region has been described in detail in Chapter 1.2. The main land uses in the area are agriculture, pastoralism and wildlife conservation. The construction of the large dam of the SEMRY II rice project at Maga (Fig. 3.2), together with decreased rainfall, has disrupted the annual hydrological regime in the region. Consequently, forage for wildlife and cattle *Bos indicus* has reduced and local people has changed their traditional use of natural resources (Njiforti *et al.*, 1989). The new activities coupled with the expansion of agricultural settlement have led to the reduction of elephant habitat and occupation of some of the animals' traditional migration routes.

History of the Conflict

The Waza-Logone region was devoid of elephants until 1947 when they crossed the Logone river near Kousseri and took up residence in Kalamaloué National Park (Flizot, 1948). Since then numbers have increased steadily as shown by Flizot's estimates: 250 in 1961, 400 in 1964 and over 600 in 1969 (Flizot, 1969). It is alleged that most of this increase was due to immigration into Northern Cameroon from Chad, probably resulting from disturbances there such as the deforestation of the Mandelia Faunal Reserve, (Fry, 1970).

In 1971, increasing elephant numbers already gave cause for concern (Corfield & Hamilton, 1971) as elephants were destroying trees in the *Acacia* woodland of Waza. Although no studies of the ecology and population dynamics of elephants in the region nor their impact on the natural vegetation and agriculture was conducted, it was decided to limit elephant numbers. As a result, in 1968/1969 big game hunters removed 62 elephants. It was estimated that the culling of about 80 elephants per year would limit elephant numbers sufficiently (Flizot, 1969).

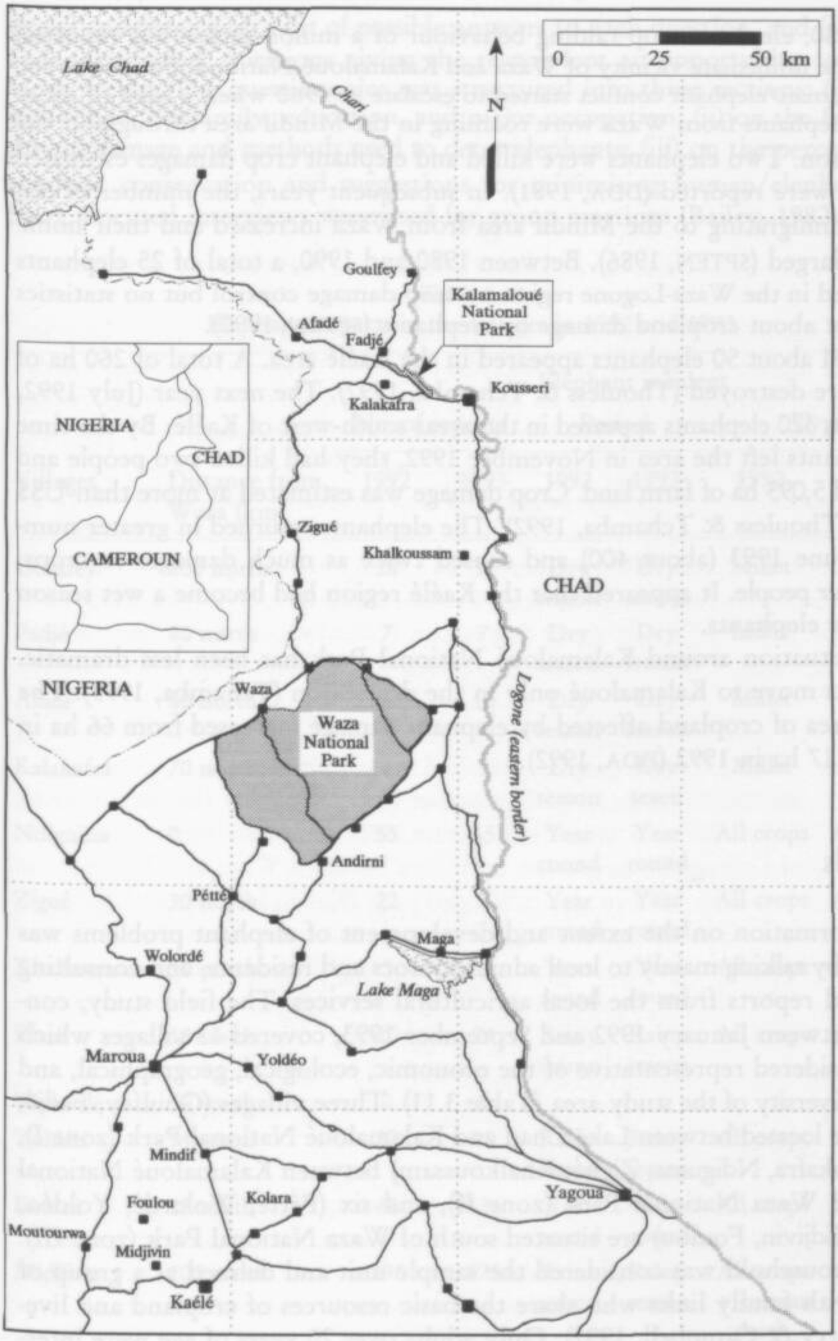

Figure 3.2

Sketch-map indicating the location of the study area and the surveyed villages

Until 1980, elephant crop raiding behaviour of a minor nature was reported only in the immediate vicinity of Waza and Kalamaloué National Parks (SPTEN, 1986). Human/elephant conflict started to escalate in 1980 when a herd of more than 30 elephants from Waza were roaming in the Mindif area throughout the rainy season. Two elephants were killed and elephant crop damages estimated at 10 ha were reported (DDA, 1981). In subsequent years, the number of elephants immigrating to the Mindif area from Waza increased and their home range enlarged (SPTEN, 1986). Between 1980 and 1990, a total of 25 elephants were killed in the Waza-Logone region on crop damage control but no statistics were kept about cropland damage by elephants (SPTEN, 1990).

In 1991 about 50 elephants appeared in the Kaélé area. A total of 260 ha of crops were destroyed (Thouless & Tchamba, 1992). The next year (July 1992, more than 320 elephants appeared in the areas south-west of Kaélé. By the time the elephants left the area in November 1992, they had killed two people and destroyed 5,093 ha of farm land. Crop damage was estimated at more than US$ 200,000 (Thouless & Tchamba, 1992). The elephants returned in greater numbers in June 1993 (about 400) and caused twice as much damages to crops, killing four people. It appeared that the Kaélé region had become a wet season refuge for elephants.

The situation around Kalamaloué National Park has been less dramatic. Elephants move to Kalamaloué only in the dry season (Tchamba, 1993). The surface area of cropland affected by elephant damage increased from 66 ha in 1986 to 117 ha in 1992 (DDA, 1992).

Methods

Basic information on the extent and development of elephant problems was obtained by talking mainly to local administrators and residents, and consulting sequential reports from the local agricultural services. The field study, conducted between January 1992 and September 1993, covered 13 villages which were considered representative of the economic, ecological, geographical, and cultural diversity of the study area (Table 3.11). Three villages (Goulfey, Fadjé, Afadé) are located between Lake Chad and Kalamaloué National Park (zone I), four (Kalakafra, Ndiguina, Zigué, Khalkoussam) between Kalamaloué National Park and Waza National Park (zone II), and six (Pétté, Wolordé, Yoldéo, Kolara, Midjivin, Foulou) are situated south of Waza National Park (zone III).

The household was considered the sample unit and defined as a group of people with family links who share the basic resources of cropland and livestock (Parry & Campbell, 1992). Only adults over 20 years of age were interviewed, and if no suitable representative of a household was located, that household was not enumerated. Randomly selected households (n=427) were interviewed using a questionnaire with two types of questions: (i) 'precise and closed' questions with a list of possible answers to each question, and (ii) 'broad and open ended' questions giving the respondent an opportunity to express views freely. The questionnaire was structured into three sections: (i) on the individual, his family, education, and major occupation; (ii) on the farm, history of damage and methods used to deter elephants; (iii) on the perception of elephant conservation and suggestions for minimising human/elephant conflicts. Focused interviews were used for group meetings (Bailey, 1982).

Table 3.11

Elephant impacts in the villages in 1992 and 1993

		Elephant incident					
		No. of reports		Period		Type	
Villages	Distance from Waza (km)	1992	1993	1992	1993	1992	1993
Goulfey	100 north	28	31	Dry season	Dry season	Millet	Millet
Fadjé	80 north	7	7	Dry season	Dry season	Millet	Millet
Afadé	80 north	6	10	Dry season	Dry season	Millet	Millet
Kalakafra	70 north	4	5	Dry season	Dry seson	Millet	Millet
Ndiguina	0	55	65	Year round	Year round	All crops	All crops
Zigué	30 north	22	7	Year round	Year round	All crops	All crops
Khalkoussam	30 north	3	5	Year round	Year round	All crops	All crops
Pétté	18 south	20	24	Rainy season	Rainy season	All crops	All crops
Wolordé	50 south	0	0	-	-	-	-
Yoldéo	54 south	37	69	Rainy season	Rainy season	All crops	All crops
Kolara	85 south	48	134	Year round	Year round	All crops	All crops
Midjivin	100 south	396	975	Rainy season	Rainy season	All crops + human death	All crops + human death
Foulou	93 south	150	191	Rainy season	Rainy season	All crops	All crops

A Problem Animal Reporting (PAR) System (Hoare, 1990) was set up in each village, so that elephant movements and damage caused by elephants were reported as soon as possible to the nearest enumerator.

Results

Current type and level of elephant impacts, crop raiding regimes

Elephants rarely kill people (0.5% of reported incidents) (Table 3.11). Dry season millet and rainy season sorghum are the most frequently damaged crops (35% and 30%, respectively, of all damage). Cotton (11%), corn (9%), peanut (9%) and vegetables (3%) are also affected. Browsing represents 52% of elephant damage to crops, trampling 38%, and uprooting 10%.

The monthly crop damage in zone III was greatest at the end of the rainy season (August-September) when crops were maturing or ready for harvest (Fig. 3.3). In zone I elephant impacts peaked in the dry season (January-February) and were negligible the rest of the year. Problem animal activity was limited in zone II and occurred in the early dry season (January) and early rainy season (June) (Fig. 3.4). These activities are related to elephant migration patterns between Waza and Kalamaloué (Tchamba, 1993).

The Kaélé and Mindif areas (Yoldéo, Kolara, Midjivin, Foulou) suffered most from elephant raiding behaviour and crop damage almost doubled between 1992 and 1993 (Table 3.12). Damage at Ndiguina (near the park border) exceeded 30% of the area under cultivation. On the other hand, damage in villages located along the migration corridors between Waza and Kalamaloué represented less than 10% of the cultivated area (Kalakafra, Zigué, Khalkoussam). At the individual farmer's level this damage has been disastrous: 23% and 27% of respondents lost their entire annual harvest during night incursions of elephants in 1992 and 1993 respectively. The total estimated crop loss increased from US$ 77,950 in 1992 to $ 127,620 in 1993 in the villages surveyed. Annual average crop loss per farmer was estimated at $ 89 in 1992 and $ 104 in 1993. A comparison between field investigations by enumerators (Table 3.12) and individual crop damage reports by farmers indicated that farmers consistently overestimated crop damage by 30 to 40%.

Indirect impacts such as disruption of social activities when people have to spend the whole day or night guarding their farms are difficult to measure. School children also lose school days when they have to help their parents guard the farms or chase the elephants. Abandoning cultivated land due to fear of crop raids by elephants was mentioned in 2% of reported cases.

Table 3.12
Level of elephant crop damages determined by enumerators in the 13 villages surveyed in 1992 and 1993

Villages	Area cultivated (ha)	Area destroyed (ha) (%)		Estimated cost in US$	
		1992	1993	1992	1993
Goulfey	119	12.5 (10)	14 (12)	2400	2700
Fadjé	28	2.5 (9)	3 (11)	480	580
Afadé	39	1.5 (4)	2 (5)	290	385
Kalakafra	27	1 (4)	1 (4)	195	195
Ndiguina	111	37 (33)	35 (31)	7130	6750
Zigué	122	15 (12)	3 (2)	2890	580
Khalkoussam	32	1 (3)	2 (6)	195	390
Pétté	237	12 (5)	15 (6)	2310	2890
Wolordé	41	0	0	0	0
Yoldéo	284	24 (8)	37 (13)	4620	7130
Kolara	375	22 (6)	45 (12)	4240	8670
Midjivin	916	201 (22)	390 (42)	38740	75180
Foulou	295	75 (25)	115 (39)	14460	22170
Total	2626	404.5 (15)	662 (25)	77950	127620

Local strategies for reducing elephant impacts

Local strategies to drive elephants out of the farms are primitive. At one extreme this consists of collective prayers and magical practices. The most common is beating drums or empty barrels to scare elephants. This only has the effect of moving the problem to other areas. Sheep dung has been burnt in the fields because people believe that elephants dislike its smell, but is ineffective. Farmers also light fires piles around crop lands or simply sleep in the crop fields to guard them from elephants.

Sticks and stones are thrown at elephants, but this sometimes ends in fatal incidents. A recent strategy has been to wound elephants by shooting them with light shotguns.

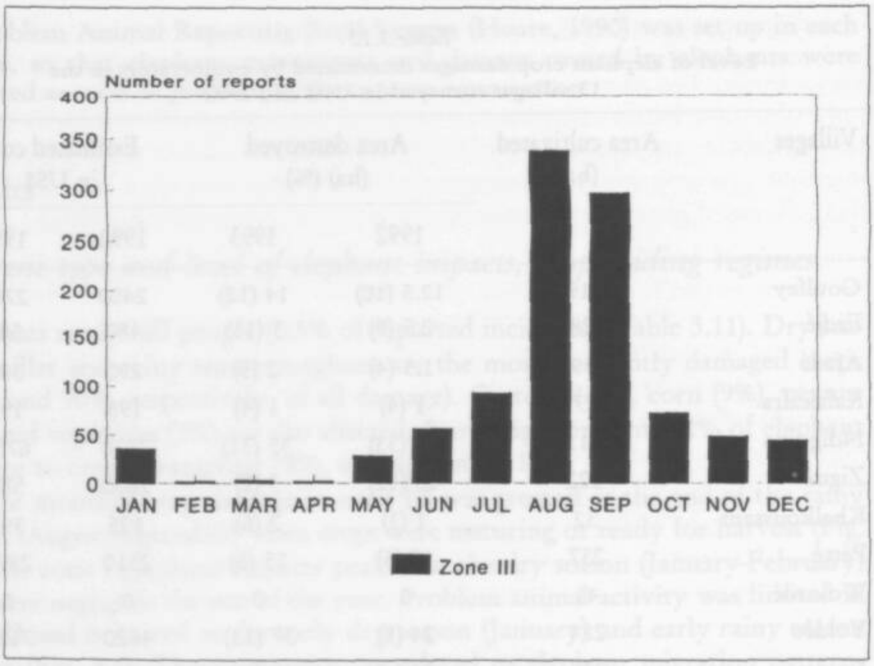

Figure 3.3

Average monthly distribution of crop damages in Zone III (1992-1993)

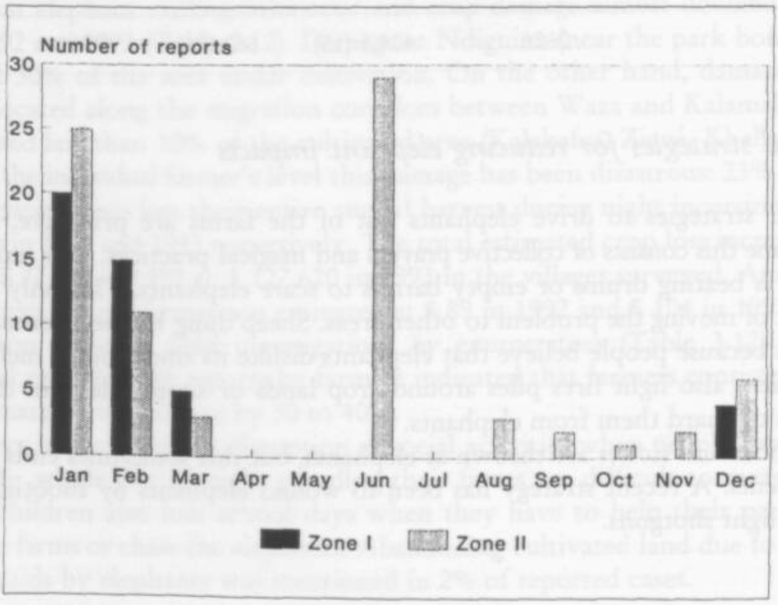

Figure 3.4

Average monthly distribution of crop damages in zone I and zone II (1992-1993)

Villager's opinion and perception of elephant conservation

The perceived benefits from elephants were based mainly on utilitarian aspects (Fig. 3.5). Over half of respondents considered that there were no benefits at all, while nearly three quaters mentioned both personal danger and loss of crops (Fig. 3.6). The majority of respondents (87%) indicated that the Protected Areas and Wildlife Department was ineffective as far as the crop damage control was concerned. They looked on the wildlife authorities primarily as representing a law- enforcement agency which serves the needs of tourists and safari companies rather than of the local people. Most of the respondents (96%) indicated that they did not benefit from crop damage control in terms of game-meat. They thought it was more beneficial to urban authorities (who usually collect most of the meat) than to the rural communities. A considerable proportion (73%) thought that more elephants should be culled.

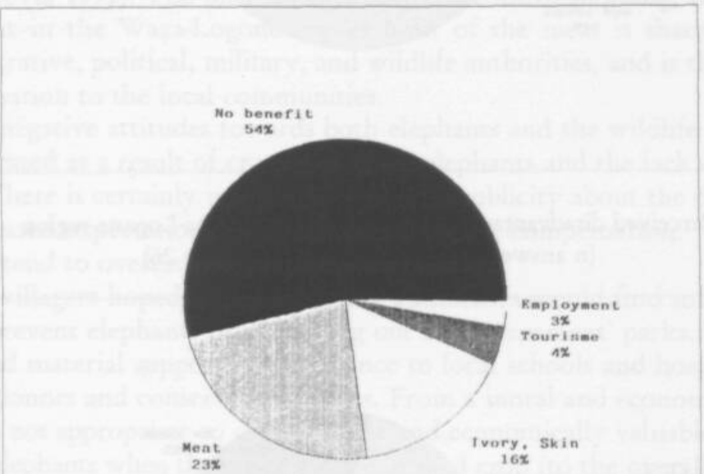

Figure 3.5

Perceived benefits from elephants in the Waza-Logone region
(n answering= 379, n not answering= 48)

Many respondents (89%) thought there was no compensation for their losses and had no idea how to obtain compensation, while 11% indicated that there was food assistance available from the World Food Program (FAO) through the government.

Suggestions on what could be done to minimize crop damage included shooting the responsible elephants (8%), scaring animals with gunshots (4%), and moving the elephants and fencing them somewhere (36%). A considerable number (29%) had no idea as to what could be done (Fig. 3.7). The majority expressed a common concern over what will happen to their croplands with the increasing elephant population.

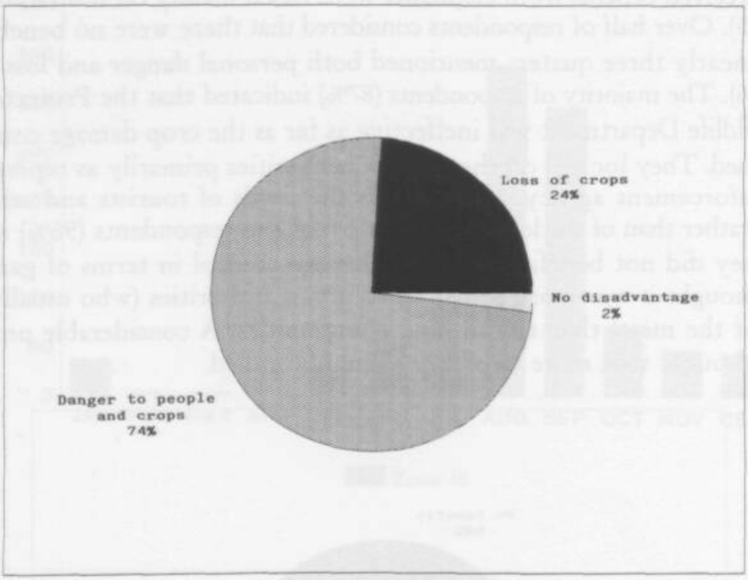

Figure 3.6

Perceived disadvantages of elephants in the Waza-Logone region (n answering= 401, n not answering= 26)

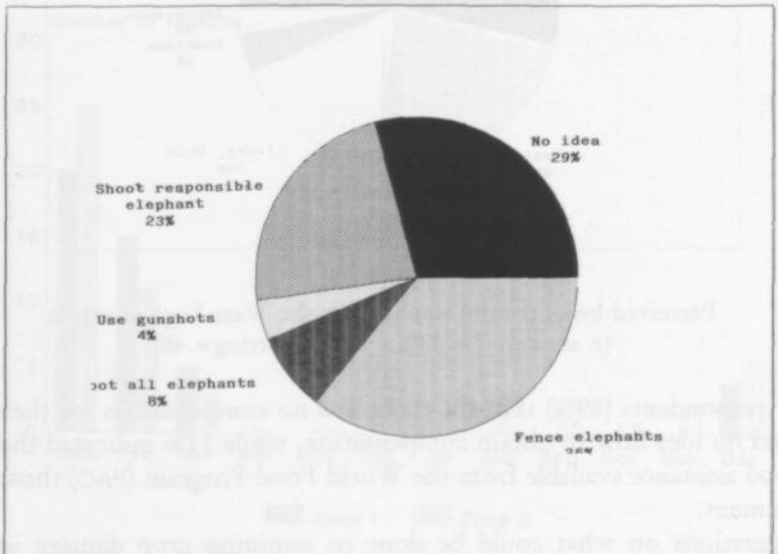

Figure 3.7

Suggestions to minimize crop damage (n answering= 368, n not answering= 59)

Discussions, Conclusions and Policy Implications

The human/elephant conflict in the Waza-Logone region has resulted from increase in the human population and expansion of agricultural land combined with the increase in elephants. Rural communities suffer chronic depredations in the Kaélé and Mindif areas and are unable to overcome the problems. The annual average crop loss per farmer is about half the local per capita income estimated at US$ 200 (PRODIEX, 1993).

The only strategy actually used by the wildlife authorities to alleviate crop damage is the indiscriminate killing of elephants in the areas affected by the human-elephant conflict. There are plans for developing a control shooting programme (Yadji Bello, Director of Wildlife and Protected Areas, pers. com.). Quantitative evaluation of control shooting has not been carried out so far and there is no evidence that it reduces the magnitude of the damage (Balakrishnan & Ndhlovu, 1992). The only major benefit of control shooting, therefore, is meat but in the Waza-Logone region most of the meat is shared between administrative, political, military, and wildlife authorities, and is therefore no compensation to the local communities.

The negative attitudes towards both elephants and the wildlife authorities are generated as a result of crop damage by elephants and the lack of compensation. There is certainly more discussion and publicity about the damage and an increased expectation by complaint regarding compensation. As a result, farmers tend to overestimate the damage.

The villagers hoped that the wildlife authorities would find solutions that would prevent elephants from moving out of 'government' parks. They also requested material support (*i.e.* assistance to local schools and hospitals) from foreign donors and conservation bodies. From a moral and economic perspective, it is not appropriate to destroy large and economically valuable mammals such as elephants when the value of the damaged crop (to the overall economy) is relatively small. To minimise human/elephant conflicts in the Waza-Logone region the following issues need to be addressed:

1. The effects of shooting to disturb and to kill selected culprit elephants should be evaluated and the Wildlife and Protected Areas Department should be better staffed and equipped to a 'problem animal control' program.
   At the beginning of the rainy season, a full-time team of technicians and local informants could defend the farms located in the vicinity of Waza National Park to avoid the dispersal of animals further into the region.
2. Limited wet season safari hunting could be opened in the Kaélé and Mindif areas. Positive attitudes could be produced if meat from culled elephants was offered to farmers and part of the revenue from professional hunting used locally to improve people's socio-economic conditions.

3. Cost-benefit analyses should be undertaken to compare consumptive with non consumptive use. At present it appears that the costs of elephants through human and crop losses outweighs the benefits from elephant-viewing tourism. Improvement of the infrastructure and management of Waza National Park could provide revenues some of which could be used to alleviate the antagonism between humans and elephants.
4. A conservation education program should be designed for the villagers in order to increase their awareness of the touristic potential of the region and the importance of natural resource conservation.
5. A good understanding of elephant movement patterns and home ranges is a prerequisite for limiting or influencing elephant movements. Physical barriers (Hoare & Mackie, 1993) could be planned through consultations between representatives of the four main spheres of interest: wildlife management, agriculture, livestock and local government (Thouless & Sakwa, 1995). However their uses may be limited by their cost and the scattered nature of local croplands. Also, it may not prove to be the most appropriate or acceptable method by the local communities (IUCN, 1989). Efforts should be concentrated towards establishing the location of elephants in dry and rainy season ranges and understanding the causes of their movements. If possible the factor determining their movements could then be manipulated to limit the movements and reduce human elephant conflicts.
6. Paying compensation could increase the tolerance level of local farmers towards elephants. However, compensation is open to considerable abuse. In addition, assessors would require special training to avoid overestimation of damage. The socio-economic hardship of Cameroon leaves little hope at present that the local administration will find funds to compensate farmers. The development of a community based natural resource management programme like the CAMPFIRE programme in Zimbabwe (Taylor, 1993) is a more promising approach towards increasing the tolerance level of farmers towards elephants than the development of a compensation system. The programme could be mainly directed towards combining problem animal control with sustainable safari hunting and zonation of land use for other wildlife management activities and agriculture. Assistance from international bodies should be sought.

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Part IV

Factors Influencing Elephant Movements

Elephant movements were followed with the help of satellite/VHF radio transmitters

4.1

Habitat Selection by Elephants in Waza National Park, Cameroon

Summary

Habitat use by elephants was investigated with dung pile counts. The distribution of dung piles was significantly different from random during the dry season, but not significantly different during the wet season. The *Acacia seyal* shrubland was the habitat most preferred during the dry season. During the wet season the floodplain became the favoured elephant habitat. Analysis of the annual habitat preference suggests that the *Acacia seyal* shrubland was the most preferred habitat and the woodland the least preferred. Continued monitoring of the *Acacia seyal* shrubland is recommended.

Introduction

The delicate balance between available water, rainfall and vegetation in the soudano-sahelian region determines to a large extent the long term survival of animal populations. Seasonal changes in distribution and habitat selection of elephants (*Loxodonta africana* Blumenbach) has been well documented in eastern and southern Africa (Laws, Parker & Johnstone, 1975; Williamson, 1975; Leuthold, 1977; Western & Lindsay, 1984; Kalemera, 1989; Viljoen, 1989; Kabigumila, 1993) and coincide with seasonal climatic changes and the corresponding changes in food and water availability. Few data are available on the habitat utilization patterns of elephants in central and western Africa (Ruggiero, 1992; Tchamba & Seme, 1993; White *et al.*, 1993). The data presented here describe aspects of habitat selection by savanna elephants in Waza National Park, northern Cameroon. The major objective was to determine which habitat types are the most important for these elephants in terms of their survival and habitat utilization in different seasons. This is a part of a larger study on the ecology of the African elephant and the interaction with people in the Waza-Logone region of Cameroon (Tchamba, 1993). The information presented here should improve the understanding of factors influencing elephant movement patterns, and lead to the design of suitable habitat management strategies.

Study Area and Methods

Details on the study area are given in Chapter 1.2. For the purpose of this study, three habitat types are recognised in the Waza National Park, each depicting an area with homogeneous vegetation and physiognomy (Wit, 1975; Esser & Van Lavieren, 1979) (Fig. 4.1). These three habitat types are described in chapter 2.2.

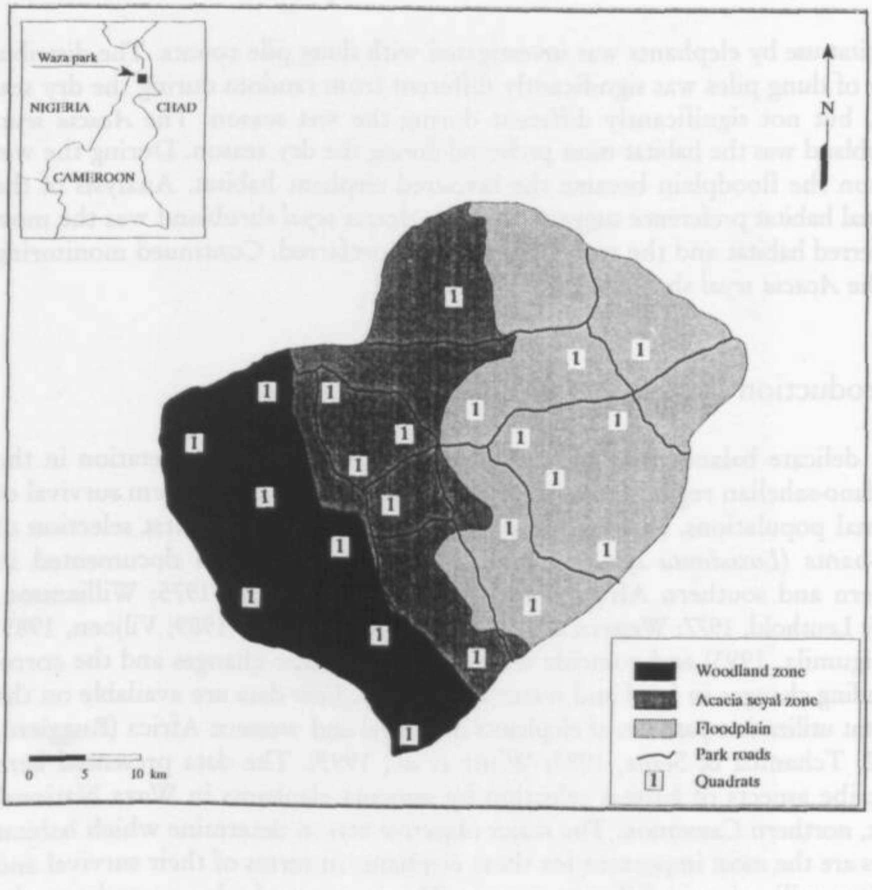

Figure 4.1
Major habitat types of Waza National Park and location of the sample quadrats

From January 1993 to December 1994, habitat use by elephants was investigated with dung pile counts. Dung counts have been widely used as an index of elephant abundance (Wing & Buss, 1970; Short, 1983; Merz, 1986; Barnes & Jensen, 1987; Tchamba, 1992; Michelmore *et al.*, 1994). Jachmann (1984) tested different methods of counting elephants on the Nazinga Ranch, Burkina Faso, and found that a dropping count using the steady state assumption gave the most accurate and most precise estimate. Dung counts have the advantage that the distribution of dung at any moment represents the accumulated distribution of elephants over the preceding period.

Inorder to estimate the rate of accumulation of droppings, twenty two quadrats, each of 200 x 20 m (0.4 hectare) were marked with plastic markers and paint on trees, and examined at six weeks intervals. Quadrats could be easily located by choosing a reference point on each quadrat and knowing its position indicated by the Geographical Positioning System (GPS). Out of 22 quadrats in total, the number in each habitat type was in direct proportion to its size (7, 6, and 9 quadrats in the woodland zone, the *Acacia seyal* zone savanna and the floodplain, respectively). The quadrats were chosen randomly. However, if a quadrat fell less than 0.5 km from a waterhole or 0.1 km from a road, it was excluded from the study. Elephants tend to use roads and the immediate vicinity of waterholes more intensively (Bos & Bus, 1992).

Dung counts in each quadrat were executed by four persons, walking at 5 m intervals. Each person counted the droppings on his right hand side only. All elephant droppings were counted. A dropping was taken as one pile of boli. The droppings were thrown outside of the quadrats to avoid double counting. It took about 25 min to complete the count in each quadrat. In addition it took about 1 hr to drive or walk between two quadrats, so four to five quadrats were completed in a day. One of the limitations of this study is that dung pile counts were interrupted between August and October because of the inaccessibility of the park during the flooding.

The data were analyzed as follows: to evaluate the elephants' habitat preference, the number of droppings per hectare in each habitat was calculated on a seasonal and a yearly basis. A preference index (P.I.) was calculated for each habitat type with an equation adopted from Viljoen (1989) where the value obtained ranges from -1.0 to +1.0, indicating the least and the most preferred areas respectively. A value of zero indicates a random association, a value of -1.0 indicates that the area was not utilized at all, and a value of +1.0 indicates a continued presence in the given area. The best available habitat for elephants is that in which elephants are observed most frequently, occur in the highest density and show the highest preference in relation to the elephants' overall distribution and the sizes of the different habitats (Viljoen, 1989).

Four variables were used in the calculations, namely:

n_x = the number of droppings per ha in habitat 'x'.
N = the sum of droppings per ha for all habitats.
a_x = the surface area of habitat 'x' (km^2).
A = the total area (km^2) of the park.

$$\text{If } n_x/N > a_x/A, \text{ then } P.I._x = \frac{1}{1 - a_x/A} \times (n_x/N - a_x/A),$$

$$\text{If } n_x/N < a_x/A, \text{ then } P.I._x = \frac{1}{a_x/A} \times (n_x/N - a_x/A).$$

A chi-square test (Sokal & Rohlf, 1981) was used to assess deviation of observed use from expected use defined by a homogenous use model (habitat use linearly related to habitat size). Subsequently, bonferroni intervals were calculated to test the deviation of use from a homogenous use model for each separate habitat (Sokal & Rohlf, 1981).

Results

Annual habitat preference

Dung pile distribution was significantly different from random (X^2=20.3); P<0.001). The preference index was highest for the shrubland and lowest for the woodland, use of these habitats differed significantly from the homogenous use model (Table 4.1). The absolute number of droppings indicates that elephants used the floodplain more than the shrubland, but the large size of the floodplain accounts for the higher value of the preference index for the shrubland. Floodplain use was not significantly different from the homogenous use model (Table 4.1).

Seasonal habitat utilization

The distribution of dung piles was significantly different from random during the dry season (X^2=28.7; P<0.001). Table 4.1 shows a high preference index for the shrubland during the dry season, and extremely low indices for the other habitat types; usage was significantly different from a homogenous use model in all habitats. When the wet season set in, the availability of water and green grass increased rapidly throughout the park and elephants were dispersed more, distribution of dung piles was not significantly different from the random ($X^2 = 1.92$; n.s.). Use of the floodplain and shrubland was not significantly different from the homogenous use model, use of the woodland was lower than expected from the model (Table 4.1). The floodplain became the favoured elephant habitat during the wet season. An increased utilization of the woodland savanna was observed during the wet season, but this habitat remained the least preferred elephant habitat.

Table 4.1
Habitat utilization by elephants in Waza National Park, Cameroon

Season	Habitat	Dung piles	Piles/ha	Preference index	95% Bonferroni interval for observed proportion of usage (p_{obs})	Expected proportion of usage (p_{exp})
Dry	woodland	8	2.8	-0.72	$0.015 \leq p_{obs} \leq 0.157$	0.312*
	shrubland	54	22.5	0.56	$0.561 \leq p_{obs} \leq 0.800$	0.269*
	floodplain	28	7.8	-0.44	$0.128 \leq p_{obs} \leq 0.342$	0.419*
Wet	woodland	14	5.0	-0.40	$0.084 \leq p_{obs} \leq 0.291$	0.312*
	shrubland	20	8.3	0.06	$0.190 \leq p_{obs} \leq 0.435$	0.269
	floodplain	48	13.3	0.14	$0.368 \leq p_{obs} \leq 0.632$	0.419
Both	woodland	22	7.9	-0.58	$0.070 \leq p_{obs} \leq 0.193$	0.312*
	shrubland	74	30.8	0.34	$0.424 \leq p_{obs} \leq 0.607$	0.269*
	floodplain	76	21.1	-0.11	$0.266 \leq p_{obs} \leq 0.440$	0.419

* P_{exp} outside 95% Bonferroni interval, indicates statistically significant deviation from the homogeneous use model.

Discussion and Conclusions

The *Acacia seyal* zone is clearly the best available habitat for elephants in Waza National Park. It would be misleading not to mention that dropping counts were not carried out in August and September, elephant distribution could have been different at that time. This is unlikely, however, since earlier observations had similar results (Esser & Van Lavieren, 1979; Meijvogel & Ekobo, 1979; Tobias & Vanpraet, 1980).

During the dry season, the widely distributed natural waterholes dry up completely and water is available only in two artificial waterholes which are filled with groundwater mechanically. These two waterholes are located in the *Acacia seyal* shrubland and, in addition to the nutritional value of *Acacia seyal*, most probably play a key role in the attractiveness of this habitat. The woodland zone, with no permanent waterhole, was largely not selected. The increased utilization of the floodplain and woodland during the wet season is an indication of optimal utilization of resources by elephants. This important mechanism for survival has been described for many elephant populations (*e.g.* Laws, Parker & Johnstone, 1975; Williamson, 1975; Leuthold, 1977; Barnes, 1982; Western & Lindsay, 1984; Kalemera, 1989; Viljoen, 1989).

Weir (1972) noted that the spatial distribution of elephants during the dry season was influenced by the distribution of sodium-rich water. It is generally accepted that water availability and distribution are the most important factors affecting or limiting elephants' movements (Laws, Parker & Johnstone, 1975; Moss, 19884; Ruggiero & Fay, 1994). The results of this study indicate that this assumption is true for the dry season distribution of elephants in Waza National Park. During the wet season, avoided vegetation types such as the woodland savanna are utilized to a greater extent as the availability of food and water improves. In addition, a large number of elephants leave the park and migrate over 100 km to the Kaélé woodlands in the south where they come into conflict with agriculture (Tchamba, 1993). Therefore, it seems that the availability and quality of vegetation are the major factors influencing the habitat choice during the wet season, when water is not a limiting factor.

Seasonal changes in the diet of the elephants is well documented (Williamson, 1975; Barnes, 1982; Viljoen, 1989; Ruggiero, 1992; Kabigumila, 1993; Tchamba & Seme, 1993; White *et al.* 1993). In areas with diverse habitat types, these changes are related to food preference. An assessment of feeding habits during both the dry season and the wet season in Waza National Park would certainly lead to a better understanding of habitat selection and consequently contribute to predicting elephant movements.

Steehouwer & Kouahou (1988) noted that elephants spent more time in the *Acacia seyal* habitat of Waza National Park where more than 25% of the shrubs exceeded the 75% damage level, a doubling compared to 1978 when 11% was browsed at that level. In 1993, Tchamba (1995) found that 38% of the shrubs were browsed at that level. The results of this study underline the need to monitor the *Acacia seyal* shrub savanna. The *Acacia seyal* is the most preferred elephant habitat and might come under greater pressure with the increasing elephant numbers and the local changes in hydrological conditions.

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4.2

Seasonal Forage Utilization by Elephants in the Waza-Logone Region, Cameroon

Summary

Observations on seasonal forage utilization by elephants were made from October 1993 to September 1994. The elephants' diet comprised at least 45 wild plant species and five cultivated crops. Trees represented 60% of the species fed upon. Elephants mostly by browsed during both the dry season and the wet season although grazing doubled during the wet season. *Acacia spp*. and *Pennisetum spp*. were the main components of the elephants' diet during the dry season and the wet season respectively. *Balanites aegyptiaca, Piliostigma reticulatum, Acacia seyal* and *Acacia nilotica* were the most preferred woody plant species. Fruit of at least 18 wild plants and five cultivated crops is eaten and the remains of at least one species of fruit were found in 53% of 340 fresh dung piles searched over a one-year period. Seventy-two percent of dung piles contained the remains of sorghum *Sorghum bicolor* during the wet season, the period when human/elephant conflict is at its peak. It is speculated that elephants' wet season migration to areas with favoured natural habitat interspaced with cropland is in conformity with expectations of optimal foraging strategy in terms of nutritive values of food and water availability.

The study concludes with a recommendation for chemical analyses of different components of plant species fed upon by elephants in order to determine if secondary properties or nutritional suitability of plants are factors that could influence elephants' migration patterns.

Introduction

The African elephant (*Loxodonta africana* Blumenbach) is described as a keystone species because of its considerable effects on vegetation dynamics and structure (Western, 1989). Numerous studies on feeding habits have shown that proportions of various plant categories in the diet vary widely from one region to another, and from one season to another (Barnes, 1982; Kalemera, 1989;

Ruggiero, 1992; Kabigumila, 1993; Tchamba & Seme, 1993, White, Tutin & Fernandez, 1993). Sukumar (1990) and Tchamba & Seme (1993) indicated that elephant feeding on crops was related to seasonal movement and optimal foraging strategy. The 'optimal foraging theory' (Pyke *et al.*, 1977), applied for elephants feeding habits, assumes that the fitness of a foraging animal is a function of the efficiency of foraging in terms of (1) energy maximisation, (2) nutrient maximisation, and (3) secondary properties (succulence, medicinal properties, etc) (Sukumar, 1990). It is known that elephants are generalist feeders, consuming a large number of plant and crop species (White *et al.*, 1993). Knowledge of feeding preference and nutritive requirements is essential in planning for habitat management, especially management towards the reduction of human/elephant conflicts.

The present study was undertaken to determine seasonal forage utilization by elephants in relation to their movements, the major source of conflict with agriculture. Earlier papers described elephant damage to the natural vegetation (Tchamba, 1995[a]), and crop raiding pattern (Tchamba, 1[b]995). This paper describes the species composition of the elephants' diet and the seasonal patterns of use of plant species.

Study Area

The Waza-Logone region (Fig. 1.1) has been described in detail in Chapter 1.2. It contains floodplain contains one of the largest elephant population (1,100 individuals) in the soudano-sahelian region (Tchamba, 1993). During the dry season, elephants' distribution is limited to Kalamaloué and Waza National Parks. At the onset of the rains, a large number of elephants leave Waza National Park and migrate over a 100 km south to the Kaélé region that has become a wet season habitat for part of Waza elephants (Tchamba, 1993). Crop damage in this region with harsh socio-economic conditions is a major constraint on local options and motivations towards conservation of the elephant population.

The Kaélé region is a mosaic of cropland (mainly *Sorghum bicolor*), woodland savanna dominated by *Combretum spp.*, *Feretia apodenthera*, *Acacia dudgeoni* and *Anogeissus leiocarpus*, and shrub savanna consisting primarily of *Acacia seyal* and *Piliostigma reticulatum*. The vegetation of Waza National Park has been described in detail by Esser & Van Lavieren (1979). It comprises a woodland savanna dominated by *Sclerocarya birrea*, *Lannea humilis* and *Anogeissus leiocarpus*, an *Acacia seyal* shrub savanna, and a floodplain grassland consisting of annual grasses such as *Sorghum arundinaceum*, *Melocia corchoriflora* and *Celosia argenthea*. Climatic factors together with the construction of a dam at Maga for the SEMRY II rice project have disrupted the region's hydrological system and have led to the desiccation of the floodplain. Consequently, perennial grasses such as *Vetiveria nigritana* have been replaced by annual grasses (Oijen & Kemdo, 1986).

Methods

Data were gathered between October 1993 and September 1994. Observations were made in Waza National Park during the dry season (December 1993 to May 1995). As the park was inaccessible during the wet season and a herd of elephants moved to the Kaélé region, observations were made in this region. Observations of elephant feeding preference were made using the 'instantaneous sampling technique' (Rollinson *et al.*, 1956) at five-minute intervals. Visual contact was sustained with an individual amongst a randomly selected small group (less than 15 individuals). Only records on adult elephants were included. The first animal seen or the closest one at the beginning of data collection was used as focal animal for that observation. Details about the focal animal such as sex, approximate age, and associations were recorded. Notes on plant species and parts eaten were kept. Nine categories of plant parts were considered : leaves and inflorescence, leaf bases, leaves, twigs, shoots, bark, wood, roots, and fruits (Kabigumila, 1993). Viewing distance from the roof of a vehicle or from tree stumps varied from of 20-50 m using standard 7 x 50 binoculars, and observations were sustained as long as possible provided that the subjects were not alarmed or disturbed.

Through a series of 22 and 12 quadrats in the Waza National Park and the Kaélé region, respectively, the abundance (relative density) of woody plant species were determined. The quadrats 200 x 20 m (0.4 hectare) were chosen randomly in the core of the occupied area and walked by 4 persons who counted and identified all woody plant species. It was difficult to obtain consistent estimates of the cover of different grass species because of the high rate of change and also most species are widely scattered.

Direct observations were complimented by the examination of fresh dung piles. Dung piles were randomly collected and examined for grass, woody material, fruit and seed content in the laboratory. The different fragments were picked from dung piles as each was broken apart and spread out using a stick, and weighted.

The number of times elephants were recorded eating different plant species was expressed as a percentage of the total feeding record during each season. For each season, the percentage of plant parts eaten (number of times being eaten in relation to total feeding records) which were considered rich in metabolic constituents (*e.g.* leaves, shoots, flowers, fruits) was calculated to determine the Food Quality Index (FQI) of the elephants' diet (Bell, 1980). The Spearman's rank correlation coefficient (Steel & Torrie, 1980) was used to test the significance of the correlation between the frequency of feeding on a woody species and its relative abundance. Thus, preference ratios for the most dominant woody plant species were calculated by using the following equation adopted from Petrides (1975) and Ishwaran (1983):

$$\text{Preference ratio (PR)} = \frac{\text{Percentage frequency of occurrence of plant species in the elephant's diet}}{\text{Percentage plant species availability}}$$

The species fed on were added together as two food types (woody plant and grass) and the percentage kept separate. Browsing was considered as feeding on woody plants. Grazing describes feeding on grasses or other non-woody material on the ground. The percentage of dung piles containing grass, woody material, fruits or any combination of these elements was calculated. The Mann-Whitney U test was used to determine significant differences between the dry season and the wet season in the variety of wild plant eaten, the variety of fruits and seeds eaten, and the preference ratio values of some tree species, respectively (Steel & Torrie, 1980). A Chi-square test was used to compare feeding types during the dry season and the wet season (Steel & Torrie, 1980).

Results

Wild plants and parts eaten

Forty-six and 27 individual elephants were observed for periods of 1-3 h (mean = 1.25 h) during the dry and wet seasons, respectively (18 males and 28 females, and 10 males and 17 females, respectively). There were a total of 960 feeding records (526 and 434 during the dry and wet seasons, respectively). Within the study area 45 plant species eaten by elephants in the wild were recorded (Table 4.2). The most commonly eaten plants were from 4 families: Mimosaceae, Graminae, Caesalpiniaceae and Balanitaceae. These taxa accounted for 49%, 21%, 9%, and 6% (dry season), and 41%, 41%, 6%, and 4% (wet season) of the feeding records respectively. Although there is a tendency for more eating of grass during the wet season, the variety of wild plants eaten was apparently not significantly different between the dry season and the wet season ($Z = -0.59$; $P > 0.05$). Table 4.3 and Table 4.4 indicate that during both the dry season and the wet season, elephant feeding frequency on dominant woody plant species was not significantly related to their relative density ($r = 0.12$; $P > 0.05$ and $r = -0.23$; $P > 0.05$ respectively).

Table 4.2

Occurrence of plant species in the elephant's diet.
n = total number of feeding records. (% = percentage frequency)

Food species	Dry season (%)	Wet season (%)	Part eaten
WOODY PLANTS			
Acacia dudgeoni	-	7.5	T, B, L, W, F
Acacia nilotica	-	8.4	T, B, L, W, F
Acacia seyal	48.6	19.2	T, B, L, W, F
Adansonia digitata	0.1	-	B
Anogeissus leiocarpus	-	0.1	L
Balanites aegyptiaca	8.6	5.9	F, L, B, W
Cadaba farinosa	0.7	0.2	L
Cassia singuena	-	1.2	F, L
Combretum aculeatum	0.5	0.4	L
Combretum glutinosum	1.2	1.3	L, B, W
Crateva adansonii	3.3	-	F, L, B, W
Detarium microcarpum	-	0.2	L, R, B
Dichrostachys cinera	-	0.3	L
Entada africana	-	5.8	R, B
Feretia apodenthera	-	0.1	L, T, S
Grewia venusta	-	0.3	L
Guiera senegalensis	0.7	1.1	L
Kigelia africana	0.5	0.3	L, W
Lannea humilis	0.5	-	L, B, W
Mitragyna inermis	3.2	-	L, B, W
Piliostigma reticulatum	5.6	3.8	F, L, B, R
Prosopis africana	0.1	0.5	B
Sclerocarya birrea	0.1	-	B
Stereospermum kunthianum	-	0.2	B, F, L
Tamarindus indica	3.2	0.2	F
Terminalia avicennioides	1.0	-	L
Ziziphus mauritiana	0.1	-	L
GRASSES & FORBS			
Aeschynomene indica	0.2	1.2	A
Blepharis linarifolia	0.2	1.6	A
Borreria stachyda	0.2	1.0	A
Chloris pilosa	0.2	0.5	A

Table 4.2
Occurrence of plant species in the elephant's diet.
n = total number of feeding records. (% = percentage frequency)

Food species	Dry season (%)	Wet season (%)	Part eaten
Cyperus iria	1.5	-	A
Diheteropogon hagerupii	0.2	0.1	A
Echinocloa colona	1.7	3.5	A, R
Echinocloa optuciflora	0.2	-	A, R
Echinocloa stagnina	2.8	3.4	A, R
Hibiscus abelmenshus	0.3	-	A
Hyparrhenia dissoluta	0.2	7.9	A, R
Ipomea aquatica	0.2	-	A
Pennisetum pedicellatum	0.2	9.3	A, R
Pennisetum ramosum	0.3	7.8	A, R
Setaria pumila	0.2	-	A
Sorghum arundinaceum	11.8	-	L, A
Sporobulus festivus	0.2	3.2	A, R
Vetiveria nigritana	1.4	3.5	A, R
FOOD QUALITY INDEX (FQI)	41.8%	89.3%	
n	526	434	

Key: A = leaves and inflorescence; B = bark; F = fruits; L = leaves; S = leaf bases; R = roots; T = twigs; W = wood.

Acacia seyal constituted the main component of the elephants' diet during both the dry season and the wet season. In addition, elephants fed intensively on *Acacia nilotica* and *Acacia dudgeoni* during the wet season. There was no significant difference in the preference ratio values of *Balanites aegyptiaca, Piliostigma reticulatum* and *Acacia seyal* (the most favoured woody plant species) in the dry season and in the wet season ($Z=-0.87$; $P>0.05$) (Table 4.3 and Table 4.4). In the wet season habitat, *Acacia nilotica* was the third most preferred woody plant species, after *Acacia seyal* and *Balanites aegytiaca*. Browsing on *Entada africana* was absent during the dry season but relatively important during the wet season (10% of the browsing records).

Grazing during the dry season was primarily on *Sorghum arundinaceum* (wild sorghum) and *Echinocloa spp.* (54% and 21% of the grazing records respectively). During the wet season elephants grazed mainly on *Pennisetum spp.* and *Hyparrhenia dissoluta* (40% and 18% of the grazing records respectively). *Vetiveria nigritana* accounted for 6% and 8% of the grazing records during the dry season and the wet season respectively.

Table 4.3

Elephant feeding preference ratios for most dominant woody plant species in the dry season habitat

Woody plant species	Percentage plant availability	Percentage occurrence in the diet	Preference ratio
Acacia seyal	20.6	48.6	2.36
Guiera senegalensis	11.4	0.7	0.06
Combretum aculeatum	8.0	0.5	0.06
Combretum glutinosum	5.2	1.2	0.23
Annona senegalensis	2.0	0.0	0.00
Sclerocarya birrea	2.0	0.1	0.05
Lannea humilis	1.8	0.5	0.27
Anogeissus leicarpus	1.7	0.0	0.00
Balanites aegyptiaca	1.6	8.6	5.37
Piliostigma reticulatum	1.5	5.6	3.73

Table 4.4

Elephant feeding preference ratios for most dominant woody plant species in the wet season habitat

Woody plant species	Percentage plant availability	Percentage occurrence in the diet	Preference ratio
Combretum aculeatum	10.9	0.4	0.04
Feretia apodenthera	9.0	0.1	0.01
Acacia dudgeoni	7.3	7.5	1.03
Combretum glutinosum	6.6	1.3	0.20
Acacia nilotica	6.0	8.4	1.40
Anogeissus leicarpus	4.1	0.1	0.02
Acacia seyal	3.6	19.2	5.33
Dichrostachys cinera	3.4	0.3	0.09
Piliostigma reticulatum	3.4	3.8	1.12
Balanites aegyptiaca	3.2	5.9	1.84

Elephants ate mostly shoots, leaves and inflorescences during the wet season, and bark, wood and twigs mainly during the dry season. The FQI of the elephants' diet was more than twice as high during the wet season than during the dry season (89.3% and 41.8% respectively).

Table 4.5

List of fruits and seeds found in the dung piles of elephants during the dry season and the wet season. (Percentage of dung piles containing seeds of each species)

Species	Dry season (%)	Wet season (%)
WOODY PLANTS		
Acacia seyal	2.4	1.8
Acacia siberiana	10.7	-
Balanites aegyptiaca	45.6	10.2
Bauhinia rufescens	2.1	1.1
Crateva adansonii	1.1	-
Dichrostachys cinera	1.5	-
Mimosa pigra	0.5	-
Piliostigma reticulatum	25.7	2.5
Tamarindus indica	1.3	3.6
Ziziphus mauritiana	1.5	-
GRASSES AND FORBS		
Aeschinomene indica	0.5	-
Blepharis linarifolia	1.5	-
Borreria stachydea	4.1	-
Colocynthis spp.	1.1	-
Echinocloa spp.	-	8.7
Hibiscus spp.	12.1	-
Pennisetum spp.	-	11.4
Sporobulus festivus	-	7.9
CROPS		
Arachis hypogea	-	1.9
Pennisetum typhoides	-	33.6
Sorghum bicolor	6.3	72.2
Vigna unguiculuta	-	2.4
Zea mays	-	14.5

Fruits or seeds were important components of the elephants' diet (Table 4.5). In 18% and 21% of the feeding records during the dry season and the wet season respectively, elephants ate fruits. A total of 340 fresh dung piles were examined (150 and 190 during the dry and wet seasons, respectively). Forty-nine percent and 56% of all dung examined showed some trace of fruits or seeds during the dry season and the wet season respectively. There was apparently no significant difference in the variety of fruits or seeds found in the dung piles during the dry season and the wet season ($Z=0.08$; $P>0.05$). Fruits of *Piliostigma reticulatum, Balanites aegyptiaca* and *Hibiscus spp.* were consumed during the dry season, whereas elephants concentrated on cultivated crops during the wet season (Table 4.5).

Browsing versus grazing

The proportions of different food types in the elephants' diet are shown in Table 4.6 and Table 4.7. Feeding habits significantly differ between the dry season and the wet season ($X^2=81.32$; $P>0.05$). Browsing was much more common during both the dry season and the wet season (78% and 57% of the feeding records respectively). However, grazing almost doubled during the wet season to reach 43% of the feeding records.

The examination of dung piles indicated that woody material was present in 100% and 95% of dung piles during the dry season and the wet season respectively (Table 4.7). The mixture of grass, woody material (mainly leaves and bark) and fruit constituted the bulk of the elephants' diet.

Table 4.6

Elephants' feeding types based on direct observations
(n = total number of feeding records)

Feeding type	Dry season (n = 526) (%)	Wet season (n = 434) (%)
Grazing	116 (22)	161 (43)
Browsing	410 (78)	273 (57)

Table 4.7

Elephants' food types based on the examination of dung piles
(n = number of dung piles)

Food types	Dry season (n = 150) (%)	Wet season (n = 190) (%)
Woody material only	3 (2)	0 (0)
Woody material + grass	3 (2)	4 (2)
Woody material + fruits	15 (10)	27 (14)
Woody material + grass + fruits	129 (86)	150 (79)
Grass + fruits	0 (0)	9 (5)

Crops consumed

Six percent and 95% of dung piles contained crop seeds or fragments during the dry season and the wet season, respectively. Sorghum *(Sorghum bicolor)*, millet (*Pennisetum typhoides*), maize (*Zea mays)*, peanut (*Arachis hypogea)*, and cowpea (*Vigna unguiculuta)* were consumed by elephants during the wet season. Sorghum made the highest contribution among crops to the elephants' diet (Table 4.5).

Discussion

Analysis of forage selection by elephants shows exploitation of a relatively large variety of the species in the study area, compared to observations made elsewhere (Ruggiero, 1992; Kabigumila, 1993). There were differences in the composition of the elephant's diet between the dry season and the wet season. These differences may be partly explained by the changes in the availability of the various food items between the season. During the dry season, after the elephants have returned to Waza National Park and the grass and forbs have dried out, elephants concentrate their feeding on leaves, fruits, and barks of trees. Field (1971) suggested that elephants browse more during the dry season because crude protein content of browse is higher than that of grass. Kabigumila (1993) indicated that grass tends to accumulate tannins and rapidly becomes fibrous, thereby decreasing its palatability during the dry season. Several authors have emphasized the importance of browse in the diet of elephants (Buss, 1961; Laws, Parker & Johnstone, 1968; Williamson, 1975; Guy, 1976; Barnes, 1982; Kalemera, 1989; Kabigumila, 1993; Tchamba & Seme, 1993). Feeding on browse better enables the elephants to maintain their physical condition throughout the year, because the browse species have higher crude protein than do grasses (Field, 1971; Williamson, 1975).

The grazing records doubled during the wet season when elephants ranged in the Kaélé region. However, the proportion of grass remained lower than the amount found in the diet of elephants in eastern and southern africa. In these regions, grass often forms 60% or more of the bulk throughout the year (Field & Ross, 1976; Guy, 1976; Barnes, 1982; Van Wijngaarden, 1985). Elephants ate high-quality food parts during the wet season when there was an increase in availability of grass, forbs and crops. Given that the Kaélé region is a dense woodland with a relatively high shrub species diversity, elephants might still browse intensively during the wet season in order to obtain certain essential nutrients or amino-acids (Williamson, 1975). The frequent chewing of the roots of *Entada africana* during the wet season might be related to secondary properties of the species rather than its strict nutritional quality. The local people use the roots of this plant to treat diarrhoea and severe stomach pains. The bark is used to treat cases of accidental poisoning from food or beverages. The chewed boluses, which are discarded by elephants, are collected by women and used as sponges and hygienic towels.

Acacia spp. were commonly consumed by elephants during both the dry season and the wet season. The various species of *Acacia* have a high tannin content (De Bie, 1991). Feeding on *Acacia* may help maintain an optimum fibre:protein ratio to ensure proper digestion of protein (Laws *et al.*, 1975), supply fatty acids (McCullagh, 1973) or minerals such as manganese, iron, boron, copper and calcium (Dougall *et al.*, 1964; Laws *et al.*, 1975). Available annual grasses such as *Sorghum spp.* and *Pennisetum spp.* were consumed more than *Vetiveria nigritana*, a very nutritive and perennial grass (Oijen & Kemdo, 1986).

The fruits and seeds of at least 23 species is eaten in the region and the remains of at least one species of fruit were found in 53% of dung piles. In east Africa, Wing & Buss (1970) recorded fruit eating by savanna elephants in Kibale Forest, Uganda, where one species, *Balanites wilsoniana*, was present in 44% of dung piles inspected. Among the wild plants, fruits or seeds of *Balanites aegyptiaca* were the most common in dung piles examined in our study area. In addition, direct observations indicated that *Balanites aegytiaca* was one of the most preferred woody plant species. Similarly, White *et al.* (1993) found that *Balanites spp.* were favoured by elephants in Gabon where they occur. It is interesting to note that crop seeds were a major component of elephant dung piles during the wet season. Their regular appearance in dung piles is an indication of the occurrence of the human-elephant conflict due to elephant incursions into the farms during the wet season.

From the earlier observations of Eijs & Ekobo (1987) and Steehouwer & Kouahou (1988) it can be noted that elephants have recently changed their movement patterns (Tchamba, 1993). The desiccation of the floodplain pastures, an food source for elephants, and the degradation of natural habitat by local people whose main activity has become the exploitation of firewood that reduces the elephants' food resources, have led to the progressive expansion to the south of the elephants' home range. Degraded land in the vicinity of Waza National Park might provide motivation for elephants to move to an area which is a mosaic of favoured natural habitats and cultivated tracts. Elephants tend to avoid below optimum habitats (Kalemera, 1989; Sukumar, 1990; Kabigumila, 1993). Migration to the Kaélé region and raiding of agricultural fields might be sought as a natural optimal foraging strategy (optimization on energy and nutrients).

Elephants are known to be prone to sodium deficiency (Olivier, 1978) and to prefer water and soils rich in sodium (Weir, 1973). Because of the very low water table, drinking water for human beings and animals is very scarce in the Kaélé region during the dry season. It is possible that the scarcity of water increases the concentration of minerals in the plants of the Kaélé area. Sukumar (1990) noted that the sodium content of millet in the inflorescence stage was strikingly higher than that of wild food plants including bark analyzed. Millet could be important for elephants which are likely to be deficient in sodium.

Strategies for reducing the human-elephant conflict depend primarily on blocking or changing elephant movement patterns. The movement patterns of Waza National Park elephants might be related to limited supply of food and/or mineral deficiencies in food items inside the Park. In this case, strategies for limiting elephant movements should include the improvement of food quantity and the compensation for mineral imbalances. To improve the understanding of the seasonal forage selection in relation to movements patterns, efforts should be carried out to determine the occurrence of various chemicals (minerals, protein, secondary compounds and carbohydrates) in the wild plants and the cultivated crops consumed by elephants in the Waza-Logone region. This knowledge is essential for setting up sound ecological infrastructures that would reduce elephant movements and alleviate human-elephant conflict.

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4.3

Nutritional Value of Some Elephant Browse and Possible Relations with the Movement Patterns of Elephants in the Waza-Logone Region, Cameroon

Summary

Significant seasonal changes were not observed in the nutritional quality of elephant browse in the Waza-Logone region of northern Cameroon. Except for calcium levels, woody foliage had a better nutritional value than bark. Leaves of all sampled woody plants had crude protein levels higher than the minimum level of 5% crude protein needed for elephant maintenance. *Acacia* spp. were particularly rich in crude protein and in sodium. The nutrient concentrations were higher in the Kaélé area than in Waza National Park (Na levels were eight times higher in Kaélé), and the roots of *Entada africana* were exceptionally rich in phosphorus.

The study suggests that elephant feeding on bark in Waza National Park is related to higher Ca levels in bark than in leaves. The dry season high preference by elephants for the *Acacia seyal* shrubland of Waza National Park is due to the good crude protein level and relatively high Ca concentration of *Acacia seyal*. The frequent chewing by elephants of the roots of *Entada africana* in the Kaélé area may be related to their levels of P. It is concluded that the alternation of a favoured natural habitat, rich in nutrients, with tasty and nutritious sorghum fields is a good motive for elephants to migrate to the Kaélé region during the wet season. It is recommended that strategies to reduce the human-elephant conflict in the region include actions that will compensate for mineral imbalances in Waza National Park.

Introduction

In African dry savannas, there are large seasonal fluctuations in plant biomass and equally large and important changes in nutrient content and digestibility

(Boutton *et al.*, 1988; Georgiadis & McNaughton, 1990; Ben-Shahar, 1993). However, in contrast to grasses and forbs, the foliage of trees and shrubs does not fluctuate greatly in nutrient content (McKay & Frandsen, 1969; Owen-Smith, 1982; De Bie, 1991). In some conservation areas, limited supplies of food and/or mineral deficiencies in food items have been suggested to regulate herbivore population (Dublin *et al.*, 1990). Large herbivores optimize the utilization of their environment by adapting their behavioural patterns according to what plants are available in space and time, or by adapting their social organization (De Bie, 1991). Elephants' selective feeding behaviour changes over seasons, depending on the nutritional requirements and which food is available during that particular period (Ruggiero, 1992; Tchamba & Seme, 1993; White *et al.*, 1993).

While many studies on the seasonal variation on the nutritional value of plant species have been conducted in East Africa, few studies on plant protein and nutrient dynamics have been conducted in Central Africa. In particular, there is scanty published work on the strategies that animals adopt to cope with the seasonal variation in the quantity and quality of forage in the ecologically and economically important Waza National Park. In previous reports we have described the migration patterns of elephants (Tchamba, 1993; Tchamba *et al.*, 1995) and the seasonal forage utilization by elephants (Chapter 4.2) in the Waza-Logone region. Observations indicated that elephants feed mostly by browsing during both the dry season and the wet season. However, it was noted that grazing doubled during the wet season (Chapter 4.2). To complement studies on the factors influencing elephant movements in this region, the seasonal and site fluctuations in nutritional value of some elephant browse were investigated. This study describes the seasonal differences in the nutritional value of some elephant browse, examines the differences in browse nutritional value between Waza National Park and the Kaélé area (a wet season habitat for some Waza elephants), and relates these differences to the elephant migration patterns in the Waza-Logone region.

Study Area and Methods

The Waza-Logone region has been described in Chapter 1.2. Details on the vegetation of Waza National Park are given in (Esser & van Lavieren, 1979). Six woody plant species (*Balanites aegyptiaca, Piliostigma reticulatum, Acacia seyal, Lannea humilis, Combretum glutinosum, Combretum aculeatum*) which contributed more than 35% of the woody plant availability in the Waza National Park and more than 65% of the diet composition of elephants, and four other woody plant species (*Acacia nilotica, Acacia dudgeoni, Dichrostachys cinera, Entada africana*) which occurred only in the Kaélé area and contributed more than 27% to the wet season elephant's diet (Chapter 4.2) were selected to represent the nutritional range in browse available to elephants. Two crops (*Sorghum bicolor* and *Pennisetum typhoides*) considered to be important for their utilization by elephants in the wet season (72% and 34% respectively, of dung piles containing seeds of these species) (Chapter 4.2) were also selected for chemical analyses.

With the available time and resources the analysis was restricted to only two periods of the year and to only those plant parts likely to influence diet selection for particular nutrients. Samples were collected during 5 days in March 1993 (the height of the dry period) and August 1993 (the height of the wet period). For each area (Waza and Kaélé), five samples were collected per species at five randomly selected sites and for each species the samples were mixed to provide a single representative sample for the species. Barks, leaves and where relevant roots (only for *Entada africana*) were collected for the woody plant species.

Samples were oven dried at 110°C for 24 h, milled into powder, and stored in sealed plastic bags for later analysis. These samples were analyzed for:

1. the percentage of ash and organic material, using standard AOAC (1980) procedures;
2. the percentage of neutral-detergent fibre (NDF), using the Van Soest-method (Van Soest, 1982). The fraction of cell content was assumed to be the difference between total organic matter and NDF (Van Soest, 1982);
3. the nitrogen concentration using the Kjeldahl analysis; crude protein concentration was calculated by multiplying the percentage nitrogen by 6.25 (AOAC, 1980);
4. the organic matter digestibility (OMD) following the procedure of Van Soest (1982);
5. the mineral contents by wet-ashing the samples, followed by readings on atomic absorption spectrophotometry.

All results were expressed in percent dry weight. Kruskal-Wallace test was used to test for differences between sample periods, between plant parts, and between areas (Waza National Park and Kaélé) (Sokal & Rohlf, 1969).

Results

Seasonal, plant part, and site differences

In Waza National Park, analysis of variance revealed that only the concentration of ash in bark and leaves differed significantly between the dry season and the wet season (Table 4.8), with higher levels in the wet season. Highly significant differences between bark and leaves occurred for Ca concentrations. Bark tended to have higher Ca levels than leaves, ranging from 2.07% to 5.12%. The concentrations of ash, and NDF were lower in leaves (ranging from 4.5% to

14.8% and 24.6% to 72.4% respectively) than in bark, and the concentrations of OMD, crude protein and cell contents were higher in leaves (ranging from 25.8% to 65.4%, 11.7% to 20.3%, and 12.8% to 70.9% respectively) than in bark (Table 4.9).

Table 4.8

Comparison of the mean nutritional properties of plant samples collected in Waza National Park between the dry season and the wet season (n = 12 for each season, all results are expressed in % dry weight, OMD = Organic matter digestibility, NDF = Neutral detergent fibre)

Nutritional property	Plant part	Season		Kruskal-Wallis tests	
		Dry	Wet	Season	Plant parts
Ash	Bark	12.20	15.13	*	*
	Leaves	7.95	12.53	*	
OMD	Bark	23.37	20.29	N.S.	*
	Leaves	45.50	49.83	N.S.	
NDF	Bark	71.28	72.45	N.S.	N.S.
	Leaves	54.10	57.35	N.S.	
Crude protein	Bark	6.24	6.92	N.S.	*
	Leaves	14.89	15.09	N.S.	
Cell contents	Bark	16.50	12.43	N.S.	*
	Leaves	37.95	30.12	N.S.	
P	Bark	0.115	0.138	N.S.	N.S.
	Leaves	0.273	0.303	N.S.	
Na	Bark	0.027	0.012	N.S.	N.S.
	Leaves	0.003	0.005	N.S.	
K	Bark	1.09	0.79	N.S.	N.S.
	Leaves	1.61	1.52	N.S.	
Ca	Bark	3.53	3.56	N.S.	**
	Leaves	0.96	1.20	N.S.	
Mg	Bark	0.22	0.41	N.S.	N.S.
	Leaves	0.25	0.26	N.S.	

* $P < 0.05$, ** $P < 0.005$, N.S., not significant.

In the Kaélé area, where samples were collected only during the wet season, leaves tended to have better nutritional value than bark. Levels of only four properties did not vary significantly between bark and leaves (ash, Na, Ca, Mg) (Table 4.10). Levels of NDF were significantly lower in the leaves (ranging from

26.2% to 71.5%) than in the bark. Concentrations of OMD, crude protein, cell contents, P and K were significantly higher in the leaves (ranging from 29.4% to 63.5%, 10.9% to 20.2%, 11.6% to 63.4%, 0.28% to 1.54%, and 1.87% to 2.37% respectively) than in the bark (Table 4.11).

Table 4.9

Nutritional properties of plant samples collected in Waza National Park during the dry season and the wet season (all results are expressed in % dry weight, OMD = Organic matter digestibility, NDF = Neutral detergent fibre)

Nutritional property	Plant part	*Balanites aegyptiaca*		*Piliostigma reticulatum*		*Acacia seyal*		*Lannea humilis*		*Combretum glutinosum*		*Combretum aculeatum*	
		Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Ash	Bark	12.4	18.6	12.9	14.5	12.8	14.5	12.7	14.7	13.4	16.8	9.0	11.7
	Leaves	8.3	13.5	5.5	14.8	4.5	9.6	11.6	13.3	6.6	9.7	11.2	14.3
OMD	Bark	20.8	21.1	9.2	9.2	18.2	18.6	20.1	22.3	35.1	35.9	36.8	36.9
	Leaves	60.3	65.4	33.9	36.4	60.8	63.7	25.8	34.3	45.7	49.4	46.5	49.8
NDF	Bark	78.6	79.4	80.3	81.2	65.2	65.4	64.3	65.8	78.8	78.7	60.6	64.2
	Leaves	51.7	60.2	66.1	72.4	24.6	25.7	63.3	65.4	65.9	66.1	53.0	54.3
Crude protein	Bark	4.9	8.2	3.4	3.7	4.1	4.2	3.2	3.3	9.5	9.7	12.3	12.5
	Leaves	19.9	20.3	11.7	11.8	15.4	15.6	12.8	12.9	12.2	12.6	17.3	17.4
Cell contents	Bark	9.0	2.0	6.8	4.3	22.0	20.1	23.0	19.6	7.8	4.5	30.4	24.1
	Leaves	40.0	26.3	12.8	28.4	70.9	64.7	25.1	21.3	27.5	24.2	35.8	31.4
P	Bark	0.05	0.07	0.06	0.10	0.03	0.05	0.17	0.21	0.19	0.18	0.19	0.22
	Leaves	0.59	0.62	0.19	0.23	0.22	0.25	0.24	0.27	0.13	0.16	0.27	0.29
Na	Bark	0.02	0.00	0.02	0.02	0.02	0.00	0.07	0.03	0.03	0.02	0.00	0.00
	Leaves	0.00	0.00	0.00	0.01	0.00	0.00	0.02	0.01	0.00	0.01	0.00	0.00
K	Bark	0.71	0.69	0.57	0.45	0.68	0.43	0.94	0.89	2.07	1.11	1.58	1.17
	Leaves	1.90	1.86	1.44	1.37	1.03	0.96	1.40	1.36	2.57	2.49	1.32	1.09
Ca	Bark	4.53	5.12	4.01	3.96	4.36	3.87	3.50	3.33	2.66	3.04	2.13	2.07
	Leaves	1.37	2.38	0.61	0.97	0.65	0.96	1.67	0.98	0.32	1.10	1.12	0.82
Mg	Bark	0.09	1.02	0.41	0.37	0.09	0.17	0.38	0.41	0.21	0.33	0.16	0.19
	Leaves	0.42	0.36	0.23	0.15	0.21	0.34	0.25	0.37	0.17	0.09	0.24	0.26

During the wet season, there were no marked differences in nutritional properties of bark between Waza National Park and the Kaélé area (Table 4.10). By contrast, levels of four important elements (P, Na, K, Mg) were significantly higher in the leaves collected in the Kaélé area than in those collected in Waza National Park (Table 4.10).

Table 4.10

Comparison of the mean nutritional properties of plant samples collected in Waza National Park (n = 12) and in Kaélé (n = 14) during the wet season (all results are expressed in % dry weight; OMD = organic matter digestibility, NDF = neutral detergent fibre)

Nutritional property	Plant part	Site		Kruskal-Wallis tests	
		Waza	Kaélé	Site	Plant-part (Kaélé)
Ash	Bark	15.13	14.10	N.S.	N.S.
	Leaves	12.53	10.77	N.S.	
OMD	Bark	20.29	18.17	N.S.	*
	Leaves	49.83	47.69	N.S.	
NDF	Bark	72.45	73.80	N.S.	*
	Leaves	57.35	51.46	N.S.	
Crude protein	Bark	6.92	5.99	N.S.	**
	Leaves	15.09	15.12	N.S.	
Cell contents	Bark	12.43	12.10	N.S.	*
	Leaves	30.12	37.77	N.S.	
P	Bark	0.138	0.014	N.S.	**
	Leaves	0.303	0.610	*	
Na	Bark	0.012	0.014	N.S.	N.S.
	Leaves	0.005	0.030	**	
K	Bark	0.79	0.68	N.S.	**
	Leaves	1.52	2.08	*	
Ca	Bark	3.56	2.21	N.S.	N.S.
	Leaves	1.20	1.39	N.S.	
Mg	Bark	0.41	0.37	N.S.	N.S.
	Leaves	0.26	0.46	*	

* $P < 0.05$, ** $P < 0.005$; N.S., not significant.

Nutritional properties of selected plant species

Leaves of *Balanites aegyptiaca*, the most preferred elephant food item (Chapter 4.2) had exceptionally high levels of OMD, crude protein, and cell contents (60.3%, 19.9%, and 40% respectively) (Table 4.9). Leaves of *Acacia* spp. appeared to have relatively good nutritional values, with significantly higher than average Na concentrations for *Acacia dudgeoni* (0.05%, $P < 0.05$). The crude protein contents of the leaves were higher in *Balanites aegyptiaca* and *Acacia* spp. than in cultivated crops (14.5% in *Sorghum bicolor*, 13.8% for *Pennisetum* *bicolor*). Leaves of *Combretum aculeatum* was also particularly rich in crude protein (17.3%). *Combretum glutinosum* was characterized by low crude protein and cell contents levels but had the highest concentrations of K in both the bark (2.07%) and the leaves (2.57%) (Table 4.9). *Piliostigma reticulatum* and *Lannea humilis* had also lower than average levels of crude protein and cell contents ($P < 0.05$) . However, their bark had significantly high Na contents (0.02% and 0.07% respectively) and the highest Mg concentrations (0.41% for each, $P < 0.05$) (Table 4.9).

Table 4.11

Nutritional properties of plant samples collected in Kaélé during the wet season (all results are expressed in % dry weight; OMD = Organic matter digestible, NDF = Neutral detergent fibre)

Plant species	Plant part	Ash	OMD	NDF	Crude prot.	Cell cont.	P	Na	K	Ca	Mg
Acacia	Bark	13.9	19.2	64.9	5.0	21.2	0.10	0.02	0.97	2.34	0.21
seyal	Leaves	10.4	63.5	26.2	17.1	63.4	0.42	0.03	2.29	1.06	0.42
Balanites	Bark	18.4	19.7	75.7	8.9	5.9	0.09	0.00	0.85	4.96	0.97
aegyptiaca	Leaves	12.9	54.8	61.4	20.2	25.7	1.54	0.02	1.89	2.49	0.51
Acacia	Bark	12.6	15.8	73.2	5.1	14.2	0.11	0.01	0.73	0.96	0.17
nilotica	Leaves	9.3	59.7	45.6	16.1	45.1	0.47	0.02	1.90	1.62	0.24
Piliostigma	Bark	15.2	9.21	80.9	3.7	3.9	0.21	0.00	0.52	3.98	0.39
reticulatum	Leaves	16.9	35.9	71.5	10.9	11.6	0.38	0.01	1.87	1.04	0.27
Acacia	Bark	11.7	15.6	76.3	8.0	12.0	0.16	0.03	0.33	0.31	0.20
dudgeoni	Leaves	10.5	60.1	42.8	17.1	46.7	0.28	0.05	2.37	0.95	0.38
Combretum	Bark	17.1	36.8	77.5	9.5	5.4	0.13	0.01	1.01	2.09	0.40
glutinosum	Leaves	8.8	30.4	65.8	12.6	25.4	0.84	0.02	2.31	1.21	1.01
Dichrostachys	Bark	9.8	10.9	68.1	1.7	22.1	0.13	0.03	0.37	0.61	0.28
cinera	Leaves	6.6	29.4	46.9	11.7	46.5	0.37	0.06	1.93	1.40	0.40
Entada	Leaves	11.2	53.2	54.7	2.2	34.1	0.17	0.00	0.31	0.22	0.12
africana	Roots	13.5	40.9	61.2	1.1	25.3	0.95	0.02	0.77	1.23	0.08
Sorghum bicolor	Inflorescence stage	14.1	63.5	21.2	14.5	64.7	1.13	0.25	1.56	0.17	1.09
Pennisetum typhoides	Inflorescence stage	24.1	59.6	17.0	13.8	58.9	1.18	0.17	1.67	0.34	0.94

Dichrostachys cinera, a species not available for elephants in Waza National Park, had the highest concentrations of Na in the Kaélé area (0.03% for bark and 0.06% for leaves, $P < 0.05$) (Table 4.11). *Entada africana*, another species specific of the Kaélé site and whose roots are chewed by elephants, had the lowest registered crude protein levels ($P < 0.05$). However, the roots had the second highest concentrations of P (0.95%) and near average levels of Na (0.02%) (Table 4.11).

Cultivated plants (*Sorghum bicolor* and *Pennisetum typhoides*) had better nutritional qualities than wild plants. The levels of organic matter digestibility (63.5% and 59.6% respectively) and cell contents (64.7% and 58.9% respectively) were significantly higher than in most wild plants ($P < 0.05$). The concentrations of neutral detergent fibre were the lowest registered (21.2% and 17.0% respectively). In addition, levels of all but one mineral component (Ca) were significantly higher than the average concentrations in wild plants ($P < 0.05$) (Table 4.11).

Discussion

In this study, chemical analysis (except for plant secondary compounds) was performed on bark and leaves of a limited number of samples of the most preferred woody plants only, and the results should be treated with some reserve, in spite of some important findings. Significant seasonal changes did not occur in the nutritional quality of woody plants. Similar observations were made in Kenya by McKay & Frandsen (1969) and Owen-Smith (1982). Comparison of nutritional properties of bark and leaves indicated that leaves had a better nutritional value than bark. Several authors (LeHouérou, 1980; Sukumar, 1989; De Bie, 1991) have indicated that woody foliage seems to provide the protein and energy required by animals better than bark and grasses. Still, in Chapter 4.2 it was noted that considerable amounts of bark were consumed by elephants in Waza National Park. Elephants feeding on bark is not yet fully understood. Laws *et al.* (1975) suggested that, during the wet season, supplementing a diet of low-fibre grass with bark helps maintain an optimum fibre to protein ratio for a correct throughput rate to ensure proper digestion of protein. The fibre in bark may help elephants to avoid colic, to which they are prone (Eltringham, 1982). Although one study found no relationship between the degree of debarking and mineral content of plants (Anderson & Walker, 1974), the present study suggests that significantly higher calcium levels in bark than in leaves (three times higher) might be an important reason for elephant feeding on bark. Such exploitation of bark for mineral calcium by elephants is similar to the debarking of *Adansonia digitata* by elephants in Yankari Game Reserve, Nigeria (Ayeni, 1976) and exploitation of the roots of *Cochlospermum* spp. by warthogs in Kainji Lake Park, Nigeria (Amubode, 1991) for the same mineral. Male elephants calcium needs may reach up to 1.7 g/day for tusk growth alone (as tusks are 45% calcium) (Sukumar, 1989), and total needs may be 8-9 g/day for a 1000 kg male (McCullagh, 1969), which Laws et al. (1975) considered to be an underestimate.

Ungulates show a positive selection of plant species and plant parts with highest protein value (Field, 1976) or minerals such as sodium (Belovsky, 1981). Leaves of all the sampled woody plants had crude protein levels higher than the minimum level of 5% crude protein needed for elephant maintenance (Sukumar, 1989). In Chapter 4.1 it was noted that dry season elephant distribution in Waza National Park was mostly related to water availability. Elephants tended to prefer the *Acacia seyal* shrubland more than the floodplain grasslands. The present study suggests that in addition to water availability, the organic matter digestibility, the crude protein level and the mineral concentrations (particularly of calcium) of *Acacia seyal* might play a key role in attracting elephants in the *Acacia seyal* shrubland during the dry season. Protein level in grass falls below 2.5% during the dry season, which is insufficient for maintenance (Sukumar, 1989; De Bie, 1991). By contrast, various species of *Acacia* have high crude protein levels even in the dry period (Sukumar, 1989; De Bie, 1991) and can supply fatty acids (McCullagh, 1973) and minerals such as manganese, iron, boron, copper and calcium (Laws *et al.*, 1975).

Comparison of nutrient concentrations in Waza National Park and in the Kaélé area during the wet season reveals higher levels of mineral elements (sodium, phosphorus and potassium) in Kaélé than in Waza. Moreover, the levels of sodium in the leaves were more than six times higher in Kaélé than in Waza. A Ca/P ratio between 1 and 2 is generally considered optimum and values exceeding this optimum are indications of mineral imbalances (Boutton *et al.*, 1988; De Bie, 1991). Ca/P ratios at Waza National Park ranged from 2.8 to 6.8 in leaves with a mean of 4.1. At Kaélé, this ratio ranged from 1.4 to 3.4 with a mean of 2.5. There is evidence that the Ca/P ratio can be critical for some herbivores, including elephants (Ayeni, 1977; Stark, 1986). The deliberate consumption of soil by large herbivores is often thought to be a behaviour by which the animals supplement their diet with nutrient minerals, or compensate for mineral imbalances (De Bie, 1991). One of the reasons for the frequent chewing by elephants of the roots of *Entada africana* in the Kaélé area might be their levels of phosphorus. Among the wild plants, roots of Entada africana had the highest phosphorus levels and a Ca/P ratio within optimum limits (1.3). It is possible that the root of Entada africana might have a mechanism for absorbing soil calcium and phosphorus and the elephants might be probing this root for these minerals. It was noted in Chapter 4.2 that the degradation of natural habitat in the vicinity of Waza National Park may have led to the progressive expansion to the south of the elephants' home range. Present observations indicate that during the wet season when water is not a limiting factor, one reason for elephants migrating to the Kaélé area may be the search for essential nutrients that are low otherwise in Waza National Park, in particular sodium, phosphorus and potassium, in order to supplement their diet. Elephants tend to avoid below optimum habitats (Kabigumila, 1993), are known to be prone to sodium deficiency (Olivier, 1978) and to prefer water and soils rich in sodium (Weir, 1973). Combination of favoured and nutrient rich natural habitat with tasty and nutritious sorghum fields is a good motive for elephants to migrate to the Kaélé region during the wet season. During the dry season, water is a limiting factor for elephants' survival in the Kaélé région and they return to Waza National Park where waterholes are available. Consequently, strategies to reduce the human-elephant conflict in the Waza-Logone region should include actions that will not only improve forage quantity for elephants in Waza National Park but also forage quality, with a special concern on supplementing elephant diet with nutrient minerals or compensating for mineral imbalances.

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Part V

Towards Reducing Human-Elephant Conflict in the Waza-Logone Region

Increasing conflicts between people and elephants in the study area may lead to higher mortality of elephants by disturbance-shooting and poaching

5.1

Potential Physical and Ecological Measures for Reducing Human-Elephant Conflict in the Waza-Logone Region, Cameroon

Summary

In recent years there has been a considerable increase in the extent and severity of crop-raiding by elephants in the Waza-Logone region of northern Cameroon. This chapter discusses potential measures regarding physical and ecological infrastructure for managing this problem. The use of ditches, stone walls and electric fences to block elephant movements and to separate Waza National Park from agricultural areas are not seen as useful methods to solve human-elephant conflict in the area, because of their high cost of installation and maintenance, and the uncertainty of their effectiveness. A strategy involving a corridor, a buffer zone and habitat enrichment measures for extending the potential elephant range is proposed in order to reconcile elephant conservation and human development. It is concluded that a successful elephant management programme will be achieved only if ecological measures are supplemented by social measures such as damage compensation and a sharing scheme of benefits from wildlife utilization.

Introduction

Developing techniques for assessing elephant threats, analysing the magnitude of the human-elephant conflict and designing appropriate management techniques for reducing this conflict is currently a top priority in elephant conservation. The challenge is that management measures implemented have to be sensitive to both farmers' needs and to the elephants' status as threatened species.

Approaches to the resolution of the human-elephant conflict are discussed by Bell & McShane-Caluzi (1984), Seidensticker (1984), Hoare (1992), Hoare

& Mackie (1993), and Thouless & Sakwa (1995). They comprise two main categories: physical measures and social measures. Physical measures result in facilitating, modifying or blocking elephant movements. Physical infrastructure the construction of barriers (fences, ditches or moats, stone walls) (Seidensticker, 1984; Hoare, 1992; Thouless & Sakwa, 1995) and ecological measures are the establishment of corridors or the enrichment of habitat to increase available range (Seidensticker, 1984; Oldfield, 1988; Mwalyosi, 1991).

Social measures apply to both elephants and people and may include the removal or displacement of the problem animals (disturbance shooting, control shooting, translocation and population reduction) (Cumming, 1981; Whyte, 1993) and conservation incentives to local communities. Conservation incentives have been used to improve local people's attitude towards conservation (Child, 1984; Martin, 1986; Anon. 1991; Taylor, 1993). They comprise (1) compensation payments for damage to crops and properties; and/or (2) benefit sharing schemes around protected areas which may provide direct financial benefits or indirect social improvements (eg. schools, dispensaries, bore holes, etc.).

This chapter discusses the possibilities of using physical and ecological measures to alleviate the human-elephant conflict in the Waza-Logone region. It is is meant to contribute to improved planning and management in order to reconcile local development priorities with the increasingly need for effective elephant conservation measures.

Study Area and Background

The Waza-Logone region has been described in Chapter 1.2. Tchamba (1993) identified three elephant sub-populations in Waza National Park. The first sub-population resides in the northern part of the park and migrates to Kalamaloué National Park at the beginning of the dry season (December-January). Elephants return at the beginning of the wet season (May-Jun). The second sub-population resides year-round inside Waza National Park. The third sub-population uses the central and southern part of the park and spills out to the south of the park at the onset of the rains (Jun-July). These elephants cause extensive damage to crops throughout the wet season and return to the Park only in November-December.

Chapter 3.3 reports on the history and present status of the human/elephant conflict in the Waza-Logone region. In 1994, food was distributed to local farmers as a form of compensation for elephant crop damages and 21 elephants were shot on control and disturbance shooting operations. Compensation failed to raise the farmers' tolerance threshold towards elephants and control and disturbance shooting had a very limited success in deterring elephants.

Any long-term solution to the human-elephant conflict in the Waza-Logone region should include both physical and social measures. In this chapter the physical measures will be discussed.

Potential Physical Measures

Physical measures or barriers have been constructed to exclude elephants from farming areas or to contain elephants in protected areas. They are based on the principle that elephants usually cross or leave protected areas at traditional sites (Seidensticker, 1984; Thouless & Sakwa, 1995). The northern sub-population of Waza National Park crosses the park's boundary during the dry season at Mbile and the southern sub-population crosses the park's boundary during the wet season at Andirni (Fig. 5.14) (Tchamba, 1993; Tchamba *et al.*, 1995). It is important to consider ecological and behavioural factors as well as technical and practical considerations in building and managing barriers that are potentially effective for elephant conservation.

Ditches or moats

Experiences to block elephant movements with simple ditches have failed because elephants eventually learnt how to break down the walls of the moat and climb through (Woodley, 1965). Steepside or deep ditches have been ineffective in repelling elephants (Milton & Binney, 1980; Blair & Noor, 1981; Thouless & Sakwa, 1995). Elephants may fill ditches with earth using their feet and head. Soil erosion accelerated by elephants is a constant threat in the wet tropics and can severely damage ditch systems thus compromising their effectiveness. Owing to the above mentioned factors and to the fact that Cameroon's Wildlife Department lacks competence and adequate resources for proper maintenance, ditches are not an appropriate physical infrastructure for alleviating the human-elephant conflict in the Waza-Logone region.

Stone walls

Thouless & Sakwa (1995) noted that stone walls were particularly ineffective compared to electric fences. Elephants can break them down by pushing with their chests. Their advantage is that they have minimal environmental impact (Thouless & Sakwa, 1995). They can be used cost-effectively where local stone is abundant. The same authors estimated the construction costs of dry stone walls in the Laikipa District, Kenya, at US$ 3,500 per km.

A major problem with using stone walls in Waza is that stone is not available close to the building sites (at least 40 km away) and tractors would have to be used, consequently increasing construction costs considerably. Blocking the movements out of Waza National Park of the northern and southern sub-populations of elephants would require a stone wall of about 80 km long, at an estimated cost of more than US$ 280,000. Cost and effectiveness are prohibitive factors for using stone walls as elephant barriers in the Waza-Logone region.

Electric fences

The most widely used and effective physical management tools to separate land uses for conservation purposes are electric fences (Woodley & Snyder, 1978; Bell & McShane-Caluzi, 1984; Sukumar, 1989; Santiapillai, 1991; Hoare, 1992; Katugaha, 1992; Mkanda, 1992; Taylor, 1993; Thouless & Sakwa, 1995). Electric fences are of most value when used to enclose areas of dense inhabitation and agriculture surrounded by large elephant habitat (Hoare, 1990).

Thouless & Sakwa (1995) showed that well-built and well-maintained fences, with adequate power supplies and good earthing could be regularly broken by elephants. In Asia, elephants have learnt to deal with each new modification of the fence (Rice, 1990); and in some places they have been observed pulling trees onto the wires (Seidensticker, 1984). But elephants do not always learn to break down fences. The fence around the Ngare Ndare Forest, the Kisima Rumuriti and Mogwooni Ranches (Kenya) has proved very successful (Thouless & Sakwa, 1995). The success of electric fencing seems to be determined by the relative urge for the elephants to migrate. If there is still natural food available in the area to which the animals have to be restricted and there are other policy measures decreasing the attractiveness of outside areas, then electric fencing may add enough as deterrent to break through (Rice, 1990; Thouless & Sakwa, 1995).

Important factors determining the success of electric fences constructed to prevent the movements of elephants are fence design, voltage, and especially the quality of maintenance (DHV Consultants, 1992). Electric fences are very expensive, often in excess of US$ 2,000 per km. Maintenance requires both professional management (constant attention to earthing and insulation) and continued input of funds (10-40% of capital costs per year) (DHV Consultants, 1992). In addition, the fence will fail if human activities and attitudes to the fence have not been assessed to ensure that the fence is sympathetic to the local community's needs and the maintenance is seen as a responsibility of those who benefit from the fence (Hoare, 1992).

Besides Waza National Park and Kalamaloué National Park, the Waza-Logone region is a mosaic of very small-scale subsistence farms (with individual lots not exceeding 2 ha), human settlement and natural habitat. Only park boundary fences could be established in the region. The following possibilities for electric fencing exist (Fig. 5.1):

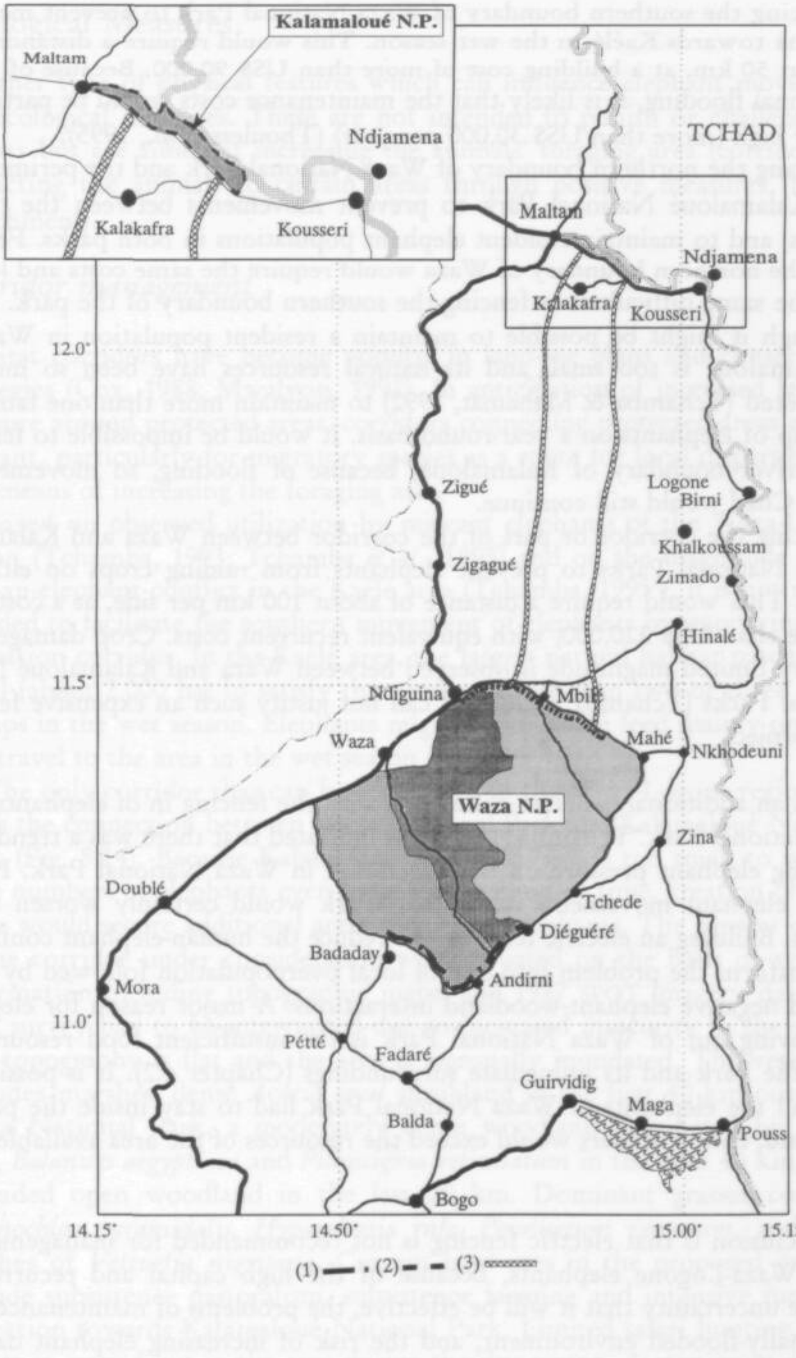

Figure 5.1
Possibilities for electric fencing in the Waza Logone region

1. Fencing the southern boundary of Waza National Park to prevent movements towards Kaélé in the wet season. This would require a distance of about 50 km, at a building cost of more than US$ 90,000. Because of the seasonal flooding, it is likely that the maintenance costs would be particularly high (more than US$ 30,000 per year) (Thouless *et al.*, 1995).
2. Fencing the northern boundary of Waza National Park and the perimeter of Kalamaloué National Park to prevent movements between the two areas, and to maintain resident elephant populations in both parks. Fencing the northern boundary of Waza would require the same costs and lead to the same difficulties as fencing the southern boundary of the park. Although it might be possible to maintain a resident population in Waza, Kalamaloué is too small and its natural resources have been so much depleted (Tchamba & Mahamat, 1992) to maintain more than one family group of elephants on a year-round basis. It would be impossible to fence the river boundary of Kalamaloué, because of flooding, so movements into Chad would still continue.
3. Fencing the corridor or part of the corridor between Waza and Kalamaloué National Parks to prevent elephants from raiding crops on either side. This would require a distance of about 100 km per side, at a cost of more than US$ 320,000, with equivalent recurrent costs. Crop damage of a very limited magnitude is observed between Waza and Kalamaloué National Parks (Tchamba, 1996) and can not justify such an expensive fencing project.

There is an additional problem connected with the fencing in of elephants in Waza National Park. Tchamba (1995[a]) has indicated that there was a trend of increasing elephant pressure on the vegetation in Waza National Park. Preventing elephant movements out of this Park would certainly worsen the situation. Building an electric fence might reduce the human-elephant conflict but transform the problem into one of local overpopulation followed by severe and negative elephant-woodland interactions. A major reason for elephants moving out of Waza National Park is the insufficient food resources within the Park and its immediate surroundings (Chapter 4.2). It is possible that if all the elephants of Waza National Park had to stay inside the park year-round, their numbers would exceed the resources of the area available to them.

My conclusion is that electric fencing is not recommended for management of the Waza-Logone elephants, because of the high capital and recurrent costs, the uncertainty that it will be effective, the problems of maintenance in a seasonally-flooded environment, and the risk of increasing elephant damages to the natural vegetation of Waza National Park as a result of total confinement.

Ecological Measures

Another type of physical features which can influence elephant movements are ecological measures. These are not intended to punish or challenge elephants but are aimed at increasing the animals' foraging area (corridors) or attracting the animals to certain areas through positive measures (habitat enrichment).

Corridor management

Habitat corridors have become popular in land-use plans and conservation strategies (Cox, 1988; Mwalyosi, 1991). In anticipation of increased land-use pressure around protected areas, corridors connecting protected areas are important, particularly for migratory species as a route for local dispersion and as a means of increasing the foraging area.

Based on observed utilization by migrant elephants of the Waza-Logone region (Tchamba, 1993; Tchamba *et al.*, 1995) and on the magnitude of the human-elephant conflict in the Kaélé area (Tchamba, 1995[b]), it is not recommended to facilitate the southern movement of elephants by improving their migration corridor. In the Kaélé area, the largest natural habitat patch is too small (about 2,000 ha) to satisfy the needs of more than two or three family groups in the wet season. Elephants migrating to Kaélé feed mainly on crops and travel to the area in the wet season (Chapter 4.2).

The only corridor that can be considered in the Waza-Logone region concerns the connection between Waza National Park and Kalamaloué National Park (Fig. 5.14). Because Kalamaloué National Park is too small to support large numbers of elephants even for a short period of time, creation of a corridor would secure additional areas for use by elephants. The present quality of the corridor under consideration was evaluated on the basis of available information including topographic maps, and 1987 SPOT imagery data. The field survey had to be interrupted due to increased insecurity in the region. The topography is flat and the area is seasonally inundated. The vegetation includes marshes, dense *Acacia seyal* shrubland in the first 40 km outside of Waza National Park, a moderately dense woodland dominated by *Acacia seyal, Balanites aegyptiaca* and *Piliostigma reticulatum* in the next 40 km, and a degraded open woodland in the last 20 km. Dominant grasses comprise *Echinochloa pyramidalis, Hyparrhenia rufa, Pennisetum ramosum,* and some patches of *Vetiveria nigritana*. Current land uses in the proposed corridor include subsistence pastoralism, subsistence farming and intensive fuelwood collection towards Kalamaloué National Park. Limited safari hunting of elephants is carried out in the area during the dry season. A maximum of 1000 people live in six villages (MINPAT, 1990).

The corridor would be 100 km long and 15 km wide. Within the corridor, only livestock grazing would be allowed and fuelwood collection would be restricted in order to avoid further degradation of elephant habitat. Prior to the establishment of the corridor, discussions between the local communities and the wildlife authorities should be carried out in order to develop mutually acceptable mechanisms for managing the corridor. The success of this corridor could be undermined by the level of disturbances around Kalamaloué and between Kalamaloué and Waza. It would be essential that local authorities devise strategies to fight poaching, armed robbery along the Waza-Kalamaloué paved road, and harassment of elephants by local people.

Habitat enrichment

Restoration and creation of waterholes

Water availability influences the distribution and movement patterns of elephants in dry savannas (Western & Lindsay, 1984). Because elephants migrate to the Kaélé region in the south only during the wet season when water is not a limiting factor, the restoration of old waterholes and/or the creation of new waterholes would only affect the dry season elephant movements to the north (Tchamba, 1993; Tchamba *et al.*, 1995). Waterholes could be created in the dense *Acacia seyal* shrubland covering the northern part of the park between Ndiguina and Mbilé, and in the *Sclerocarya* woodland in the south, where waterholes are lacking. Increasing water availability could increase the use of waterholes by elephants later into the dry season and result in one or any combination of the following (Thouless *et al.*, 1995):

1. Fewer elephants moving out of Waza National Park to Kalamaloué;
2. Elephants waiting longer before leaving Waza National Park;
3. A reduction of the damage done around the only two waterholes that keep water throughout the dry season (Chapter 4.1);
4. A reduction of elephant pressure on the central *Acacia seyal* shrubland, an area suffering from increasing elephant damage (Tchamba, 1995[a]).

Increasing the proportion of elephants staying in Waza National Park will not dramatically affect the vegetation if elephants are not confined inside the Park and can disperse, and move freely between the Park and the corridor.

Provision of salt licks

Several authors have suggested that elephant movements and distribution are influenced by the distribution of environmental sodium (Weir, 1972; Jachmann, 1984; Van Wijngaarden, 1985; De Bie, 1991). The provision of appropriate minerals at judicious locations and times may reduce the range that elephants need to cover in each year (Weir, 1972; Seidensticker & McNeely, 1975). The presence of natural salt licks in Waza National Park has not yet been documented. Bos & Bus (1992) noted that at the end of the dry season, in Waza National Park that the conductivity of waterholes in the *Acacia* shrubland was significantly higher than in the floodplain grassland, and that elephants tended to use waterholes with higher conductivity more intensively. In Chapter 4.3 it was noted that the mineral content of plants in the Kaélé region, a wet season refuge for Waza elephants, was higher than in the Waza National Park. The provision of artificial salt licks may therefore result in a reduction of the number of animals moving out of the park.

Fire management

In Malawi and Zambia, elephant distribution and impacts on woodland has been manipulated to some extent by burning (Bell & Mphande, 1980; Lewis, 1982). Elephants tended to avoid burnt areas and in consequence the impact of elephant on woodland in burnt areas was reduced (Jachmann, 1984). In line with this, the present fire management policy of burning most parts of Waza National Park might have the effect of increasing elephant browsing pressure on the limited not burnt areas. In addition it could reduce the forage production, because the burning is often done late due to inadequate organization and capacity, consequently the ability of the Park to maintain large number of elephants on a year-round basis is reduced. In the absence of additional information on fire management from research findings in the Park, it is recommended that only half of the park be burnt annually (of which a part early and a part late, in rotation). This will improve grass quality and forage production in the woodlands, while retaining open understory which is ecologically important to the woodland antelopes and aesthetically attractive for wildlife viewing by tourists.

Reflooding of the floodplain

One of the major objectives of the IUCN Waza-Logone Project is to rehabilitate the floodplain by releasing water from the Logone River into areas which have been affected by the reduction of flooding that followed the construction of the Maga dam. The possible impacts of the reflooding on the elephants of Waza could include:

1. an improvement in perennial grasses which may encourage a larger number of elephants to use the floodplain more during the dry and the wet seasons;
2. an increasing availability of water for elephants longer into the dry season.

Observations made in Waza National Park indicated that use of the floodplain by elephants in the wet season was not significantly different from the homogeneous use model (Chapter 4.3). Elephants selected against floodplain in the dry season. Water availability and forage quality were considered the main factors in elephant distribution (Chapter 4.3) and grazing doubled during the wet season (Chapter 4.2). These findings indicate that reflooding might delay or reduce elephant movements out of Waza National Park. Available data are insufficient to conclude whether reflooding might change the quality or composition of the vegetation in the *Acacia seyal* shrubland affected by the reflooding. However, only a minor part of the *Acacia seyal* shrubland will be affected by flooding (Wesseling *et al.*, 1994).

Conclusions

To alleviate the human-elephant conflict the movements of elephants should be steered so that they stay away from agricultural areas. There is no easy way to reach this, but some measures can be recommended depending on the ecological and behavioural factors, in addition to the technical considerations.

At first, possibility is to erect physical barriers. The greatest objections to such barriers are their high capital installation and recurrent costs, their inflexibility, and their probable failure through lack of maintenance. Ditches, stone walls and electric fences are not seen as useful methods to solve the human-elephant conflicts in the Waza-Logone region. Such barriers could favour habitat fragmentation. One of the conditions for a genetically sound population in the future is prevention of habitat fragmentation leading to genetically isolated sub-populations.

Alternatives to these barriers are ecological measures such as the establishment of a corridor between Waza National Park and Kalamaloué National Park, and the enrichment of the habitat of Waza National Park. The latter measure may include the restoration and/or the creation of waterholes, the provision of salt licks, the change of the fire management policy, and the reflooding of the floodplain. These strategies might increase the capacity of the Park to hold more elephants for longer periods. However, the benefit of delaying and/or reducing northwards and southwards elephant movements will have to be weighed against the additional degradation of vegetation within the Park.

From the perspective of tourism, it would be preferable to allow elephant densities to continue to increase, rather than having to cull numbers down to a level where there would be no need for elephants to leave the Park. From an ecological point of view, this would only be desirable if elephant population growth could be achieved without further negative impact on the woody vegetation, and without reducing the biological diversity of the area. A system of objectives and priorities for woodland dynamics and elephant management must therefore be worked out by the Wildlife Department. If the objective of the park management is to maximise biological diversity, reduction in elephant numbers by safari hunting or culling must be considered, and the offtake adjusted to include known losses to poaching.

Ecological measures are potentially long-term solutions to the human-elephant conflict. However, they should be supplemented by social measures such as damage compensation and a sharing scheme of benefits from wildlife utilization, in an integrated strategy.

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5.2

Perspectives on Control and Disturbance Shootings as Elephant Deterrent Techniques in the Waza-Logone Region, Cameroon

Summary

Some observations on the impact of control and disturbance shootings on the magnitude of crop damage, on people's attitude towards wildlife authorities, and on elephant movements were made from July to November 1994. Compared to 1993, the level of crop damage was not significantly reduced. The number of gunshots or the number of animals killed did not influence the distance travelled by the elephants. There was a decreasing effect of the order of operation. Control and disturbance shootings prevented the elephants from moving further south and dispersing into the region.

Control and disturbance shootings positively improved people's attitude towards wildlife authorities. However, the sharing of elephant meat from control shooting was a cause of concern among local people who did not consider elephant meat as an acceptable form of compensation.

It is concluded that the stress and/or trauma of control shooting culling and disturbance shooting was not a sufficient stimulus to induce the elephants to leave the farmland area and return to the park, nor to stay inside the park. The chapter ends with recommendations to improve the efficiency and effectiveness of control and disturbance shootings in the region, and suggests that studies on the social organization of the family groups and the social organization of the migrant herd be conducted so that proper management actions can be taken to influence the movements of this herd.

Introduction

The management of elephants (*Loxodonta africana,* Blumenbach) outside protected areas increasingly involves addressing their conflicts with rural people.

The growing human population and agricultural expansion have resulted an in increasing encroachment of elephant habitat by humans. As elephants spill out of the protected areas and enter the farmlands, they come into conflict with farmers. Elephants are killed, people are killed, farms are damaged and crops lost.

Several studies have analyzed the nature and the extent of the human-elephant conflict under different circumstances (Damiba & Ables, 1993; Hoare & Mackie, 1993; Taylor, 1993; Thouless, 1994; Tchamba, 1996). An understanding of the conflict between humans and elephants is important for determining whether coexistence is possible, and at what cost. If humans and elephants are to coexist, the level of conflict must be reduced.

Several strategies have been suggested to alleviate the problem of wildlife crop damage. They include fencing (Hoare, 1992), ecological infrastructure (Seidensticker, 1984), damage compensation (Bell, 1987; McNeely, 1988), and culling and disturbance shooting (Bell, 1984; Hoare, 1996; Whyte, 1993). Each conflict is unique and often requires a site-specific solution. A formula used to address the problem in one area can not be directly transferred to another area.

Local people have developed methods to protect their crops. However, these local methods are usually primitive and often lead to fatal incidents (Marks, 1976; McNeely, 1988; Damiba & Ables 1993; Tchamba, 1996). Local people very often suggest the shooting of crop raiding animals in order to alleviate crop damage (Balakrishnan & Ndhlovu, 1992; Tchamba, 1996). Control shooting is also a common practice for wildlife authorities in the absence of other practical alternatives. However, the impact of control or disturbance shooting in controlling or reducing elephant damage, or the impact on elephant movements are not as yet well documented.

The present chapter reports on some observations made during a crop damage control operation carried out by the Wildlife Service between July and September 1994 in the Waza-Logone region of northern Cameroon. It provides analyses of the impact of control and disturbance shooting on the level of crop damage, on the attitude of local people, and on elephant movements.

Study Area and Methods

The Waza-Logone region (Fig. 1.1) has been described in detail in Chapter 1.2. In recent years there are increasing complaints about elephants which have moved from the Waza National Park into the agricultural areas to the south of the Park.

The history and present status of the human/elephant conflict in the region are described in Chapter 3.3. Because of fast growing political and social pressures, and in the absence of a practical alternative, the wildlife authorities decided in July 1994 to conduct a very intensive control and disturbance shooting operation. They hoped that elephants would return to Waza National Park and human-elephant conflict would be reduced.

The control and disturbance shootings were carried out by a team of five game guards. One .458 calibre rifle was used for killing elephants, and four World War II guns (MASS .36) were used for disturbance shooting. The elephants killed were chosen randomly and disturbance shooting consisted basically of one to 18 gunshots in the air. On fourteen occasions elephants were killed and on twenty seven other occasions disturbance shots were fired. Efforts were made to force elephants in the direction of Waza National Park by always positioning the guards south of the elephant herd.

The main source of information for crop damage was the Problem Animal Reporting System (Hoare, 1995) established in six villages (Pétté, Wolordé, Yoldéo, Kolara, Midjivin, Foulou) in 1992 (Tchamba, 1996). In each village, elephant movements and damages are reported as soon as possible to the nearest enumerator. The enumerators have been recruited by us and have been trained on the method of spatially and temporarily quantifying elephant damage (Tchamba, 1996). Information from enumerators was supplemented by data obtained from the Departmental Delegation of Agriculture which has a number of substations and outposts in the area. The magnitude of crop damage (area destroyed) in 1992, 1993 and 1994 was compared using an analysis of variance (Sokal & Rohlf, 1980).

Attitudinally a survey was conducted in the six villages mentioned earlier, by interviewing people at their homes during November 1994. The survey was designed to assess local attitudes and opinions about the control and disturbance shootings that had recently taken place. The household was considered the sample unit (Parry & Campbell, 1992). One-hundred and twenty households (20 households per village) randomly-selected from a list of farmers provided by the local representatives of the Departmental Delegation of Agriculture were visited. Specific questions were followed by open discussions, giving the respondent the opportunity to express views freely about the results of control and disturbance shooting (Table 5.1). Additional information on the attitudinal survey is found in Chapter 3.3.

Elephants' response to control and disturbance shooting was observed on 27 occasions. Data on elephant movements were collected by a combination of telemetry and direct observations. Control and disturbance shooting were conducted on a herd with a radio/satellite collared adult cow elephant. The collared animal was used to document herd movements. The herd, of approximately 160 elephants, stayed in one large group throughout the observation period. The location of the point where control or disturbance shooting was conducted was determined by a Geographical Positioning System (GPS).

Table 5.1
Brief english translation of the house-to-house attitudinal survey carried out in November 1994

Subdivision .... Village .... Household number ....

Name .... Amount of land ....

What has been the impact of control and disturbance shooting on crop damage?
(circle) - reduction - increase - no impact

What do you think about the intensity of the operation? (circle)
- insufficient - sufficient - opposed

Reasons for liking or disliking the operation

Did you benefit from crop damage control in terms of elephant meat? (circle)
- yes - no

Do you like or dislike elephant meat as compensation?
- like - dislike

Reasons for liking or disliking elephant meat as compensation

Do you have any comments?

Full technical details for position-finding and data-acquisition by telemetry are discussed by Tchamba *et al.* (1995). The number of elephants killed and the number of rounds of ammunition used (gunshots) were recorded. The distance travelled by the herd in reaction to control or disturbance shooting was considered to be the distance between the control or disturbance shooting site and the next 'fix' (collared animal location) or GPS location at the point where elephants stopped or changed direction of travel.

In order to normalize the distribution as well as to equalize the variances, the Box-Cox transformation (Sokar & Rohlf, 1980) was used on the data on distance travelled. The relationship between the distance travelled and the order of the shootings, the number of elephants killed and the number of gunshots, respectively, was analyzed using regression analysis. A multiple regression incorporating the order of the shootings, the number of gunshots and the number of elephants killed as the independent variables and the distance travelled as the dependent variable was carried out to enable a better prediction of the distance travelled (Sokal & Rohlf, 1980).

As with other studies assessing crop damage in relation to elephant movements and deterrence activities, the observations made and subsequent analyses had limitations. The major limitations during this study were:

1. it was impossible to determine how much damage would have occurred in the absence of control and disturbance shooting;
2. because of the rains, accessibility and ease of movement in the study area was limited. Therefore, the collared animal could not be tracked on a round-the-clock basis. In addition, the satellite transmitter had a 24/72 hour on/off duty schedule. This makes the comparison of the distances between fixes, or GPS locations, difficult as periods between tracking varied from several minutes to two days.

Given these shortcomings, there is still some useful information that has emerged.

Table 5.2

Level of crop damage in 1992, 1993 and 1994 in the six villages surveyed. Villages arranged in table from north to south

Villages	Area Cultivated (ha)	Area destroyed ha (%)		
		1992	1993	1994
Pétté	237	12 (5)	15 (6)	23 (10)
Wolordé	41	0 (0)	0 (0)	0 (0)
Yoldéo	284	24 (8)	37 (13)	55 (19)
Kolara	375	22 (6)	45 (12)	39 (10)
Midjivin	916	201 (22)	390 (42)	191 (21)
Foulou	295	75 (25)	115 (39)	107 (36)
Total	2148	334 (16)	602 (28)	415 (19)

Results

Crop damage and human death

Table 5.2 indicates that there was less crop damage in 1992 than in 1993 and 1994, respectively (16%, 28%, and 19% of farmland damaged in 1992, 1993 and 1994, respectively). However, there were no significant differences in crop damage ($F=0.29$; $df=17$; $P>0.05$). If last two years are compared, the largest reduction of crop damage was observed at Midjivin (a 50% reduction), whereas Pétté and Yoldéo suffered from increased crop damage in 1994 (a 53% and 49% increase, respectively). As in 1992 and 1993, elephants did not visit the Wolordé area. In Kolara and Foulou, there was a 13% and 7% reduction of crop damage, respectively, in 1994. The geographical pattern of crop damage indicates that in the area north of Mindif (Pétté, Yoldéo) there was an increase in elephant crop damage in 1994, whereas there was a reduction in crop damage in the area south of Mindif (Kolara, Midjivin, Foulou).

In 1994, no human death related to elephant activities was recorded, compared to four deaths in 1993 and 2 in 1992 (Tchamba, 1996).

People's attitude towards control and disturbance shooting

Fifty-seven percent of the respondents believed that control and disturbance shooting had considerably reduced crop damage (Table 5.3). Of those expressing favourable attitudes about the reduction of crop damage by control and disturbance shooting, there were significantly more respondents (42%) residing in the villages south of Mindif than in the area north of Mindif ($X^2=21.27$; $df=5$; $P<0.001$). Eleven percent felt that they personally suffered more damage than the previous year (most (9%) resided in Pétté and Yoldéo; $X^2=6.83$; $df=1$; $P<0.05$). Thirty-two percent indicated that they suffered the same damage as the previous year (most (26%) resided in the area north of Mindif; $X^2=39.17$; $df=5$; $P<0.001$).

Table 5.3

Local people's opinion about the impact of control and disturbance shooting (n=120)

Villages	Number of respondents feeling that crop damage has been reduced	Number of respondents feeling that crop damage has been increased	Number of respondents feeling that there has been no impact
Pétté	9	6	5
Wolordé	0	0	20
Yoldéo	9	5	6
Kolara	16	1	3
Midjivin	19	0	1
Foulou	15	1	4
Total	68 (57%)	13 (11%)	39 (32%)

The satisfaction about the wildlife authorities following the control and disturbance shooting did not differ significantly between the villages (Table 5.4) ($X^2=3.5$; $df=5$; $P>0.05$). The majority of the respondents (82%) indicated that they were happy about the wildlife authorities who they believed had done their best to protect crops and property. A low proportion (9%) stated that the operation should have been more intensive and that more elephants should have been killed (most of these respondents (8%) resided in Pétté and Yoldéo; $X^2=4.17$; df=1; $P<0.05$). Nine percent indicated that they were opposed to control and disturbance shooting. Most of them (5%) resided in Wolordé, a village that has not suffered from elephant crop damage for the past 3 years ($X^2=10.17$; df=1; $P<0.05$).

Table 5.4

Local people's opinion about the intensity of control and disturbance shooting (n=120)

Villages	Number of respondents satisfied	Number of respondents satisfied	Number of respondents opposed
Pétté	13	4	3
Wolordé	14	0	6
Yoldéo	13	5	2
Kolara	19	1	0
Midjivin	20	0	0
Foulou	19	1	0
Total	98 (82%)	11 (09%)	11 (09%)

Table 5.5. Distribution of respondents who benefited or not from crop damage in terms of elephant meat (n=120)

Villages	Number of respondents who benefited	Number of respondents who did not benefit
Pétté	7	13
Wolordé	0	20
Yoldéo	8	12
Kolara	3	17
Midjivin	4	16
Foulou	6	14
Total	28 (23%)	92 (77%)

Most of the respondents (77%) indicated that they did not benefit from crop damage control in terms of elephant meat but felt that they should have (Table 5.5). The six surveyed villages were equally of that opinion ($X^2=2.93$; df=5; $P>0.05$). Eighty-six percent mentioned that even if they would have received meat, this still would not have been sufficient compensation. They noted that the meat would have been hardly enough for everybody and that there will always be injustice in the sharing of the meat. A majority expressed additional concerns: will they be compensated for the elephant crop damage of 1994, and what measures are being taken to prevent future elephant damage to crops and property?

Responses of elephants to control and disturbance shooting

The data collected are summarized in Table 5.6. By the end of the operation a total of 21 elephants had been killed. Of these elephants killed, one was a juvenile, 10 were sub-adults and 10 were adults. There were 12 bulls and 9 cows (two which were pregnant). Figs 5.2, 5.3 and 5.4 show the relationship between the distance travelled by the elephants and the operation number, the number of gunshots and the number of elephants killed, respectively. The mean distance travelled by elephants in response to disturbance shooting only was not significantly different from the mean distance travelled in response to shooting and killing ($t=1.38$; $df=39$; $P>0.05$). The mean distance travelled between two successive fixes was 11.7 km. As it can be seen from Figs 5.3 and 5.4, there was no relationship between the distance travelled and the number of gunshots ($R=0.08$; $F=0.16$; $df=26$; $P>0.05$), and also no relationship between the distance travelled and the number of elephants killed ($R=0.01$; $F=0.005$; $df=26$; $P>0.05$). Fig. 5.2 shows that there was a negative relationship between the distance travelled and the operation number ($R=-0.65$; $F=18.67$; $df=26$; $P<0.001$). The F-ratio of 7.42 associated with the multiple regression model is significant ($df=26$; $P<0.05$). However, the low significance level for the 'number of gunshots' and 'number of elephants killed' variables ($P=0.10$ and $P=0.$-53, respectively) in the multiple regression model fitting suggests that they could be dropped from the model. The high significant level for the constant term (21.52) and the coefficient for the 'operation number' variable (-0.66) ($P=0.00$ in both cases) is an indication that they provide useful predictive information. Furthermore, adding the independent variables 'number of gunshots' and 'number of elephants killed' to the independent variable 'operation number' does not significantly increase the coefficient of multiple determination of the dependent variable 'distance travelled'; with 'operation number only, $R^2=0.42$; with 'operation number' and 'number of gunshot' only, $R^2=0.48$; with 'operation number', 'number of gunshots' and 'number of elephants killed', $R^2=0.49$. 'Operation number' provided the best fit for the observed data and may be used separately to predict 'distance travelled' in response to control and disturbance shooting.

Table 5.6
Summary of control and disturbance shooting data

Operation number	Date	Nearest village	Number of gunshots	Number of elephants killed	Approximate distance travelled (km)
1	07-07-94	Mizao	1	0	16
2	08-07-94	Foulou	8	1	15
3	11-07-94	Kahéo	7	1	21
4	12-07-94	Yoldéo	4	0	7
5	18-07-94	Mizao	4	0	5
6	19-07-94	Moulva	18	0	64
7	25-07-94	Pétté	4	1	8
8	28-07-94	Zouzoui	2	1	35
9	01-08-94	Foulou	7	0	11
10	02-08-94	Yoldéo	15	2	7
11	04-08-94	Foulou	7	3	7
12	04-08-94	Matfay	5	1	8
13	05-08-94	Laf	10	1	8
14	06-08-94	Laf	15	3	8
15	08-08-94	Sabongari	12	0	20
16	13-08-94	Wirdiwo	9	0	9
17	16-08-94	Doubbel	8	0	8
18	17-08-94	Doubbel	11	2	2
19	18-08-94	Pétté	15	1	24
20	15-09-94	Yakang	6	2	8
21	16-09-94	Zouzoui	4	0	11
22	17-09-94	Yoldéo	8	1	4
23	19-09-94	Bogo	7	1	4
24	27-09-94	Sabongari	9	0	2
25	29-09-94	Sabongari	10	0	2
26	01-10-94	Sabongari	8	0	2
27	02-10-94	Sabongari	9	0	1

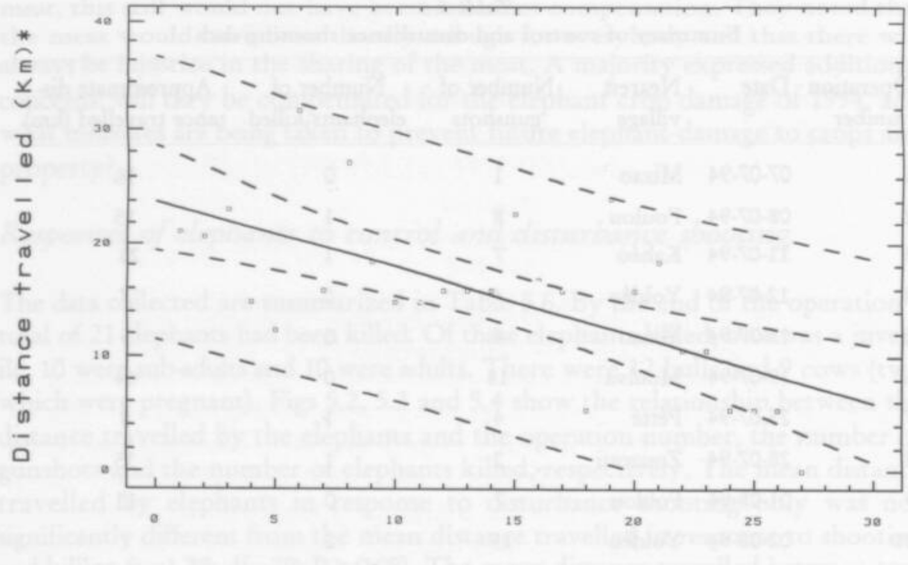

Figure 5.2

Scatter plot and regression line between the distance travelled by the elephants and the operation number (* Box-Cox transformation of distance)

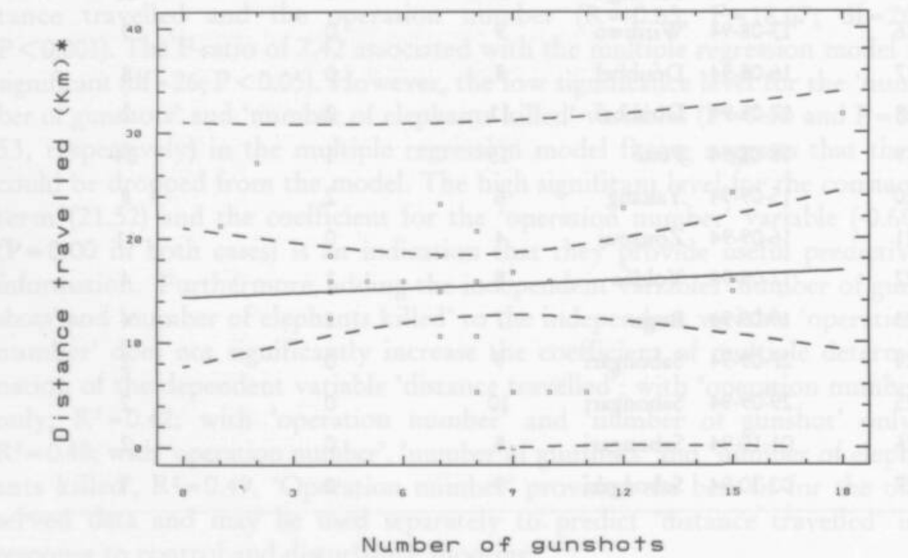

Figure 5.3

Scatter plot and regression line between the distance travelled by the elephants and the number of gunshots (* Box-Cox transformation of distance)

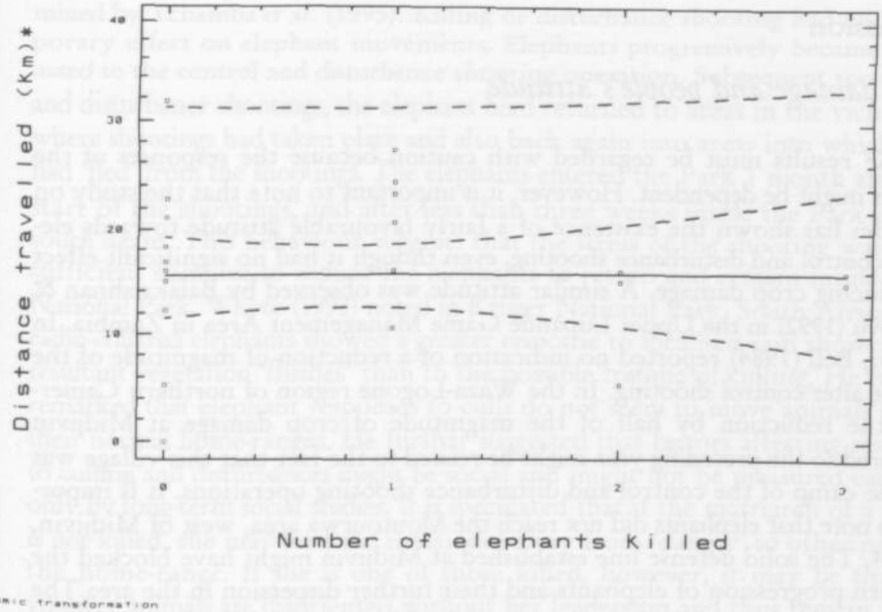

Figure 5.4

Scatter plot and regression line between the distance travelled by the elephants and the number of elephants killed (* Box-Cox transformation of distance)

On 33% only of the operations, were 'significant' movements (in that they exceeded the mean recorded distance between fixes). Long distance movements were observed after the 6th and the 8th operations when elephants travelled 34 km and 35 km, respectively, but rather slowly (5 days each time). After the 19th operation the entire herd travelled 24 km in one day and entered Waza National Park 2 km east of Andirni. They had spend 73 days outside the park. No shooting was done inside the park. The elephants stayed 19 days inside the Park. When they left the Park for a second time they were in greater numbers than before (approximately 200 individuals). Control and disturbance shooting activities stopped after the 27th operation when it was realised that many elephants had been killed and additional shooting was having little effect as the elephants had become habituated to the shootings. The elephants had become more aggressive and did not move more than 2 km from the shooting sites. During their second trip outside the Park the elephants stayed 57 days. They returned to the Park following the same route by which they had come and without any human intervention.

Discussion

Crop damage and people's attitude

The X^2 results must be regarded with caution because the responses of the farmers might be dependent. However, it is important to note that the study on attitudes has shown the existence of a fairly favourable attitude towards elephant control and disturbance shooting, even though it had no significant effect on reducing crop damage. A similar attitude was observed by Balakrishnan & Ndhlovu (1992) in the Upper Lupande Game Management Area in Zambia. In Malawi, Bell (1984) reported no indication of a reduction of magnitude of the damage after control shooting. In the Waza-Logone region of northern Cameroon, the reduction by half of the magnitude of crop damage at Midjivin compared to the preceding year might be related to the fact that this village was the base camp of the control and disturbance shooting operations. It is important to note that elephants did not reach the Moutourwa area, west of Midjivin, in 1994. The solid defense line established at Midjivin might have blocked the southern progression of elephants and their further dispersion in the area.The extent of damage might have increased in Pétté and Yoldéo because these villages are located along the elephants' migration corridor (Tchamba, 1993). The elephants went back and forth several times, trampling the farms around these villages. Damage in the Kolara area was mostly done by a resident elephant population estimated to no more than 20 individuals (Tchamba, 1993). This damage might not be expected to drop significantly by actions taken on the migratory herd. It is also important to observe that no human death was recorded in 1994. However, it is difficult to judge if this is a consequence of the control and disturbance shooting operations or simply due to the fact that local people have become more careful in approaching elephants, or to any other factor.

The major benefit of control shooting, which is usually meat (Mishra, 1982; Parker, 1984; Child, 1984; Balakrishnan & Ndhlovu, 1992), was not perceived as appropriate compensation for damage by the local people. Firstly, because elephants were not necessarily shot in the vicinity of the villages where they had done most of the damage and, secondly, because they hardly got any meat. Most of the meat was collected by game guards and sold in the market for their personal benefits or, distributed to urban authorities.

Elephant movements

Studies on the home-range of the collared elephant started in January 1994, and the animal stayed inside the Park until June 1994. The control and disturbance shootings did not take the elephant outside its normal home-range as determined by Tchamba *et al.* (1995). Killing or disturbance shooting had only temporary effect on elephant movements. Elephants progressively became habituated to the control and disturbance shooting operation. Subsequent to control and disturbance shootings, the elephant herd returned to areas in the vicinity of where shootings had taken place and also back again into areas into which they had 'fled' from the shootings. The elephants entered the Park 1 month after the start of the shootings, and after less than three weeks inside the Park moved south again. This behaviour suggests that the stress of the shooting was not a sufficient stimulus to induce the elephants to return and remain inside Waza National Park. Whyte (1993) noted in Kruger National Park, South Africa, that radio-collared elephants showed a greater response to localised rain showers and resultant vegetation 'flushes' than to the possible trauma of culling. He further remarked that elephant responses to culls do not seem to move animals out of their normal home-ranges. He further suggested that factors affecting response to culling and disturbances might be social and might not be measured easily or only by long-term social studies. It is speculated that if the matriarch of a group is not killed, she may lead the remainder away from 'danger' to other parts of the home-range. If she is one of those killed, however, it may be that the younger animals are disoriented without her leadership and thus remain in the area of the shooting (C.R. Thouless, pers. comm.).

Long term studies are needed, but in a time of growing social and political pressures in Cameroon, measures to be taken cannot wait till the completion of such studies. This bears the risk that untested, non-productive, or perhaps contra-productive measures are taken. If shooting is conducted in the same manner in subsequent years, the elephant population dynamics may be adversely affected. Future plans for managing destructive elephants through control shooting will have to ensure that the minimum viable population size is maintained.

Conclusions, Recommendations and Further Research

Control and disturbance shootings were not very effective in reducing crop damage in the Waza-Logone region. However, they improved people's attitude towards wildlife authorities. Meat from culled elephants was not perceived by local farmers as a benefit because it was not enough and it was not well distributed. Because of the lack of planning, the inadequate organisation and the inexperience of game guards, the control and disturbance shootings were not a sufficient stimulus to induce the elephants to leave the farmland area and return to the Park nor to stay inside the Park.

To alleviate human-elephant conflicts in the Waza-Logone region, long-term alternatives to control and disturbance shooting have to be investigated. They include the possibility of improving the elephant habitat in Waza National

Park in order to limit the expansion of elephant range outside the Park, and the development of conservation incentives to improve local people's attitude towards elephants.

If in the mean time control and disturbance shooting will be practised because of increasing political and social pressures, then at least the following conditions should be met:

1. The control and disturbance shooting requires adequate preparation. The game guards should be trained in shooting elephants and in the identification of elephants (age and sex) (Thouless *et al.*, 1995). Basic equipment is essential. This includes: boots, uniforms, sleeping bags, tents, bicycles and walkie-talkies. Game guards involved in the deterrence of elephants also need an incentive payment in order to be more motivated to take on the additional and potentially dangerous duty.
2. At the beginning of the wet season (June), a full time team of at least 10 guards and local informants, led by an elephant control expert, should establish a solid front line at Andirni, to defend the farms located in the vicinity of Waza National Park and to avoid the break-through of elephants further to the south (Thouless *et al.*, 1995)
3. Limited wet season safari hunting could be developed in the region. Revenues from professional hunting should then mainly be used to improve people's socio-economic conditions. The present wildlife and fiscal legislation urgently need reform. As these laws are currently written, local people can not share directly the benefits from wildlife-related activities in their area.
4. More positive attitudes could be produced if meat from elephants shot on control was given directly to local farmers. Game guards should be reprimanded for selling or distributing elephant meat in urban areas. A formal protocol for meat distribution should be established.

The Waza-Logone region offers opportunities for studying elephant behaviour and the factors affecting the responses of elephant to control and disturbance shooting. Investigations into: (1) the social organization of family groups and the social organization of the migrant herd, (2) subsequent experimental evaluation of the responses to specific disturbance or control shooting; and (3) elephant responses to taped playback of infra sound vocalisations from elephants being killed, (4) elephant response to capsicum (pepper smell), and (4) elephant responses to playbacks of low-frequency conspecific calls (Langbauer *et al.*, 1991), would likely contribute to the choice of better strategies for reducing the human-elephant conflict.

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5.3

Importance of Tourism in Waza National Park, Cameroon, with Special Reference to the Economic Value of Elephants in the Waza-Logone Region

Summary

During the period 1981 to 1992, an average of 5000 tourists visited Waza National Park annually. They provided a direct annual revenue of about US$ 41,000. Safari hunting of elephants generated about US$ 14,000 per year (7 elephants per year). The number of tourists increased up to 1986, but due to increased insecurity in the region, since that year it has decreased continuously.

A survey conducted in 1991 and 1992 showed that only 18% of the visitors to the park were cameroonians. Most visitors (74%) indicated that the admission fee to the park was low (from US$ 3 to US$ 5). A doubling of the admission fees (up to US$ 7.5 for Cameroonians, and US$ 12.5 for expatriate residents and abroad tourists) and hunting fees (US$ 4,000 per year) could generate at least US$ 98,000 per year. Visitors mentioned that the most important improvements needed were the amelioration of the road infrastructure (30%) and the creation of a small information centre at the park's entrance.

Elephants were the most attractive animal of Waza (54% of the visitors) and the sizable value of elephants could be estimated to at least US$ 71,000 per year, which represented more than 70% of the revenues generated by the wildlife-based industry. If Waza National Park's benefits are to be increased and resource profits enjoyed by local people, the key issues are restoring security in the region, developing an integrated programme of community education, developing alternative sources of supplemental income for villagers, modifying park regulations and achieving stricter law enforcement.

Introduction

In Africa, the ability of many protected areas to conserve representative ecosystems and significant refuges for many species is jeopardised by park-people conflicts (Lewis, 1992). These conflicts have developed through widespread deficiencies in effective integrative policies between protected areas authorities and surrounding human communities (Parry & Campbell, 1992). How can the 'luxury' of land devoted exclusively for wildlife be justified in the face of pressures from expanding human populations and increasing demands for land and natural resources? The present situation is particularly significant for subsistence communities when they loose access to basic resources such as construction material, fodder and meat (Balakrishnan & Ndhlovu, 1992; Heinen, 1993) or suffer human casualties and livestock and crop losses when wildlife authorities are unable to control wildlife movements (Kiiru, 1995; Tchamba, 1995).

While there are many reasons to conserve biological resources, economic arguments appear to carry the greatest weight with politicians, development planners and local people (Prins, 1987; Dixon & Sherman, 1991). Tourism in African national parks represents a potentially significant economic resource with numerous opportunities for development (Dixon & Sherman, 1991). Whether established to play a valuable role in maintaining biological diversity or to increase economic benefits from tourism, national parks should be viewed within a broad ecological and social framework, rather than as ecological islands (Western, 1984). The idea of integration of wildlife conservation areas into local rural economies is gaining wide acceptance, although in most areas it has still to be put into practice (Prins, 1987; Anonymus, 1991; Taylor, 1993).

The Waza-Logone region of northern Cameroon is no exception to the global trend of increasing park-people conflict. This study aims at examining how revenues derived from wildlife based tourism in and around Waza National Park could be partially used to minimize the antagonistic attitudes of the local people and improve the relationships between park and people.

The present chapter examines the past and present economic value of tourism in and around Waza National Park, discusses its potential value, and analyses the role played by elephants in wildlife-based tourism. Finally, it gives considerations to the role that tourism may play in winning the support of local people for conservation.

Study Area and Methods

The Waza-Logone region has been described in Chapter 1.2. Details on the vegetation and wildlife are found in Wit (1975) and Vanpraet (1977), respectively. Loss of land to wildlife, prohibited access to protected areas' natural resources, livestock losses from wild carnivores, and mainly elephant crop damage are major constraints on local options and motivations towards wildlife conservation (Tchamba, 1995). Waza National Park is one of the best in west and central Africa in terms of the numbers and variety of game, and the ease with which it may be seen. The park has more than 300 km of dirt roads and a small airfield. At present, the park is closed to tourism from July to October on account of the floods and inaccessibility. There is an attractive and comfortable 100-bed hotel situated on an inselberg overlooking the park and neighbouring marshes. A proper management of Waza National Park can potentially increase the benefits from tourism, offer sustainable benefits to the local communities, and contribute to the winning of their support for wildlife conservation.

The economic value of tourism can be measured in various ways (Dixon & Sherman, 1991). At the simplest level, one can examine the expenditures of tourists for transportation, guides, park admission, food, accomodations and souvenirs. To measure the true economic gain from visiting Waza National Park, one would need to measure consumer's surplus. The consumer's surplus is the difference between what a person actually pays as fees for park use and the maximum amount he or she would be willing to pay (Dixon & Sherman, 1991). This would require carrying out a travel-cost study carefully controlling for origin, visitor background, and other variables. This approach would provide data from which one can estimate a demand curve. With the available time and resources however, no travel-cost and/or costs-benefits analyses could be performed. Instead, survey-based approaches were used to determine the sizable values of Waza National Park as tourist attractions, and of its surroundings as safari hunting areas.

The main sources of information for the number of visitors in Waza National Park and earnings from entrance fees and safari hunting, for the period 1980 to 1992, were the records of the provincial delegations of the Ministry of Tourism and the Ministry of Environment and Forests (SPTEN, 1986; DPTEN, 1990; PNW, 1992). During the 1990-1991 and 1991-1992 touristic seasons, 1078 ramdomly selected tourists (547 and 531 respectively) were interviewed at the entrance of Waza National Park. Information was recorded on the status of the visitor (Cameroonian, expatriate resident, abroad tourist) and the nationality. Expatriate residents are tourists living in Cameroon, and abroad tourists are non-residents from abroad. Visitors' opinions (low, fair, high) on the actual entrance fees were asked. They were also asked as to the maximum amount they would be willing to pay to visit the park. Other information gathered in the survey included the listing of the most important improvements needed. Six professionnel hunters were asked to comment on the level of safari hunting fees.

In an attempt to determine the relative importance of elephants as touristic attraction in Waza National Park, visitor patterns and time spent searching for and viewing elephants were ascertained. Visitors were asked to rank the most attractive animals of the park (elephant, giraffe, lion, roan antelope, topi, kob, ostrich, other avifauna). In addition, on 34 occasions tourists were observed throughout their visit of the park. The total time spent inside the park, the time spent viewing wildlife, and the time spent looking for and then viewing elephants were recorded.

Results

Past and present economic value of tourism in and around Waza National Park

During the period 1981 to 1992, the average annual number of visitors to Waza National Park was 5000 and the revenues generated averaged US$ 41,000 annually. The number of visitors reached its maximum in 1986 with 7000 paying visitors (Fig. 5.5) and with a total of admission fees of US$ 53,000. The period before 1986 had on average 6000 annual visitors and US$ 44,000 of revenues. Since 1986, an almost continuous decrease of visitors has been observed. During the period after 1986, the average annual visitors was only 5000 and the average annual revenues US$ 38,000, a reduction of 17% and 14% respectively, compared to the preceding period. In 1992 the fewest number of visitors and the smallest revenues were recorded (4,200 and US$ 33,000 respectively).

Safari hunting of elephants in the area north of Waza National Park has consistently generated an annual revenue of about US$ 14,000 during the period 1981 to 1992 (average of 7 elephants per year from a hunting quota of 10 elephants). The total direct revenues generated by the wildlife-based tourism (wildlife viewing and safari hunting) can be estimated to US$ 55,000 annually, as an average of the whole period.

Potential economic value of tourism in and around Waza National Park

The large majority of visitors (Fig. 5.6) to Waza National Park were expatriates (82%). Of these the larger part, namely 49% were foreign residents of Cameroon, and only 33% were non-resident foreigners. Cameroonians represented only 18% of the visitors. French, germans, and dutch represented 50% of the tourists (22%, 17% and 11% respectively) (Fig. 5.7), followed by americans, swiss and british (9%, 9% and 5% respectively). Africans other than Cameroonians were almost absent from Waza (2% of tourists).

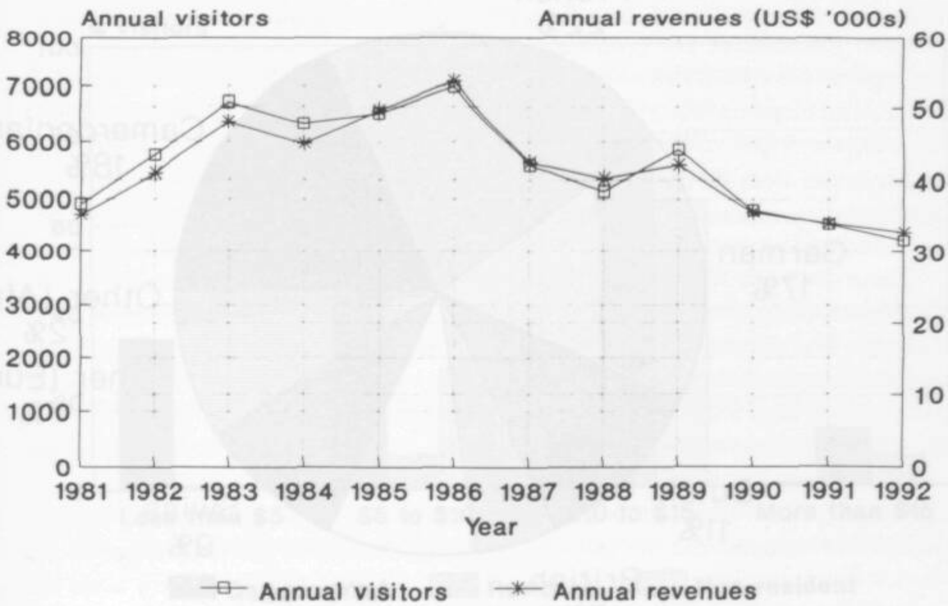

Figure 5.5

Number of paying visitors to Waza National Park and revenues generated (US$) over the last 12 years (1981-1992)

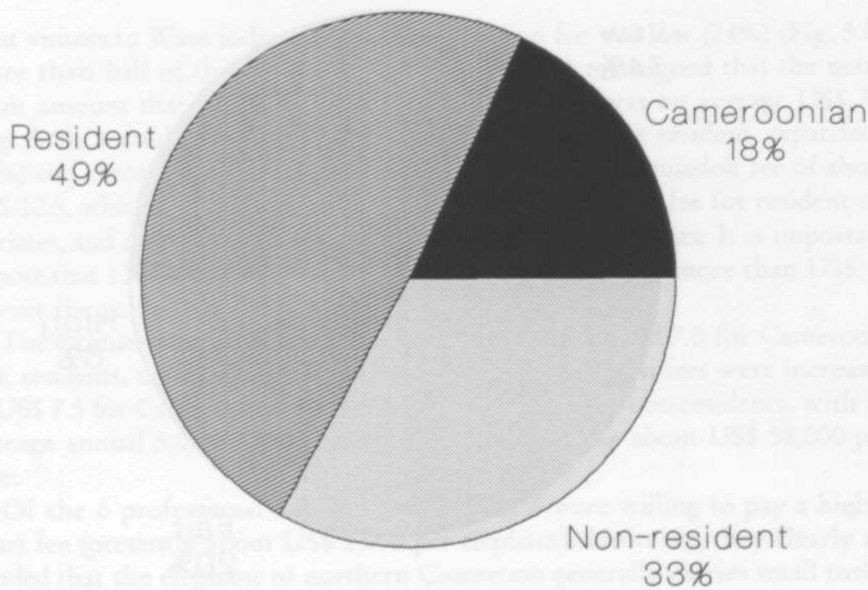

Figure 5.6

Status of visitors to Waza National Park (1990-1992)

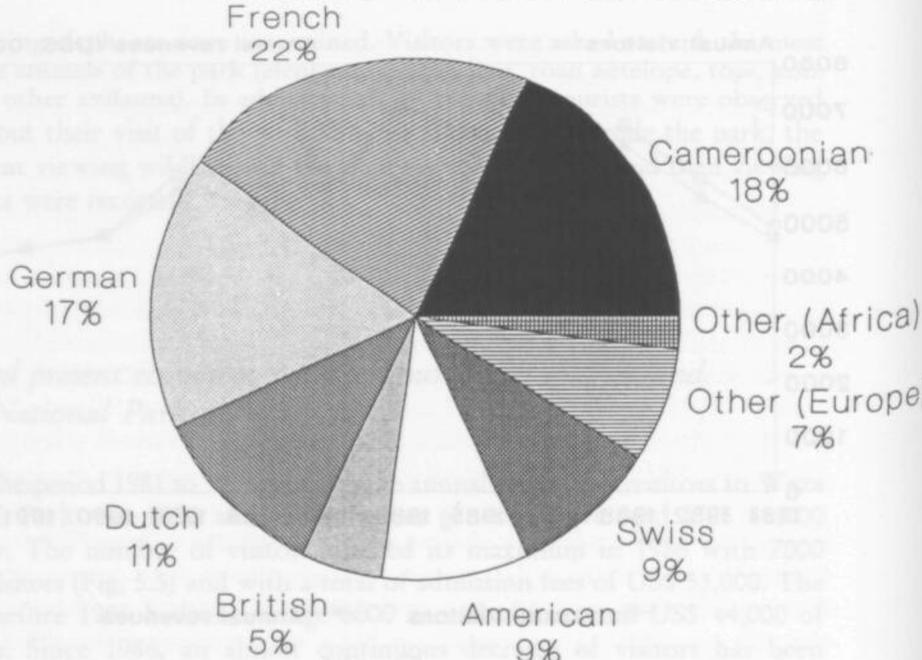

Figure 5.7
Nationality of visitors to Waza National Park (1990-1992) (n=1078)

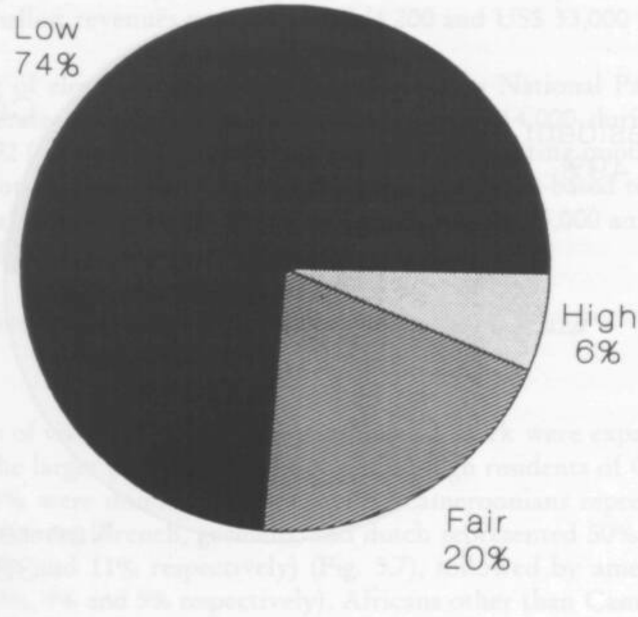

Figure 5.8
Visitor's opinion on the admission fee to Waza National Park (1990-1992) (n=1078)

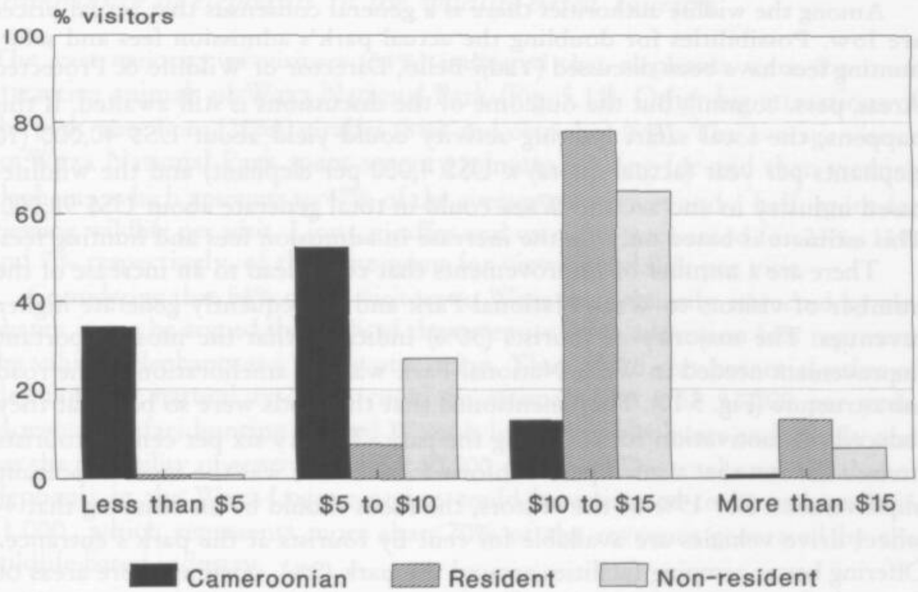

Figure 5.9
Maximum amount that Cameroonians (n = 194), residents (n = 528) and non-residents (n = 356) visitors to Waza National Park would accept to pay (1990-1992)

Most visitors to Waza indicated that the admission fee was low (74%) (Fig. 5.8). More than half of the Cameroonian visitors (52%) mentioned that the maximum amount that they would pay to visit the park was on average US$ 7.5 (Fig. 5.9), a doubling compared to the actual fee. Most resident expatriates (78%) and abroad tourists (65%) would pay a maximum admission fee of about US$ 12.5, which represents more than four times the actual fee for resident expatriates, and more than twice the actual fee for abroad tourists. It is important to note that 13% of resident expatriates were willing to pay more than US$ 15 to visit the park.

The estimated consumer's surplus was US$ 4.5, 9.5, and 7.5 for Cameroonians, residents, and non-residents respectively. If admission fees were increased to US$ 7.5 for Cameroonians and 12.5 for residents and non-residents, with an average annual 5,000 visitors, the park would generate about US$ 58,000 per year.

Of the 6 professional hunters interviewed, 4 were willing to pay a higher safari fee (presently about US$ 2,000 per elephant). However, they clearly reminded that the elephant of northern Cameroon generally carries small tusks, rarely exceeding 25 kg each side, a factor weighing doubtlessly against high safari fees.

Among the widlife authorities there is a general consensus that actual prices are low. Possibilities for doubling the actual park's admission fees and safari hunting fees have been discussed (Yadji Bello, Director of Wildlife & Protected Areas, pers. comm.), but the outcome of the discussions is still awaited. If this happens, the local safari hunting activity could yield about US$ 40,000 (10 elephants per year (actual quota) x US$ 4,000 per elephant) and the wildlife-based industry in and around Waza could in total generate about US$ 98,000. This estimate is based only on the increase in admission fees and hunting fees.

There are a number of improvements that could lead to an increase of the number of visitors to Waza National Park and consequently generate higher revenues. The majority of tourists (30%) indicated that the most important improvement needed in Waza National Park was the amelioration of the road infrastructure (Fig. 5.10). They mentioned that the roads were so bad that they reduced the motivation for revisiting the park. Twenty six per cent of tourists stressed the fact that a small park's information centre was the most important improvement. For 19% of the visitors, the focus should be on ensuring that 4-wheel drive vehicles are available for rent by tourists at the park's entrance. Offering better camping facilities around the park (9%), opening more areas of the park for tourism (6%), and offering more wildlife viewing opportunities (3%) were also suggested. Other suggestions (in total 8%) included the construction of miradors, the training of guides, the putting of signs inside the park, and the identification of more sites and better time for wildlife viewing.

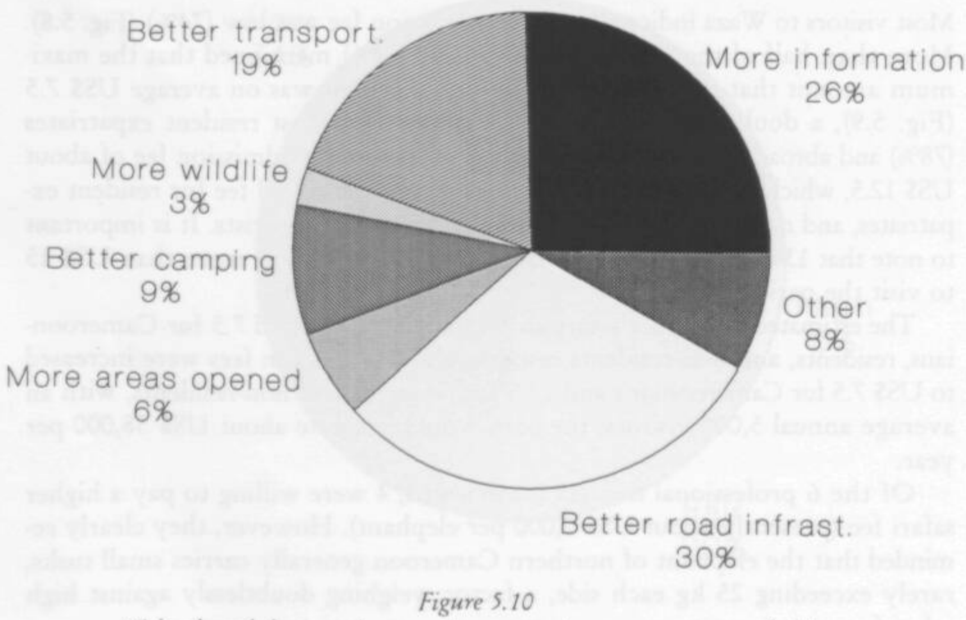

Figure 5.10

Visitor's opinion on the most important improvements needed in Waza National Park (1990-1992) (n = 1078)

Importance of elephants in the wildlife-based tourism

The vast majority of visitors (54%) indicated that elephants were the most attractive animals of Waza National Park (Fig. 5.11). Other big attractions of the park were lions (22%), giraffes (8%) and ostriches (6%). The average visitor to Waza National Park spent seventy minutes looking for and then viewing elephants, which amounts to 47% of the average two hours and a half, spent for viewing wildlife per visit. Lions, giraffes and ostriches accounted for 23%, 11% and 7% respectively, of the time spent for viewing wildlife per visit.

Considering that 54% of the visitors to Waza are primarily attracted by elephants, it can be argued that 54% of the revenues from admission fees represent the value of elephants as a tourist attraction. Thus, the direct potential value of elephants as natural resource could be estimated to US$ 31,000 per year. Moreover, safari hunting around Waza is limited to elephants exclusively and has the possibility of generating US$ 40,000 per year. The total annual value of elephants in the Waza-Logone region could be estimated to be at least US$ 71,000, which represents more than 70% of the revenues generated by the wildlife-based industry.

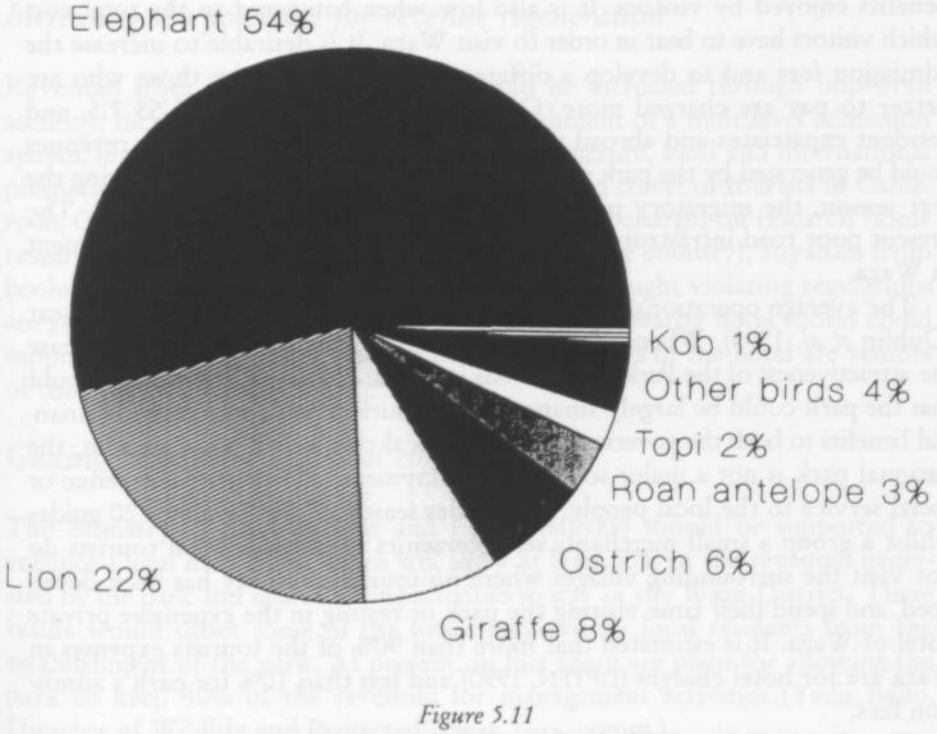

Figure 5.11
Visitor's opinion on the most attractive animal of Waza Nationa Park (1990-1992) (n = 1078)

Discussion

Tourism is big business in countries like Kenya where it is worth an estimated US$ 350-400 million per year and involves a great deal of the indirect demand for goods and services produced by the economy (Dixon & Sherman, 1991). Cameroon still has a long way to go before it reaches such a level of touristic attractiveness. However, Cameroon badly needs foreign exchange in this period of economic hardship. Hence, it is advisable to develop the foreign exchange currency earning capacity of Waza National Park, the most famous of Cameroon's national parks, by developing tourism. In recent years, the number of visitors to Waza National Park has consistently decreased, due to increased insecurity in the region since 1986. Successive fights between the local Arab Choa and the Kotoko tribes, coupled with frequent armed robberies on the highway to Waza, have seriously hampered the development of tourism. Unless security is urgently restored in the region, Waza will loose its place as a focal touristic point of Central Africa. With a strong political will shown by local authorities and with security measures taken by military officials, it can be anticipated that security could be significantly improved in the near future.

Admission fees to the park are very small when compared to the sizable benefits enjoyed by visitors. It is also low when compared to the total cost which visitors have to bear in order to visit Waza. It is desirable to increase the admission fees and to develop a differential pricing whereby those who are better to pay are charged more. Cameroonians may well pay US$ 7.5, and resident expatriates and abroad tourists from US$ 12.5. Still higher revenues could be generated by the park if the touristic season was extended. During the wet season, the migratory palearctic birds could be a major attraction. The present poor road infrastruture is a major limitation for tourism development in Waza.

The average operational budget for the park is about US$ 26,000 per year (Dublin *et al.* 1995). When infrastructure improvements are made to increase the attractiveness of the Park, this also has its costs. However, there is no doubt that the park could be largely financed from tourism and could provide financial benefits to both the government and the local communities. At present, the national park is not a major source of employment, and neither a revenue or social service to the local people. It provides seasonal jobs for about 20 guides whilst a group a small merchants sells souvenirs to tourists. Most tourists do not visit the surrounding villages where no touristic activity has been developed, and spend their time visiting the park or resting in the expensive private hotel of Waza. It is estimated that more than 90% of the tourists expenses in Waza are for hotel charges (DPTEN, 1990) and less than 10% for park's admission fees.

Western & Henry (1979) estimated the gross worth of lions in Amboseli National Park in Kenya, in terms of generating tourism revenues, to be US$

27,000 annually, an elephant herd was worth US$ 610,000 per year! Elephants of Waza are still far from generating comparable revenues. However, they may yield significant benefits to the local communities. Elephants are the most attractive animals of the park but also the major source of conflicts between wildlife authorities and villagers (Tchamba, 1995). The long term conservation of natural resources in Waza National Park greatly depends on the reduction of these conflicts and the diversion of part of the benefits from tourism to the local people.

Conclusions

Waza National Park plays a valuable role in maintaining biological diversity and represents a potentially significant economic resource with opportunities for local development. The expected benefits from tourism will materialize and tourism will play a significant role in winning the support of local people for conservation if measures are taken to (i) increase the potential for revenue regeneration; and (ii) get the benefits to the local communities.

Increasing the potential for revenue regeneration

Revenues from Waza National Park could be increased through improved security, increased admission charges, establishment of a multilevel admission system, improvement of the park's road infrastructure, local and international promotion of the park, and facilitation of access and travel of tourists in Cameroon. Other small sources of revenues might include charges on research (some research topics yield benefits that accrue outside the country), royalties from books, photographs and films. Strict fining of those caught violating regulations are yet another source of funds. A special tax on the nearby hotel rooms could support conservation efforts as virtually all customers of the hotel are visitors of the park.

Getting benefits to the local communities

The Ministry of Environment and Forest (MINEF) should be supported to enhance a legal mechanism which will allow at least 50% of the revenues generated by the park and safari hunting activities to stay in the Waza District. These funds would offset some of the losses incurred by local residents from the establishment of the park. At present, in fact there are plans for allowing the park to keep 30% of the revenues for management activities (Yadji Bello, Director of Wildlife and Protected Areas, pers. comm.).

An environmental awareness programme in the Waza Sub-Division may improve local people's understanding of the economical and ecological importance of the park. A public relation campaign may provide a number of incentives to the community. When touristic development is undertaken, nearby residents should receive preference for jobs within and near the park. Park maintenance (*i.e.*, grading the roads after the wet season, digging waterholes) and research activities (*i.e.*, drivers, guides, tranlators) will provide job opportunities. A system of reward for real information about poachers should be developed in order to create an incentive for local people to collaborate in anti-poaching activities.

The experiences of Zambia (Bell, 1988) and Zimbabwe (Cumming, 1988) could be used for developing Wildlife Management Areas, with special opportunities for safari hunting of elephants. These could generate jobs to villagers and other benefits through meat, skin and hides. However, the concept of Wildlife Management Areas can not be naively transfered to the Waza-Logone region. There are many steps which Cameroon would need to go through to consider a decentralized system of decision-making and revenue-distribution. At present, the existing fiscal laws and land property legislation don't allow local villager land rights and ownership of wildlife. A starting point may be the redefiniton of the competences of the State and the local communities in the management of natural resources.

Expected benefits from tourism will not fully compensate for elephant damage to agricultural crops (estimated to more than US$ 200,000 (Thouless & Tchamba, 1992)). Consequently, strategies to reduce the antagonism between local people and the park should include actions that will restrict elephant movements out of Waza National Park.

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5.4

Assessment of Elephant Damage Compensation as a Strategy for Reducing the Human-Elephant Conflict in Northern Cameroon

Summary

Within the field of conservation in Africa and Asia there is an increasing concern about human-elephant conflict. Suggestions have been made to develop conservation incentives in an effort to raise local people's tolerance threshold towards elephants. This chapter discusses the shortcomings in the present elephant damage compensation system of northern Cameroon and describes the experiences from southern Africa (Zimbabwe's CAMPFIRE programme) and western Africa (Burkina Faso's Nazinga Ranch project). Furthermore it examines the essential steps to an effective compensation system that could alleviate the strains caused by human-elephant conflict in the region.

The present compensation system is disorganized and politically motivated. The current obstacles to an effective compensation scheme include: its lack of administration, considerable abuse and corruption, and invalid assessment of damage levels. Steps towards developing and implementing an effective compensation include: the development of wildlife utilization in order to strengthen, diversify and increase the revenues generated, the establishment of some type of local institutional framework for managing the compensation fund, the training of agricultural extension agent in elephant crop damage assessment, the development of mutually acceptable damage reporting and compensation-distribution procedures, the stimulation of millet production in areas not affected by crop damage, policy reform recognizing the rights of communities living with wildlife to utilize and benefit from these resources, the building of local capacity in local resource management, and the development of environmental education programmes.

The chapter concludes that a well developed compensation system is only a short-term solution to the human-elephant conflict and recommends that long-term solutions be sought by combining an effective compensation system with

strategies that will deal with limiting elephant numbers and movements, and sustainable use of elephants in the buffer zone.

Introduction and Background

As human populations expand, there is a growing need for increasing agricultural production to meet food requirements. In most African countries, this is achieved mainly by expanding cropland at the direct expense of wildlife habitat. Conflicts arise mainly because increasingly wildlands are converted to agriculture, and the natural habitats of many game animals are reduced and fragmented. As a result of land conversion game animals destroy crops as they trek their traditional routes or migrate in the search of favoured habitats. Human-wildlife conflicts will probably escalate in the future because they originate from increasingly critical problems like human over-population and global environmental degradation (Lewis, 1992).

In spite of the fact that human-elephant conflicts around Africa share many characteristics, each conflict is unique, with its own peculiar cultural, political, ecological, and historical context (Taylor, 1987; Damiba & Ables, 1993; Hoare & Mackie, 1993; Taylor, 1993; Thouless, 1994; Tchamba, 1996). As a consequence each requires a specific approach. The solution to a human-elephant conflict comes from a choice between alternatives (culling, control or disturbance shooting, fencing, digging of ditches, habitat enrichment and expansion, creation of buffer zones and/or corridor, developing conservation incentives). The choice should be based on a balance of cost, effectiveness and extent to which the interests of the farmers and the elephants are served.

During the past few decades the local resource management approach has increasingly captured the attention. It is based on utilization of wildlife resources and management by communities living with wildlife. It uses wildlife as an economic resource and, by returning income from the resource to communities living with wildlife, it not only aims to contribute to rural development, but also to a change in attitudes towards wildlife and therefore to the conservation of the resources. Zimbabwe's CAMPFIRE programme is an interesting case regarding this approach. It is probably the best known example, but similar initiatives have been taken in Zambia, Tanzania, Namibia (Martin, 1986; Kiss, 1990; van den Breemer *et al.*, 1995), Burkina Faso (Lungren, 1990) and elsewhere.

The ideas described here are part of a project on the ecology of elephants in northern Cameroon in relation to conflicts with humans (Tchamba, 1993). This chapter examines the shortcomings of the present damage compensation system in northern Cameroon, describes the experiences from southern Africa (Zimbabwe's CAMPFIRE programme) and western Africa (Burkina Faso's Nazinga Ranch project), and recommends essential steps towards developing and implementing an effective compensation system which could contribute to the reconciliation of elephant conservation and human development in northern Cameroon.

The Waza-Logone region has been described in Chapter 1.2. Details on the history and present status of the human/elephant conflict in the Waza-Logone region are presented in Chapter 3.3. In 1994, a very intensive control and disturbance shooting operation was carried out by the Cameroon Wildlife Service in order to deter elephants from the Kaélé region, a wet season refuge for elephants. This operation was not effective in stopping elephant crop raiding. At this stage, it appears necessary to complement these actions with strategies such as a damage compensation scheme for increasing the level of farmer's tolerance towards elephants.

Experiences from Zimbabwe and Burkina Faso

Zimbabwe's CAMPFIRE programme

CAMPFIRE stands for Communal Areas Management for Indigenous REsources. The concept has its origins in the 1970s and early 1980s. The programme tries to integrate conservation, local resource management, community empowerment and rural development. It is meant to 'provide the institutional structure under which communities can carry out their own management of natural resources and maximize the returns in any given location' (Martin, 1986). Although initial project proposals were written and accepted in principle in 1982, it took another 6 years before the principles were put into practice. The granting of Appropriate Authority empowers the land-owner or the Council to exploit their wildlife, receive all payments directly, carry out their own problem animal control and law-enforcement, and protect the resource (Murombedzi, 1992).

The programme is coordinated by the CAMPFIRE Collaborative Group, consisting of governmental agencies and non-governmental organizations. Most income is derived from sport hunting. Other sources of income include: sales of hides, skin and ivory (as a result of problem animal control), tourism and wildlife cropping (Peterson, 1991). An estimated 40-50% of all income is elephant-related. Slightly more than 50% of CAMPFIRE income has been allocated for disbursement to communities. The other half has been used for operating costs, administrative claims, and in some cases for strategic reserves (Olthof, 1995).

Although CAMPFIRE has played an important role both in conservation and rural development, it had faced a number of difficulties. Local communities have benefited in terms of development projects, meat, cash receipts, and/or compensation for crop damage, but have hardly participated in management and decision making (Murumbedzi, 1992). To many people the District Council or the District Wildlife Committee are remote and regarded with scepticism. For local residents it has been difficult to distinguish between development projects originating from the CAMPFIRE's funds and those financed by the Central Government and donors. CAMPFIRE has shown that although a sound financial base is an essential precondition of any resource management, it is not sufficient for and should be complemented by appropriate institutional arrangements and active local-level participation (Olthof, 1995). Finally, income from CAMPFIRE may be important and welcome but can only be considered supplementary to income from crops and livestock (Bond, 1993).

Burkina Faso's Nazinga Ranch project

The Nazinga Ranch project in Burkina Faso was initiated in 1973 but officially began in 1979 after adoption by the Government Council. The original objectives were '... to research, design and develop rational utilization of the wildlife resources in the Nazinga area, in order to increase the resources for the profit of the local people ...' (Lungren, 1990). Extensive consultation and dialogue with local communities was an essential element from the beginning and throughout project design and development. The Burkina Faso Ministry of Environment and Tourism is responsible for project implementation, with the local community participating through representation on the Management Committee and on the Village Advisory Committee. Village hunting zones are managed directly by Village Hunting Committees gradually taking over the responsibility for anti-poaching, designation of hunting guides, distribution of meat, and allocation of revenues for community development project. Most income is derived from safari hunting and game cropping operation. Other sources of income include sales of live animals and tourism for game viewing.

Tangible benefits for the local community includes: improved fishing, health and social services, schools, wells, employment, a portion of the trophy tax and all the meat from safari hunting. However, the project activities have centered around the Nazinga Ranch itself and the project staff has made all important management decisions (Lungren, 1990).

Shortcomings of the Present Damage Compensation System in Northern Cameroon

Cameroon recently revised wildlife legislation originally enacted in 1981. While the *Forests, Wildlife and Fisheries Act* (Law No. 94/01) (1994) took effect in January 1994, enabling legislation was formalised in July 1995. The Act provides for the control shooting of wild animals in defence of people or their property, through Ministerial Order. There is no provision for compensation for damage caused by wildlife. With the increasing human-elephant conflict and its growing socio-political influence, an informal elephant damage compensation system has been developed in northern Cameroon. It is an ad hoc system with no legal back-up.

Elephant damages are reported to the local Agricultural Officer who keeps records of the farmers' names and villages, the type of crops and the size of the farmland damaged. In most cases the Agricultural Officer does not assess the damage and relies on information provided by the farmers. The records are compiled by the Agricultural Officer and sent to the Sub-Divisional Officer (resident government representative). Depending on the extent of the reported damages, the publicity surrounding the incident and the political heat it has generated, the central government decides on whether the losses due to elephants should be compensated or not. In 1993, 200 tons of rice and milk from the World Food Program were distributed to local farmers who suffered elephant crop damage (MINAGRI, 1993). In 1994, the Head of State decided that US$ 2 millions should be spent in northern Cameroon for elephant damage compensation and food assistance to drought victims. Rice, millet, cotton oil and cattle feed were distributed to local farmers. In addition, specific people or institutions such as local civil servants, deaf, blind and dumb people, schools, and women's groups also received food assistance. Eventually, however, it appeared that the government's funds had been misused because of corruption, injustice, inadequate organisation of the compensation scheme, unclarity about those who were entitled to assistance, lack of real assessment of the damages, power conflicts between the different government services and the local elites, and the political nature of the compensation programme.

Essential Steps Towards Developing and Implementing an Effective Compensation System

Carpenter & Kennedy (1985), Hough (1988) and Lewis (1992) discussed the obstacles and steps towards effective management of wildlife or park-local people conflicts under different circumstances. The mentioned obstacles and the steps to be taken have to be considered also for the situation in Cameroon. Thus essential steps towards developing and implementing an efficient damage compensation system in northern Cameroon include: identifying the potential sources of funding for the compensation scheme, the management of these funds; the accurate estimation of the magnitude of the damage; identifying the appropriate types of compensation; the development of a damage reporting process and compensation procedure that are efficient and easy to understand by the local farmers; and finally, the development of an environmental education programme and the building of local expertise in community-based local resource management.

Estimation of the damage

Accurate crop damage assessment is a key element of any compensation scheme. At present, elephant crop damage is estimated by the affected farmer who reports to the nearest local Agricultural Officer as far as 30 km away. Because of a lack of means of transport and a lack of motivation, the Agricultural Officers rarely visit the destroyed farmlands. Consequently, local and regional crop damage estimations are entirely based on biased visual assessments from farmers. Tchamba (1996) compared field investigations by trained enumerators and individual crop damage reports by farmers, and noted that farmers consistently overestimated crop damage by 30 to 40%. The extent of the problems caused by elephants is overestimated intentionally due to the expectation that potential compensation will be related to the level of damage declared.

Measurements to assess crop loss are far more accurate than visual estimations (Nsiska & Deodatus, 1991). The National Agricultural Extension Programme could play a vital role in the developing methods for accurate assessment of elephant crop damage. Because elephant crop damage is seasonal, and agricultural extension agents are equipped with motorbikes and keep records on supervised farmers, they could bear the responsibility of crop damage assessments. A Problem Animal Reporting System (Hoare, 1995) should be set up in each of the affected villages, so that elephant movements and damage are reported as soon as possible to the nearest Agricultural Extension Agent. The Agricultural Extension Agents should be carefully trained on the methods for spatially and temporally quantifying elephant damage, for instance methods as developed by Hoare (1995).

Type of compensation

Distribution of food has so far been the only form of compensation for crop losses, with rice being the most frequently distributed food item to farmers. The reason being that rice is available at cheap prices from the Food and Agricultural Organization (FAO) through its World Food Programme. Zwaal (1995) indicated that 71% of the farmers of the Waza-Logone region preferred millet as compensation. Rice, oil and milk received as compensation are very often sold and the money used to buy millet. There is a risk of shortage of millet in the local market and consequently of increasing millet prices if tons of millet are bought for the compensation scheme. Millet production has to be stimulated in other areas of the country, not suffering from elephant crop damage, so that the surplus can be made available for the compensation scheme.

Because of the fact that most elephant crop damages occur more than 100 km from Waza National Park, it is difficult for these local people to realize the connection between wildlife and the benefits received from its presence. Therefore, approaches to stimulate positive attitudes towards elephant conservation should include awareness programmes and ensure that all community development projects (schools, clinics, bore holes, etc.) funded from wildlife revenues are posted with a sign to this effect.

At present, local people enter Waza National Park illegally to collect grass for building material. Most houses in the Waza region are roofed with thatch grass, and the canes of tall grasses are traditionally used to construct walls and partitions both outside and inside the house, as well as for handicrafts. Local people recognize that these materials are abundant in the Park and have become rare outside due to overgrazing by livestock. Most of these materials are destroyed by control burning conducted by the Park authorities in the dry season to facilitate wildlife viewing and to ensure regeneration of fresh grass during the dry season. Allowing local people to harvest a restricted amount of these natural resources could be an effective contribution to the economy of people living in the vicinity of the Park in exchange for restrictions imposed by park legislation, and wildlife damage to their crops or property.

Furthermore, the planning, development and management of a buffer zone around Waza National Park should be performed in close collaboration with local people. A number of potentially appropriate activities that could be developed in this zone may well include sustainable harvesting of guinea fowl and gum arabic, and collection of firewood for non-commercial purposes. All these activities however require caution and careful monitoring.

Sources of funding for the compensation scheme

A compensation fund based on assistance from the Head of State is not sustainable. With Cameroon facing harsh socio-economical problems at a national level, this scheme should mostly be financed from wildlife generated revenues at a more local level. It is of high importance to identify a reliable and constant source of funding for the compensation scheme.

During the period 1981 to 1992, revenues generated by wildlife-viewing tourism in Waza National Park (Cameroon's most famous national park) averaged US$ 41,000 per year (DPTEN, 1990, Chapter 5.3). This low revenue is due to the lack of promotion, the poor facilities and infrastructures available, limited access (only 5 to 6 months per year), and the low entrance fee (from US$ 3 to US$ 5 for the whole tourist season). In recent years, insecurity in the region (activity of armed robbers) has greatly reduced tourist numbers. During the period 1981 to 1992, safari hunting of elephants generated about US$ 14,000 per year (Chapter 5.3). Only about 7 elephants were killed each year, from a hunting quota of 10 elephants per year, because of the lack of promotion and the poor organization of the safari hunting activity.

There is an urgent need for the provisions of a pragmatic policy that views wildlife as a natural renewable resource that can be used correctly for the benefit of people. Revenues from tourism could be doubled by promoting of tourism, by extending the tourist season, and by doubling of the entrance fees in national parks. Tourism to North Cameroon can be made more attractive by improvement of the road infrastructure in the touristic areas and by improvement of security in the region. This requires a strong political will from the highest levels of government.

Control shooting of elephants moving out of Waza is actually conducted to protect people and their properties. Better organisation and tighter coordination of this control shooting could accrue benefits to the local communities. Elephant meat is highly valued in Cameroon and meat from control shooting could be sold and revenues used for the compensation fund. The dead elephants would be skinned and the carcasses cut up and transported to the nearest village where the meat would be cut into thin strips, brined and sun-dried on wire mesh racks, and the products sold in local markets. Appropriate preservation methods and marketing mechanisms of elephant meat in compliance with various veterinary and health regulations still have to be developed. Sale of elephant meat could generate about US$ 30,000 (10 elephants x 1,000 kg of meat x US$ 3 per kg), part of which could be used for the compensation scheme.

Limited safari hunting of elephants has been carried out in the Waza-Logone region for many years. Hunting is either sold as individual hunts with predetermined quota for each hunt, or an annual quotum is offered on tender to a registered safari operator. With the actual hunting quota of 10 elephants per year and the potential doubling of the elephant hunting fees (to US$ 4,000 per elephant), the local safari hunting activity could yield US$ 40,000, part of which could be used for the compensation scheme (Taylor, 1993).

Taken together, tourism, selling of elephant meat from problem animal control and population reduction shooting in addition to safari hunting could generate at least US$ 128,000 ($ 58,000 from tourism and $ 40,000 from safari hunting (chapter 5.1), US$ 30,000 from sale of elephant meat).

Wildlife management is not without costs. At present the total operational budgets of Waza and Kalamaloué National Parks and the Provincial Wildlife Department is below US$ 50,000 (Boubakari Mana, Provincial Delegate for Environment and Forests, pers. comm.).

Although proper evaluation of the costs of wildlife management in northern Cameroon has not been carried out it is important to note that even if all the revenues generated by the wildlife-based activities where directed towards compensation, they would represent less than one quarter of the estimated elephant damages in the area (Thouless & Tchamba, 1992; Tchamba, 1996). An isolated damage compensation scheme would not be self-sustaining. It could only be effective if used in combination with other strategies aimed at reducing elephant movements outside the Waza National Park and, thereby, significantly reducing elephant crop damage.

Compensation fund and community-based natural resource management

Cameroon is no exception to the problems of corruption that face most African cou ntries. At the moment it is not clear what organization or branch of government is best suited for managing a compensation fund. Whatever type of management scheme is developed, the local authorities will have to be involved. The institutional environment represents a fundamental obstacle to conflict resolution (Hough, 1988; Lewis, 1992). It takes a long time to develop and explain procedures. In addition, there is often a poor relationship between authorities and local people, characterized by a lack of trust and by power struggle. This lack of trust stems from experiences in the past when famine relief destined for local communities was hijacked by local government. The difference in power between local communities and local government is one of the root causes of the conflict in that the desires of the central government are forced on the relatively powerless resident populations.

Establishing trust between parties is a basic prerequisite to successful establishment and implementation of a compensation scheme and conflict resolution in northern Cameroon. Initial distrust might be overcome by the introduction of third parties arbitrators, who are perceived as being neutral (Bowonder, 1983). They could be representatives of local non-governmental organizations. The lack of education of the local people leads to numerous misunderstandings and difficulties in communication with authorities. Environmental education is an essential component of the conflict resolution strategy.

Real power must be given to the local people through some type of local institutional framework in which they participate. The establishment of such an institution is considered crucial in establishing trust and cooperation between politicians, wildlife authorities and local people (Hough, 1988). However, under the current legal, political and economical situation of Cameroon, a decentralised system of decision making and revenue-distribution as the CAMPFIRE programme in Zimbabwe is unrealistic. The first steps that Cameroon has to go through include the changing of the existing fiscal laws and land property legislation to allow local communities land rights and ownership of wildlife. The national policy reform should address the key questions of 'Who gets what' and 'Who decides who gets what'.

Damage reporting and compensation procedures

The actual compensation system is informal and poorly understood by the local people. Farmers report to their chief or to the local Agricultural Officer. These intermediaries are very often difficult to contact and the farmer has no means or power to check the outcome of his verbal report. Zwaal (1995) noted that 59% of the farmers did not know of the existence of any compensation system. Those who knew of its existence complained about the chief and the Agricultural Officer. In all cases where farms were inspected by a chief's representative or by the Agricultural Officer, farmers did not receive any written evaluation or report. Consequently, the compensation received during a well-publicized ceremony organized in each village and involving all the local authorities was not at all related to the level of damage declared. Because local farmers have no control over the compensation procedure, the system is open to abuse and it is possible that some of the millet or rice destined to compensate the local people is embezzled by the authorities, the chiefs or the Agricultural Officers.

In developing a procedure, one should bear in mind that every step taken, from the complaints of the farmer until the final compensation payment, should be easy to understand and to control by the local farmers. In order to achieve this the local farmers could form a local committee to mediate discussions between local communities and government authorities. There is a need for developing mutually acceptable mechanisms for damage reporting and distribution of compensation.

Environmental education and building local capacity

Environmental awareness involves the sensitization of people at all levels to the objectives and benefits of wildlife conservation and management and the importance of participation of local communities in this effort. Education of policy makers is essential for developing legislation that will empower local communities and facilitate the development of wildlife utilization enterprises. Education of local people aims to increase their appreciation of the value of wildlife resources and their role in maintaining them. Furthermore, wildlife authorities need education concerning the importance of building and maintaining cooperation with local communities.

Community-based local resource management requires that local authorities and local communities have considerable knowledge and skills in a wide variety of areas including: community relations, organization and leadership; business and financial management; economic analysis; public administration; land use planning; wildlife biology and management; poaching control; hunting; handling and processing and marketing of wildlife related products (Kiss, 1990). At present, experience is lacking and the necessary technical or managerial skills are insufficient. There is a need for external financial assistance and human resources for building the local capacity in local resource management.

Conclusions

One of the traditional ways of increasing the tolerance level of rural communities towards elephants has been to pay compensation to affected farmers. The compensation experiment in Malawi was abandoned, as was the official countrywide compensation scheme in Kenya (DHV, 1992). The problem with all compensation schemes is their administration, considerable abuse and corruption, and inaccurate assessment of damage levels. The present compensation system of northern Cameroon is guided more by political agendas than by the technical or scientific aim of raising the farmers' tolerance threshold.

The World Bank is now preparing a biodiversity project in northern Cameroon, with contributions from the Global Environmental Facility (GEF), the French Technical Aid (FAC), the Netherlands Directorate General for International Cooperation (DGIS) and the World Wide Fund for Nature (WWF). One of the objectives of the project is the development of village-based management of natural resources in general and of hunting blocks in particular (de Iongh, 1995). The key to successful community-based natural resource management is the grassroots involvement of the communities themselves (Kiss, 1990). No matter how urgent conservation objectives may be, they can only be realized through cooperation with rural communities if the priorities of these communities are built in from the beginning. Each case of community-based management of natural resources is different and following a blueprint is not a guarantee for success. Nevertheless it is useful to develop some principles emerging from local field experience and experiences from other countries such as the CAMPFIRE programme in Zimbabwe and The Nazinga Ranch project in Burkina Faso.

Human tolerance towards wildlife is being achieved in Zimbabwe through placing an economic importance on elephants, which presently is being realised through high valued international safari hunting, game viewing and photographic safaris (Taylor, 1993). Through the CAMPFIRE programme, benefits from wildlife revenues are returned to the local inhabitants and communities, who are increasingly participating in the control and management of wildlife and are becoming both responsible and accountable for their wildlife and wildland resources (Anonymous 1991; Taylor, 1993).

Potential earnings from wildlife utilization in northern Cameroon is far below the losses due to elephant crop damage. Consequently, an isolated compensation scheme would not be sustainably funded. Furthermore, the implementation of a common property management scheme is not compatible with the present realities of fiscal regulations and land tenure policy.

The experiences of Zimbabwe and Burkina Faso provide good examples of the complexities involved in local participation in implementation and management of natural resources. Alleviating the human-elephant conflict in northern Cameroon will require creating an enabling environment for sustainable wildlife utilization and reduction of elephant crop damage, through policy reform, education and investment.

On the financial side, there is a need for increasing revenues from tourism. This could be mainly achieved by extending the tourist season, increasing the entrance fees in national parks, and improving the security in the region.

On the policy side, there is a need to redefine the competences of the State and the local communities and to recognize that the management of natural resources is a matter of a triangular partnership between the State, the municipalities and the local population. Through policy reform local communities must regain legal access to the value which wildlife represents, in the form of revenues from tourism, safari hunting, meat and other products. Education is needed to make people aware of the potential economic value of wildlife.

On the investment side, external capital and technical assistance is needed in building local capacity in wildlife management and community-based natural resource management. Training of game wardens is a great need for optimal control of elephant movements and reduction of elephant crop damage. Finally, further research is recommended to develop and implement an ecological measures to increase the capacity of the park and its buffer zone to hold elephants and to allow a sustainable use of elephants in a buffer zone around the park.

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Part VI

Conclusions and Recommendations

6.1

Conclusions

Wherever elephants have been managed, the relevant authorities have expressed concern over at least one of the following issues: (1) elephant poaching; (2) elephant impact on the vegetation and the risk of irreversible change; and (3) elephant damage to crops, properties and human life. The focus on these main elements of elephant management has changed in recent times. From a grave concern with the number of elephants that were being killed by humans, which resulted in the ivory trade ban, the attention has now turned to the numbers of people being killed by elephants and the damage of human property. The Waza-Logone region of northern Cameroon is no exception to this general trend of increasing human-elephant conflicts. The ultimate challenge to conservationists now appears to be reducing the costs to humans of living with elephants, while conserving viable populations of elephants. Based on the results of the study, the following conclusions are drawn.

Elephant Numbers and Population Growth

1. The Waza-Logone elephant population is estimated to 1,100 individuals and the age structure of the Waza elephant population seems to be one of a stable population (Chapters 2.2 and 2.3). The mean calving interval (3.1 years) however indicates a growing population, which has also been found in practice. The annual growth rate between 1977 and 1991 is 6.3% (Chapter 2.3). This discrepancy between the age structure and the annual growth rate is a combination of the artefact of the techniques used and undocumented immigrations from Chad. The Waza-Logone region was devoid of elephants until 1947 when the first elephants immigrated from Chad (Chapter 3.3). Since then numbers have increased steadily. Until 1969, most of the increase was due to immigration from Chad. Elephants were permanently disturbed in Chad by habitat fragmentation (destruction of the Mandelia Forest Reserve), civil war and poaching. It is possible that further undocumented immigration from Chad has taken place after 1970 (Chapter 2.3).

Division of the Waza Elephant Population into Sub-populations

2. The elephant population of Waza National Park is divided into three sub-populations (Chapters 2.1, 2.4 and 2.5). The first sub-population is resident, and uses almost the entire park. The second sub-population resides in the north of the park and migrates more than 100 km north of the park during the dry season. The third sub-population resides in the south of the park and migrates more than 100 km south of the park during the wet season. It appears that the movement patterns can be changed anytime, depending on locally unpredictable occurrences (Chapter 2.5).

Basic Problems of Elephant Management inside Waza and Kalamaloué National Parks

3. It is not likely that the Waza National Park and its surroundings will sustain a further elephant population growth whether this is due to immigration from Chad or natural recruitment. Approximately two-fifths of the total area of the park consists of floodplain. Elephants mostly use the remaining 1,000 km^2 (Chapter 4.1). This gives a density of more than one elephant per km^2 if elephants would remain in Waza throughout the year, a density considered high even in optimal savanna habitats. The increasing Waza elephant population has important implications not only for the park management but also for those concerned with land-use planning and regional development.

4. Increasing elephant numbers are already adversely affecting the woodland vegetation of Kalamaloué and Waza National Parks (Chapters 3.1 and 3.2). Large scale killing of mature trees and serious damage to regenerating vegetation in both parks are preventing regeneration from balancing the losses. It is significant that the number of *Acacia seyal* trees killed by elephants in Waza National Park has doubled in 15 years (Chapter 3.2). The *Acacia seyal* shrubland zone is a very important wildlife habitat for elephants and giraffes, in particular. If the present trend continues, elephants may have considerable negative effects on the *Acacia seyal* shrubland structure.

Basic Problems of Elephant Management outside Waza and Kalamaloué National Parks

5. Increasing elephant population size coupled with rapid human population growth and the expansion of agricultural land have escalated human-elephant conflict in the Waza-Logone region (Chapter 3.3). Until 1980, elephant crop raiding behaviour was reported only in the immediate vicinity of Waza and Kalamaloué National Parks and was of a minor nature. The conflict started to escalate in 1980, and in subsequent years, the number of elephants immigrating to the Mindif area from Waza increased and their home range expanded. Elephant damage to crops doubled between 1992 and 1993 in the Kaélé and Mindif areas and did not significantly dropped in 1994 when intensive control and disturbance shootings were carried out.

6. Local methods for deterring elephants often leads to fatal incidents and control and disturbance shootings by inexperienced teams coupled with improperly organized food relief programs have failed to reduce the human-elephant conflict (Chapters 3.3 and 5.2).

Factors Influencing Elephant Movements

Identification of factors influencing elephant movements is the backbone of the management of human-elephant conflict. Numerous authors have shown that the selective feeding behaviour of elephants changes over seasons, depending on the nutritional requirements and food availability in time and space.

7. The observations made indicate that the *Acacia seyal* shrubland is clearly the best available habitat for elephants in Waza National Park (Chapters 2.2 and 4.1). During the dry season, water is available only in two waterholes which are filled with groundwater mechanically. These two waterholes are both located in the *Acacia seyal* zone. In addition, this plant species has good crude protein levels and organic matter digestibility, and relatively high calcium concentrations, even during the dry season (Chapter 4.3). The combination of water availability and quality of *Acacia seyal* as forage probably plays a key role in the high preference of the *Acacia seyal* shrubland by elephants in the dry season.

8. It was observed that preferred food items are the same in Kalamaloué National Park and in Waza National Park (Chapters 3.1 and 3.2) , and water is abundant in Kalamaloué which is bordered by the Logone and Chari Rivers. The elephant migration from Waza to Kalamaloué is most

likely not determined by the need for some food items but mainly by the search for sufficient water. Elephants are 'pushed' out of Waza by the limited water supply.

9. Comparison of nutrient concentrations in Waza and in Kaélé (a wet season destination south of the Park) reveals higher levels of mineral elements in Kaélé than in Waza (Chapter 4.3). Moreover, the levels of sodium in the leaves were more than eight times higher in Kaélé than in Waza. The calcium to phosphorus ratio is near optimum in Kaélé. However, the scarcity of water is more a limiting factor in the Kaélé region than in Waza during the dry season. Previous studies have shown that elephants are prone to sodium deficiency, prefer water and soils rich in sodium, and may raid agricultural fields to supplement their diet. The evidence accumulated by this research indicates that: during the wet season, the nutritious sorghum fields are a strong motivation for elephants to move to the Kaélé region. Elephants are thus 'pulled' out of Waza during the wet season.

Towards Reducing Human-Elephant Conflicts in the Waza-Logone Region

There is a gap between the perception of elephants by the 'international conservation community' and by local people. The local people who live in harsh environments increasingly regard elephants as a western fantasy, an agricultural pest and an obstacle to their development. The future of elephant conservation therefore depends on the development of approaches which will allow sustainable, mitigative intervention to prevent the conflicts from developing into a disaster.

Guiding Elephant Movements

10. One approach is to guide, modify or block elephant movements. Drives have been successful in moving elephants over long distances. However, in most cases elephants have moved back. This management is not recommended for the Waza-Logone region. Using beaters is dangerous, time consuming, and difficult to organize. Aerial drives are very expensive and may not be effective in the long term.

11. Stone walls, ditches or moats are not recommended because of their limited effect and the high cost of construction (Chapter 5.1). Electric fences are one of the most widely used and effective tools for elephant management but are not appropriate for the management of the Waza-Logone elephants,

because of the high capital and recurrent costs, the uncertain effectiveness and the problems of long-term maintenance (Chapter 5.1).

12. Disturbance and control shootings had a short term effect on elephant movements and did not significantly reduce crop damage (Chapter 5.2).

Increasing the carrying capacity of Waza National Park and its surroundings

13. The capacity of the Park to hold elephants may be increased through habitat enrichment (Chapter 5.1). The restoration of old waterholes and/or the creation of new waterholes would only affect elephant movements to Kalamaloué. The provision of artificial salt licks may result in fewer animals moving out to Kaélé or animals waiting longer before leaving the Park. Increasing numbers of elephants will not dramatically affect the vegetation in the Park if disturbances are minimum and elephants can disperse, and move freely between the park and the proposed corridor. A corridor that would maintain a geographical connection between Waza and Kalamaloué would secure additional areas for use by elephants.

14. Elephant distributions and impact on woodland can be manipulated to some extent by burning. The present fire management policy might have negative effects on forage production because of the fact that the burning is often done very late due to inadequate capacity and organization (Chapter 5.1).

15. Evidence from this research indicates that reflooding might delay or reduce elephant movements out of Waza National Park. Available data are insufficient to conclude whether reflooding might change the quality or composition of the vegetation in the *Acacia seyal* shrubland, a very important wildlife habitat.

Controlling elephant numbers

If the elephants currently moving to Kaélé are successfully confined within the Park as a result of management actions, then controlling elephant numbers may have to be considered in order to deal with the increasing damage to the natural vegetation.

16. Translocation is theoretically a potential solution for the Kaélé problem, and for the increasing elephant numbers in Waza. However, there are three main reasons why it may be inappropriate and unpractical. It is expensive

and high technology is required. Moreover, there is no suitable destination within the range of Kaélé to sustain these elephants. Obviously they would have to be moved further south. It is also possible that the elephants may return to Waza or create a new conflict area.

17. Culling is generally regarded as a rather drastic approach to solving problems of overpopulation. It is most likely of value for herds pocketed in small patches of natural habitat totally surrounded by agriculture. It is likely that partial reduction of elephant numbers will have to be considered in the near future, particularly if the animals currently moving to Kaélé are successfully confined within the Park as a result of management actions.

Raising local people's tolerance threshold

One approach is to raise local people's tolerance threshold towards elephants by providing people with real economic incentive for retaining elephants as part of their rural resource base.

18. The shortcomings in the present informal damage compensation system of northern Cameroon is that it is cumbersome and expensive to administer, and that there is considerable cheating on claims, abuse of power and corruption (Chapter 5.4). In addition, there are not sufficient funds, and accurate quantitative assessment of damage levels is difficult.

19. The data presented in this study indicate that the revenues from wildlife-based tourism in the Waza-Logone region could be significantly increased (Chapter 5.3). Sustainable safari hunting around Waza National Park together with the full spectrum of wildlife and scenery which characterise the Park could generate revenues to the local population. However, in the present economical and legal context, there is no mechanisms to return wildlife revenues to the appropriate beneficiaries who are the rural poor and peasant farmers.

6.2 *Recommendations*

In spite of the fact that human-elephant conflicts all over Africa share many characteristics in common, each conflict has its own cultural, political, ecological and historical context. Consequently, each will require a specialized approach and the choice between alternatives will depend on a balance of cost, effectiveness and the extent to which the interests of the elephants and the farmers are served. A sustainable solution to the 'elephant problem' in the Waza-Logone region must integrate four major considerations: ecological, social, economical, and legal/administrative. The chosen strategy used to mitigate human-elephant conflict must be financially and technologically within the capacities of the local people implementing them, if they are to be long-term solutions.

Ecological Aspects

Separate attention is imperative for the different elephant sub-populations for future management policies of the elephants and of Waza National Park. For the resident sub-population the cues have to be found inside the park. But for the other two sub-populations, management inside the park has to be combined with land-use planning and regional development activities, in order to avoid that the management will be off-set by forces outside the park, forces over which the park managers have at present no control.

20. Disturbance shooting used in combination with control shooting within a well planned campaign may be important for managing the southern sub-population. Control shooting can be effective management tool if suitable animals (culprit animals) are selected, and if the shooting is done as part of an overall plan. In the face of political and social pressures, improved control shooting will be the initial management technique of preference for the Kaélé area. Control and disturbance shootings require adequate preparation, basic equipment is essential and the game guards should be trained and led by an elephant control expert.

21. Control and disturbance shootings are not appropriate however in the Kalamaloué area where elephants (northern sub-population) roam only during the dry season with limited damage to crops. Limited safari hunting could be developed in the Kalamaloué area during the dry season.

22. Guiding elephant movements can only be of secondary/subsidiary value. Therefore, it is strongly recommended that strategies to restrict elephant movements outside of Waza National Park in order to reduce human-elephant conflict should tackle the problem at its sources: the relationship between water availability, forage quantity and quality, and elephant requirements where needs outstrip availability in the Park. The provision of salt licks within Waza National Park and the securing of additional areas for use by elephants between Waza and Kalamaloué National Parks is recommended in order to limit the movements of the southern sub-population towards Kaélé.

23. The hydrological rehabilitation of the floodplain by the IUCN Waza-Logone Project may affect vegetation composition, increase forage quality and improve water availability, and therefore influence elephant movements. Consequently, it should be closely monitored.

24. Only some parts of Waza National Park should be burned annually in rotation to improve grass quality and forage production in the woodlands.

25. Further research on forage quantity and quality in relation to elephant requirements and movements is needed to develop and implement more ecological measures to increase the capacity of the Waza National Park and its surroundings to hold elephants.

Social and Economical Aspects

25. It is recommended that the IUCN Waza-Logone Project assists the wildlife authorities in the establishment of a buffer zone around Waza National Park. In the buffer zone, local communities will be assisted in carrying out programmes for sustainable resource use. In addition, the buffer zone will contain some elephants moving out of the Park. When it does not conflict with conservation interests, some resources from the Park such as dead fuelwood, thatch and fish might be exploited by local people. Further studies (needs of elephants for use of additional habitat outside Waza National Park, need for buffer zones to protect the Park, reasonable needs of the local people for cropland, forest products and grazing, availability of land for buffer zones) would need to be carried out on feasibility.

26. Environmental education is needed to make local people aware of the potential economical value of wildlife.

27. The potential benefits from tourism and safari hunting will materialize only if revenues from admission charges and hunting fees are increased, a differential pricing system is established, security is improved, local and international promotion of Waza National Park is carried out, the Park's road infrastructure is improved, and the access and travel by tourists in Cameroon is facilitated. A special bed night tax on the hotel rooms nearby Waza National Park could support conservation efforts as virtually all customers of the hotel are visitors of the Park.

Legal and Administrative Aspects

28. On the policy side, there is need to recognize that the management of natural resources is a matter of triangular partnership between the State, the municipalities and the local population. Through policy reform local communities must gain legal access to the value which wildlife represents, in the form of revenues from tourism, safari hunting, meat and other products. Enabling legislation for the new *Forests, Wildlife and Fisheries Act* should clearly define a framework for the custodianship of and right to utilize the wildlife on private or communal lands. When the municipalities are the appropriate geographical units for the management of natural resources, the councils of these municipalities should be given the necessary institutional and legal means to reinforce their powers.

29. Finally, external capital and technical assistance is needed in building local capacity in wildlife management and community-based natural resource management.

It is my hope that this thesis has shown some promising directions in the management of elephants, in general, and in the Waza-Logone region, in particular. The challenge to managing human-elephant conflicts to honour the needs of both humans and elephants will greatly depend on the collaborative efforts of local people, local wildlife authorities and the 'international conservation community' in developing an integrated management strategy.

Summary

The objective of this publication is to contribute to the integration of the needs of local people and elephants in a sustainable agricultural and pastoral system in the Waza-Logone region. The main problems of elephant management in the region are the impact of relatively high densities of elephants on the woody vegetation, and the conflicts between people and elephants. Five key questions are addressed:

1. What is the trend in the elephant population (size, distribution, dynamics and movement patterns) and what are the causes?;
2. what is the extent of the woodland-elephant interaction?;
3. what is the extent of the human-elephant interaction?;
4. what are the factors determining the distribution of elephants and their movement patterns?; and
5. what management options could be taken to alleviate the elephant problem in the Waza-Logone region?.

Elephant Population Size, Dynamics, Distribution and Movement Patterns

Regular surveys provide a basis for measuring trends in population size and distribution. In spite of the ecological and economical importance of Waza National Park, no survey of large mammals was conducted in the Park since 1977. This study presents the only available data which show the trend in elephant numbers over the last 14 years.

The elephant population size estimated by aerial count, using systematic sampling, is approximately 1,100 individuals. This population shows a significant increase of 6.1% per year since 1977. The age structure obtained by photogrammetric methods shows that the present elephant population is stable. The mean calving interval is currently estimated at 3.1 years, while the age at first conception is estimated at 10.2 years. Mortality occurs at a mean annual rate of 9.2%. Increasing elephant numbers may mainly stem from undocumented immigration from Chad. The discrepancy between the age structure, the mortality rate and the annual growth rate is a combination of the artefact of the techniques used and undocumented elephant immigrations from Chad.

The available evidence obtained by combining ground-truthing, VHF-radio and satellite telemetry suggests that there are three elephant sub-populations in

Waza National Park. The first sub-population is resident, and uses almost the entire Park. The second sub-population migrates more than 100 km north of the Park during the dry season. The third sub-population migrates more than 100 km south of the Park during the wet season. Both migrating sub-populations have considerably larger home ranges than the resident sub-population. An important conclusion of this study is that the timing and routes of migration ultimately depend on the specific circumstances at a specific time. These findings can have implications for the understanding of elephant ecology which is greatly affected by conflicts between man and elephant.

Impact of Elephant on the Natural Vegetation and the Local Agriculture

The need for monitoring elephant habitat has often been stressed by many authors. The negative impact of elephants on the woodland of the Waza-Logone's protected areas has become a cause of concern for wildlife authorities, but field evidence was lacking. The Waza and Kalamaloué National Parks were sampled by means of line transects to assess damage to trees caused by elephants. In Waza National Park, the mortality of *Acacia seyal* trees (20%) exceeds their regeneration potential (16%). Elephant damage to *Acacia* trees is serious and if the trends continue (a doubling in of the number of trees killed in 15 years), elephants might have considerable negative effects on *Acacia* dynamics and structure. The size class distribution of trees indicates a declining population of *Acacia seyal*.

The most important conclusion drawn from the elephant damage assessment in Kalamaloué National Park is that elephant damage to vegetation is significant. Ninety-five per cent of trees in the regeneration class are damaged and of all trees browsed the majority (57%) come from the recruitment class. The seasonally high density of elephants has lead to large scale killing of mature trees and serious damage to the regeneration vegetation.

Elephant damage to crops has doubled between 1992 and 1993 in the Kaélé and Mindif areas, and elephants have caused increasing loss of human life. Local strategies for deterring elephants often led to fatal incidents. Control shooting by inexperienced teams and improperly organized food relief programmes have failed to reduce the human-elephant conflict.

Factors Influencing Elephant Movements

There is scanty published work that relates elephant movements to specific variation in the quantity and/or quality of forage or water in central Africa.

Furthermore, no study has dealt with elephant feeding strategies in Waza National Park. Dung pile counts and aerial observations made clearly indicate that the *Acacia seyal* shrubland is the best available habitat for elephants in Waza National Park. Combination of water availability in the *Acacia seyal* zone and quality of *Acacia seyal* as forage probably play a key role in the preference of *Acacia seyal* shrubland by elephants in the dry season.

Comparison of preferred woody plants in both Kalamaloué and Waza National Parks indicates that they are the same and comprises: *Acacia seyal, Piliostigma reticulatum, Combretum spp.*, and *Balanites aegytiaca*. Water is abundant in Kalamaloué (during the whole year) which is bordered by the Logone and Chari rivers. Elephants are 'pushed' out of Waza by the limited water supply.

Comparison of nutrient concentrations in Waza National Park and in the Kaélé region (a wet season habitat for some elephants) reveals higher levels of mineral elements (sodium, phosphorus and potassium) in Kaélé than in Waza. However, the scarcity of water is a limiting factor in the Kaélé region during the dry season. During the wet season, nutritious sorghum fields are a strong factor motivating elephant migration to the Kaélé region. Elephants are 'pulled' out of Waza during the wet season.

Towards Reducing Human-Elephant Conflict in the Waza-Logone Region

The future of elephant conservation in northern Cameroon depends on the development of approaches which will allow sustainable, mitigative intervention to prevent the conflict from developing into a disaster. The use of stone walls, ditches or moats and electric fences to block elephant movements and to separate Waza National Park from agricultural areas are not seen as useful methods to solve human-elephant conflict in the area, because of their high cost of installation and maintenance, and the uncertainty of their effectiveness.

In the short term, disturbance shooting used in combination with control shooting within a well planned campaign may be of some importance for elephant management. Although disturbance shooting disminishes in effectiveness as the animals habituate, improved control and disturbance shooting will be the initial management technique of preference for the Kaélé area. It is not appropriate in the Kalamaloué area where elephants roam only during the dry season and cause limited damage to crops.

Reduction of elephant numbers may have to be considered in the near future, particularly if the elephants currently moving to Kaélé are successfully confined within the Park as a result of management actions. However, such management action will require careful monitoring of elephant population dynamics.

A well developed damage compensation system could only be a short-term solution to the human-elephant conflict. Local people's tolerance threshold towards elephants could be raised by providing them with real economic incentive. Tourism and safari hunting have potential benefits. However, these benefits will materialize only if revenues from admission charges and hunting fees are increased, security is improved, a public relations campaign is carried out, proper attention is given to local needs, and a legal mechanism is established by which part of the revenues generated by wildlife-based tourism stay in the local community.

The long term strategy should put emphasis on developing sound ecological measures that will expand the available range of natural habitat. A corridor that would maintain geographical contact between Waza and Kalamaloué National Parks would secure additional areas for use by elephants. It is recommended that a buffer zone be established around Waza National Park, and that local communities be assisted in carrying out programmes for sustainable resource use in the buffer zone (gum arabic, thatch and dead fuelwood collection, livestock grazing, fishing, guinea fowl harvesting).

The capacity of Waza National Park to hold elephants may be increased by actions to enrich the habitat. The restoration of old waterholes and/or the creation of new waterholes would only affect elephant movements to Kalamaloué National Park. The provision of salt licks may result in fewer animals migrating to Kaélé or animals waiting longer before leaving the Park. An increase of the numbers of elephants will not dramatically affect the vegetation as long as the elephants are not confined in Waza National Park and if disturbances (i.e. poaching) are minimal and elephants can disperse, and move freely between the Park, the buffer zone and the corridor.

The present fire management policy might have negative effects on forage production. It is recommended that only some parts of the Park be burned annually, in rotation, to improve grass quality and forage production in the woodlands and that this policy be strictly controlled.

The hydrological restoration of the floodplain will increase water availability and improve grass quality. Available data are insufficient to conclude whether reflooding might change the quality or composition of the vegetation in the *Acacia seyal* shrubland, a very important wildlife habitat.

In the Waza-Logone region, the ultimate challenges to conservationists will be reducing the costs to local people of living with elephants, while conserving viable populations of elephants and preventing woodland decline and biodiversity losses. This thesis outlines some promising approaches. Unless an integrated management strategy to deal with the human-elephant conflict, a regular monitoring programme of elephant population and vegetation, and habitat management actions are developed and implemented in the very near future, our work for the conservation of elephants in the Waza-Logone region will have been vain.

Samenvatting

Het doel van deze publikatie is een bijdrage te leveren aan de integratie van de belangen van lokale bewoners en olifanten in een systeem van duurzame landbouw en veehouderij in het Waza-Logone gebied.

De belangrijkste problemen voor het beheer van olifanten in het gebied zijn de invloed van een hoge olifantendichtheid op de vegetatie en conflicten tussen lokale bewoners en olifanten.

De volgende onderzoeksvragen zijn gesteld:

1. Wat is de trend in de ontwikkeling van de olifantenpopulatie (omvang, distributie, dynamiek en trekpatronen) en welke factoren beïnvloeden een eventuele trend?
2. Wat is de aard en omvang van de interactie tussen olifanten en vegetatie?
3. Wat is de aard en omvang van de interactie tussen olifanten en lokale bewoners?
4. Welke factoren beïnvloeden de distributie en de trek van olifanten?
5. Welke beheers-opties zijn aanwezig om een bijdrage te leveren aan het oplossen van de problemen veroorzaakt door olifanten?

Populatie-omvang, dynamiek, distributie en migratie

Regelmatige surveys vormden een basis om trends in de populatie-omvang en distributie vast te stellen. Ondanks het ecologische en economische belang van het Waza Nationaal Park was er geen fauna census uitgevoerd sinds 1977.

Deze studie omvat de meest recente fauna census in het Waza Park en geeft een overzicht van de trend en de aantallen olifanten gedurende de laatste 14 jaar. De totale olifanten populatie werd geschat, op basis van een luchtverkenning, op 1100 dieren. De populatie is sinds 1977 met gemiddeld 6,1% per jaar gegroeid. De leeftijdsopbouw, verkregen met behulp van een fotogrammetrische methode, wijst op een stabiele populatie.

Het gemiddelde kalf-interval is geschat op 3,1 jaar, terwijl de leeftijd van de eerste conceptie wordt geschat op 10.2 jaar. De mortaliteit wordt geschat op een gemiddelde van 9,2% per jaar. Een toename van de olifanten populatie wordt waarschijnlijk vooral veroorzaakt door immigratie vanuit het buurland Tsjaad.

De discrepantie tussen leeftijdsopbouw, de mortaliteit en de gemiddelde groei per jaar komt voort uit een combinatie van een onnauwkeurigheid in de gebruikte methodiek en niet gedocumenteerde migratie van olifanten vanuit Tsjaad.

Informatie verkregen door een combinatie van radio en satelliet telemetrie en veldwaarnemingen geven een aanwijzing voor het onderscheiden van drie olifanten-subpopulaties in het Waza Park. De eerste subpopulatie resideert in het park en gebruikt de gehele oppervlakte van het park. De tweede subpopulatie migreert naar het 100 km ten noorden van Waza gelegen Kalamaloué Park gedurende het droge seizoen. De derde subpopulatie migreert meer dan 100 km ten zuiden van het Waza Park, gedurende de regentijd.

De migrerende subpopulaties hebben een significant grotere 'home range' dan de residente subpopulatie. Een belangrijke conclusie van de studie is, dat de tijdsplanning en routes van de migratie gerelateerd zijn aan specifieke omstandigheden op een bepaald tijdstip. Deze bevindingen zijn van belang voor een beter begrip van de ecologie van olifanten in relatie tot conflicten tussen mensen en olifanten.

De impact van olifanten op de natuurlijke vegetatie en de lokale landbouw

De noodzaak om de habitat van olifanten te monitoren is benadrukt door verschillende auteurs. De negatieve impact van olifanten op de vegetatie van het Waza Park is een bron van zorg voor de lokale autoriteiten, maar concreet bewijs voor een degradatie van de vegetatie werd tot voor kort niet geleverd.

In het Waza en Kalamaloué Park werden lijn-transecten uitgezet om de olifantenschade aan de vegetatie te kunnen meten. In het Waza Park blijkt het aantal dode *Acacia seyal* (20%) bomen het regeneratie potentieel door jonge bomen (16%) te overschreiden. Olifantenschade aan *Acacia*-bomen is aanzienlijk en als de gevonden trend zich voortzet (een verdubbeling van het aantal dode bomen iedere 15 jaar), dan kunnen de olifanten een aanzienlijke negatieve impact hebben op de dynamiek en structuur van de *Acacia*-zone in het Waza Park.

De belangrijkste conclusie, die werd getrokken uit het vegetatie-onderzoek in het Kalamaloué Park is dat de olifantenschade hier ook aanzienlijk is. Van de bomen in de regeneratie-klasse was 95% ernstig beschadigd en van alle bomen die werden beschadigd door foeragerende olifanten komt 57% uit de recruitment klasse. De aan het seizoen gerelateerde hoge olifanten dichtheden hebben op grote schaal geleid tot het afsterven van volgroeide bomen en ernstige schade aan bomen in de regeneratie-klasse.

De olifantenschade aan landbouwgewassen is verdubbeld gedurende 1992 en 1993 in de gebieden rond Mindif en Kaélé, en de aanwezigheid van olifanten hebben hier ook geleid tot een toename van slachtoffers onder de lokale bevolking.

Verstoring van de olifanten door afschot met onervaren teams en slecht georganiseerde programma's voor voedselleveranties aan de lokale bevolking hebben tot heden niet bijgedragen aan een oplossing voor het conflict tussen mens en olifant.

Factoren die van invloed zijn op olifantenmigratie

Er bestaan weinig wetenschappelijke publicaties over de relatie tussen olifantenmigratie en variaties in kwaliteit en kwantiteit van voedsel of water in Centraal Afrika. Verder zijn de voedselstrategieën van olifanten in het Waza-Logone gebied, vóór deze studie werd uitgevoerd, nooit onderzocht.

Onderzoek naar olifantenmest en luchtverkenningen gaven aan dat de *Acacia seyal* zone in het Waza Park de meest aantrekkelijke habitat vormt voor olifanten. Een combinatie van de beschikbaarheid van water en de kwaliteit van *Acacia seyal* als voedsel voor olifanten zijn de belangrijkste factoren die bijdrage aan een voorkeur van olifanten voor deze zone.

Een vergelijking van preferentiële vegetaties als olifantenvoedsel in zowel het Waza als het Kalamaloué Park geeft aan dat de soortensamenstelling vergelijkbaar is en bestaat uit *Acacia Seyal, Piliostigma reticulatum, Combretum* spp. en *Balanites aegyptiaca*. Water is het gehele jaar beschikbaar in het Kalamaloué Park, dat wordt begrensd door de rivieren Logone en Chari. Olifanten worden waarschijnlijk op hun noordelijke migratie door gebrek aan water in het Waza Park naar Kalamaloué 'gedreven'.

Een vergelijking van de nutriënten in het Waza Park en in het gebied rond Kaélé geeft aan, dat rond Kaélé hogere gehaltes worden aangetroffen aan mineralen (natrium, fosfor en kalium) dan Waza. De schaarste aan water is echter een beperkende factor rond Kaélé in de droge tijd. Gedurende de regentijd vormen voedselrijke sorghumvelden rond Kaélé een belangrijke motivatie voor olifanten om naar dit gebied te migreren. Op de zuidelijke migratie worden olifanten door de sorghumvelden naar Kaélé 'toegetrokken'.

Bijdrage aan een oplossing van mens/olifant conflicten in het Waza-Logone gebied

De toekomst voor de bescherming van olifanten in Noord Kameroen is afhankelijk van de ontwikkelingsmodellen die duurzame interventies toestaan als bijdrage aan een oplossing voor de mens/olifant conflicten en zodoende voorkomen dat deze conflicten escaleren.

Het gebruik van stenen muren, kanalen en electrische barrières om olifanten migratie te stoppen of om te buigen en de olifantenpopulatie in het Waza Park te isoleren van de omringende landbouwgebieden, worden niet zinvol geacht als bijdrage aan een oplossing, omdat de kosten van constructie en onderhoud te hoog zijn en er twijfels bestaan over de effectiviteit.

Op korte termijn vormt verstoring van olifantenmigratie door afschot, als onderdeel van een goed geplande campagne, een belangrijk instrument om olifantenmigratie te beïnvloeden. Een verbeterde verstoringsmethode zal de komende jaren dan ook een belangrijke bijdrage kunnen leveren aan een oplossing van het probleem. Dit instrument is echter niet rond het Kalamaloué Park, waar olifanten alleen in de droge tijd verblijven en beperkte schade toebrengen aan landbouwgewassen.

Een reductie van de aantallen olifanten kan overwogen worden in de nabije toekomst als met name de olifanten die naar Kalamaloué migreren door nieuwe beheersmethoden in het Waza Park blijven. Een dergelijke interventie vereist echter een zorgvuldige monitoring van de olifantenpopulatie.

Een goed ontwikkeld schade-compensatiesysteem kan alleen op korte termijn een bijdrage leveren aan het mens/olifant conflict. De tolerante grens van lokale bewoners ten opzichte van olifanten zou verhoogd kunnen worden door economische prikkels. Toerisme en safari-jacht vormen hierbij een potentieel.

De potentiële positieve effecten kunnen echter pas gematerialiseerd worden als de inkomsten van de toegangsprijzen van het Waza Park en de prijzen voor sport-jacht worden verhoogd, de veiligheid wordt vergroot, een voorlichtingscampagne wordt uitgevoerd en voldoende aandacht wordt besteed aan lokale bewoners, en tenslotte het wettelijke kader wordt geschapen om een deel van de inkomsten uit toerisme en safari-jacht aan de lokale bevolking te doen toekomen. De lange-termijn strategie zou een nadruk moeten leggen op het ontwikkeling van een goede ecologische structuur, waarbij het areaal aan natuurlijke habitat voor olifanten wordt uitgebreid.

Er moet een corridor van natuurlijke habitat totstandkomen, die een verbinding vormt tussen het Waza Park en het Kalamaloué Park. Bovendien wordt aanbevolen een bufferzone aan te leggen rond het Waza Park, terwijl lokale bevolkingsgroepen betrokken worden bij programma's voor een duurzaam gebruik van natuurlijke hulpbronnen (arabische gom, visserij, veehouderij, exploitatie van parelhoenders).

De capaciteit van het Waza Park voor de olifantenpopulatie kan worden vergroot door maatregelen, die leiden tot een verbetering van de habitat. De restoratie van oude drinkplaatsen en/of het aanleggen van nieuwe drinkplaatsen zal alleen de noordelijke migratie naar het Kalamaloué Park beïnvloeden. Het aanleggen van zout-licks zou ook kunnen bijdragen tot een reductie van het aantal olifanten dat migreert naar Kaélé.

Een toename van het aantal olifanten in het Waza Park zal maar beperkte schade toebrengen aan de vegetatie, als de olifanten zich vrijelijk kunnen bewegen tussen de bufferzone, de corridor en het Park.

Het huidige beleid ten aanzien van het branden van de vegetatie in het Waza Park kan een negatieve invloed hebben op het voedselaanbod voor olifanten. Het wordt aanbevolen om bepaalde delen van het Park jaarlijks in rotatie te branden, zodat de kwaliteit van het beschikbare gras verbeterd. Hierbij moet deze methode strikt en consequent worden toegepast.

Het hydrologisch herstel van de Waza-Logone vloedvlakte zal bijdragen aan een toename van het aanbod van water en voedsel voor olifanten. Op basis van de beschikbare gegevens kan geen conclusie worden getrokken of het hydrologisch herstel bij kan dragen aan de kwaliteit en samenstelling van de *Acacia seyal* zone.

In het Waza-Logone gebied vormt het reduceren van het mens/olifant conflict een belangrijke uitdaging voor natuurbeschermers, tegelijkertijd met de bescherming van de aanwezige olifantenpopulatie en het voorkomen van een degradatie van de natuurlijke vegetatie en het gerelateerde verlies aan biodiversiteit.

Deze thesis beschrijft veelbelovende benaderingen van het probleem. Als we er in de nabije toekomst er niet in slagen een geïntegreerde beheersstrategie te ontwikkeling en toe te passen om het mens/olifant conflict op te lossen, samen met een consistent monitoringprogramma van de olifantenpopulatie en de natuurlijke vegetatie en maatregelen gericht op habitatbeheer, dan zullen onze inspanningen om olifantenpopulaties in het Waza-Logone gebied te beschermen vruchteloos zijn.