Productive Sector Growth and Environment Division
Office of Sustainable Development
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Foreword

In cooperation with the authors, the USAID Africa Bureau's Office of Sustainable Development, Productive Sector Growth and Environment Division (USAID/AFR/SD/PSGE), is pleased to support the publication and distribution of this material. We believe the information will allow Chadians and their development partners to make more informed and better decisions in their efforts to achieve environmentally sound broad-based economic growth.

David A. Atwood
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U.S. Agency for International Development

Acknowledgments

This document provides important information for those interested in biological diversity in Chad and the Sahel in general.

The authors participated in two environmental impact assessments in Chad during February through June 1993. The first was as part of a team working with Chemonics International for the U.S. Agency for International Development (USAID) evaluating potential environmental effects of an Agriculture Trade Policy Reform Program proposed by USAID and the second was an Initial Environmental Examination for the use of Zinc Phosphate for Rodent Control in Chad, this time working with the U.S. Department of Agriculture Denver Wildlife Research Center. In the course of these two tasks, a wealth of data, much in French, was analyzed and synthesized.

This paper, in part, is a product of that endeavor and we acknowledge with gratitude the USAID Mission in Chad (since closed) and Chemonics International for their support during the seven weeks the authors worked in Chad.

The other members of the Chemonics team included J.E. Hecht, regional planner and team leader; Joseph Tabor, agronomist/pedologist; Scotty Deffendol, range scientist; G. E. Karsh, forester; and R Hanchett, USAID Regional Environmental Officer. Discussions among team members increased awareness of natural resource use in Chad and enhanced perspectives on possible environmental consequences of human use of resources in the future. For this, we are especially thankful; their assistance was most valuable because they were experts in their fields and experienced with conditions in Sahelian Africa.

Executive Summary

Chad is one of the larger countries in Africa and contains deserts, mountains, shrub steppes, savannas, forests, lakes, and wetlands. This array of habitats originally supported one of the most unique and diverse faunas in Africa. The ibex, oryx, addax, Barbary sheep, kudu, wild ass, eland, buffalo, rhinoceros, elephant, and many kinds of antelope ranged in the rich Chadian habitats, along with the lion, cheetah, leopard, and many smaller mammalian species. Many populations of the larger mammals were decimated between 1960 and the present during the civil unrest that followed Chad's independence from France. Civil war destroyed the stability of human life and traditional practices and values. Transportation and weapons, acquired for combat, enabled harvest of wildlife for food and profit. Poaching, overharvest of fish and wildlife, drought, and disease greatly reduced numbers of animals.

Most avian palearctic migrants pass through Chad on their annual migrations between Europe and Africa. Many of those birds and some afrotropical species from the south nest in the rich forest, savanna, and wetland habitats of Chad. The wetlands of Chad are among the most important in North Africa. They provide energy to support migration of birds within Africa and between Africa and Europe. Without healthy wetlands just south of the Sahara Desert, such migration would be impossible and birds that migrate would disappear.

The human population, in its original state, hunted, gathered, and farmed in a sustainable manner. With an increase in the human population and longevity in the middle 1900s, farming greatly expanded into natural habitats. Later, agriculture was intensified in limited areas to include irrigation, shorter fallow cycles, and the use of fertilizers, herbicides, and insecticides. This trend towards increased use of land and intensified farming will accelerate because the human population is continuing to increase and the demand in foreign markets for foodstuffs produced in Chad is rising, especially in Nigeria.

Planning and education are needed on options for land use in Chad to ensure that development considers the proper use, maintenance, and enhancement of its remaining natural resources, and especially the needs of fish and wildlife populations and their habitats. Chadians traditionally have harvested wildlife and their very rich fisheries to supplement their diets. Remaining fish and wildlife resources should be managed in conjunction with agriculture, protection of habitats in parks and reserves, creative use of resources in those protected areas, and ecotourism so that the greatest sustainable benefits for the human population can be attained in the future.

Glossary of Acronyms and Abbreviations

CIRAD	Centre de Cooperation Internationale en Recherche Agronomique pour le Developpemen t (International Center for Cooperation in Agronomy Research for Development)
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
EEC/FED	European Economic Community / Fonds European du Developpement
IPM	integrated pest management
IUCN	The World Conservation Union
RAMSAR	Convention on Wetlands of International Importance Especially as Waterfowl Habitat
SECA	Société d'Eco Amenagement
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
USAID	U.S. Agency for International Development

Introduction

Chad is one of the larger countries in Africa. It extends from the arid Sahara desert (24° N lat.) to the large rivers and equatorial forests of the south (8° N lat.). The variety of habitats existing in this spectrum of climatic conditions originally supported a richness and diversity of birds, large mammals, and other vertebrates that was comparable to the fauna of eastern and southern Africa. In the last several decades, however, Chadians have seriously depleted their fish and wildlife resources and have greatly reduced the ability of their environment to support wild animals.

Chad has suffered from either civil strife, drought, or famine almost continually since gaining independence from France in 1960. The growing human population has expanded the area used for agriculture and has increased numbers of both resident and transhumant livestock grazing on rangelands. This intensity of land use has reduced the quantity and the quality of habitats for wildlife despite remedial efforts (Depierre and Gillet 1971). The opening of boreholes, which enabled former nomadic people and their herds to remain continuously in areas that previously were only grazed for relatively short periods, has also had an adverse impact on wild ungulates in drier sites (Newby 1980). Periodic drought throughout the 1970s and 1980s, in addition to civil wars, depressed cotton prices in 1985, and invasions of desert locusts *(Schistocerca gregaria)* between 1986 and 1988 exacerbated the deteriorating conditions for peasant farmers.

The herds of wild ungulates, the larger birds such as ostriches and bustards, and the abundant fish resources were heavily utilized to supplement crops during periods of food scarcity. As elsewhere in Africa, guns, ammunitions, and vehicles acquired for combat between rival forces provided mechanisms for harvesting wildlife at a scale not previously possible (Newby 1980). Demand for food and wanton killing of game resulted in severe reductions in many animal populations. Thomassey and Newby (1990) reported that elephant *(Loxodonta africana)* and black rhinoceros *(Diceros bicornis)* were severely harvested during this period and that an outbreak of rinderpest in 1982 and 1983 seriously reduced populations of buffalo *(Syncerus cafer)* and giant eland *(Taurotragus derbianus).*

Yet the fish and wildlife resources in Chad today still are sufficient, if used properly, to create incentives for local villages to protect and manage remaining populations. Villagers have learned that over-harvest and habitat destruction can greatly reduce fish and wildlife populations of value to them, and they realize that those resources will be lost unless they are afforded protection and properly managed. If the local people derive benefits from the wild animal resources in their area, they will police poaching and protect wildlife habitat from destruction by overgrazing and poor agricultural practices.

The intent here is to discuss wildlife species, their habitats, and the threats of human activities to the animals' continued existence in Chad. It is hoped these considerations will lead to programs that will help local villages benefit from protection they can provide to wildlife as they further develop their country.

Animals and Plants of Chad

BIRDS OF CHAD

The first listing that included birds in Chad was by Malbrant (1952), who described the characteristics and range of 527 species in French Central Africa (Chad and the northern two-thirds of the Central African Republic). A rather comprehensive survey of birds in Chad was undertaken by Salvan (1967, 1968, and 1969), who visited all 14 prefectures and recorded a total of 488 species. Vielliard (1971 and 1972) continued those surveys and integrated his and Salvan's findings into a checklist with revised taxonomy that included 464 species. Stuart and Adams (1990) estimated there were 496 species in the country. Vielliard (1971) reported that 59 species of raptors occurred in Chad. Serle et al. (1977) is a good guide to the birds that occur in Chad, but not all the species recorded in Chad are described or illustrated. Bird names in this paper follow Clements (1991).

MAMMALS OF CHAD

No reference exists that describes the kinds, abundance, and distribution of mammals in Chad. Malbrant (1952) included 71 species of larger mammals, 66 rodents, 21 bats and 8 insectivores in his account of the mammals of French Central Africa. Happold (1987; Table 1.4) listed mammals that occur in the Sudanian and Sahalian savannas in Nigeria, which includes most of the mammals that would be expected in southern Chad. He listed 50 larger mammals (which, of course, did not include the 15 large mammals that occur in northern Chad), and 22 rodents, 22 bats, and 8 insectivores. Kindler et al. (1989) claimed very few of the 60-65 medium to large mammals of Chad survived outside of the Zakouma National Park. Vielliard (1974) recorded 21 species of bats from Chad. Stuart and Adams (1990) estimated there were 131 species of mammals in Chad. Fiedler (1994) discussed the problems created by certain rodents in eastern Africa. Mammal names in this paper follow Wilson and Reeder (1993).

FISHES OF CHAD

As in the case of the mammals and birds, Chad was blessed with an exceptional number of species and abundant quantities of fishes. However, over-exploitation, drought, and wetland degradation have drastically reduced the catches of what had been a major industry. In Lake Chad, the most important fishes have been the characin *(Alestes baremoze)* and the Nile perch *(Lates niloticus)*. The former has drastically decreased in numbers, while the latter, which used to attain a very large size, now seldom exceeds 5 to 8 kg. The distribution of fish species in Chad is largely determined by the catchments which segregate them. These include: the extensive Lake Chad basin; the smaller Lake Fitri basin in central Chad; the isolated southwestern watershed of the Mayo-Kebbi river; and the streams, wadis, and gueltas (pools) of the Tibesti-Ennedi massifs.

The fishes of the Lake Chad basin and those of the adjacent Mayo-Kebbi basin have been studied extensively by Blache and Miton (1963) and Blache (1964). Their works are used for names of fishes in this paper. Nelson (1976) grouped the species of fishes in Chad into 12 families, suborders, and subclasses. Stuart and Adams (1990) gave a figure of 130 species of fishes in Chad.

REPTILES AND AMPHIBIANS OF CHAD

There apparently is no comprehensive review of this component of the Chadian fauna. Little work has been done on the distribution and systematics

of species in Chad. Le Berre (1989) and Wake and Kluge (1961) listed some species, but both works mainly covered only northern Chad. Ernst and Barbour (1989) reported six species of turtles and tortoises from Chad, of which the African spurred tortoise *(Geochelone sulcata)* is of special interest because of its scarcity and susceptibility to take by humans. The Nile crocodile *(Crocodylus niloticus)*, the African slender-snouted crocodile *(Crocodylus cataphractus)*, and the water monitor lizard *(Varanus niloticus)* have been extensively hunted for the skin trade, and now are seldom encountered. African rock pythons *(Python sebae)* are widely hunted for their skins, and also are killed because natives fear them. The African toad *(Bufo regularis)*, the savanna chameleon *(Chamaeleon gracilis)*, and the orange-headed agama *(Agama agama)* are widespread and common. The snakes of Chad have not been adequately studied. Eleven species were recorded in Zakouma National Park. Matheson (1986) listed seven vipers from Chad.

INVERTEBRATES OF CHAD

The summer rains produce enormous numbers of insects, many of which are agricultural pests. The flood plains of the Chari Basin are a breeding ground for the African migratory locust *(Locusta migratoria)*, the Sudan plague locust *(Ailopus simulatrix)*, desert locusts, and tree locusts *(Anacridium melanorhodon)*, all of which at times occur in plague numbers in the Sahel. Tsetse flies *(Glossina* spp.) formerly were present along the Chari River and elsewhere in southern Chad, but their range appeared to contract concurrently with the elimination of game animals and deforestation. The dense numbers of chironomid midges that occur at Lake Chad are of great importance both for the fish population and for migrant birds who build up fat reserves to fuel their 1500 km Sahara crossing. Honey bees *(Apis mellifera)* occur sparingly throughout the savanna woodlands, but no bee-keeping appears to be practiced in Chad. There has been little work on butterflies, but 7 species of swallowtails are said to exist in Chad (Stuart and Adams 1990). No invertebrates are listed as endangered in Chad (Wells et al. 1983).

PLANTS OF CHAD

There are about 1600 species of vascular plants in Chad (IUCN 1986; Stuart and Adams 1990), of which 1516 occur south of about 16 N latitude. This is a very low number considering the size and diverse climatic conditions in Chad. The number of endemic plants is unknown. The Tibesti Mountains are estimated to have about 450 species of plants, with a mix of Mediterranean, Saharan, Sahelian, and afromontane elements (IUCN 1986).

Botanical exploration has been reasonably comprehensive in Chad, and the results are covered in various checklists and maps (Pias 1970; Lebrun et al. 1972, 1976, 1977; and Ozenda 1977).

Biogeographical Regions of Chad

Chad changes dramatically in climate and in vegetation from the northern mountains and deserts (Saharan zone), to the extensive shrub steppe (Sahelian zone) in the central portion of the country, and then to the extensive woodland savanna (Sudanian zone) in the south. Tropical deciduous forests (Guinean zone) exist in the extreme southern tip of the country. These biomes reflect differences in annual rainfall, which also govern land use by humans and the kinds and abundance of fish and wildlife that occur throughout the country (Fig. 1). Chad is largely a vast basin with the lowest elevation in the center of the country. Only seasonal drainages exist in the northern half of Chad. Perennial rivers and their tributaries drain the entire south of the country; most flow northwest into Lake Chad, and provide about 95 percent of the water entering the lake (Wanzie 1990). During periods of high precipitation, Lake Chad can fill and flow northeast into an ancient lake basin in the center of the country.

NORTHERN DESERTS AND MOUNTAINS

The Saharan zone of the north has low rainfall (50 to 200 mm) and the deserts are characterized by poorly developed and unstable soils with a sparse cover primarily of annual grasses and forbs that produce forage and seeds only during the rainy season. There are two distinctive habitats in the deserts of the north: the mountains, and the wadis and depressions. Both the wadis, which are desert drainages, and the depressions have shallow water tables. Farmers irrigate vegetable gardens and date groves in the wadis throughout the year and cultivate cereal grains in the depressions. The Tibesti mountains in the north are a high desert plateau, formed by volcanoes, with several peaks above 3300 m. They contains 12 large springs that support palms and other vegetation. The Ennedi and Ouaddaï plateaus of wind-eroded sandstone lie along the eastern edge of Chad at lower elevations, and are covered with only sparse vegetation.

The avifauna of northern Chad is dominated by migrants that are mainly seen during the brief period of their migration. However, Guichard (1955) listed 30 resident species in the Tibesti mountains. The most spectacular of threatened birds in the north are the bustards. Malbrant and Receveur (1955), Malbrant (1957), and Gillet (1960) have studied the birds of the northern-most

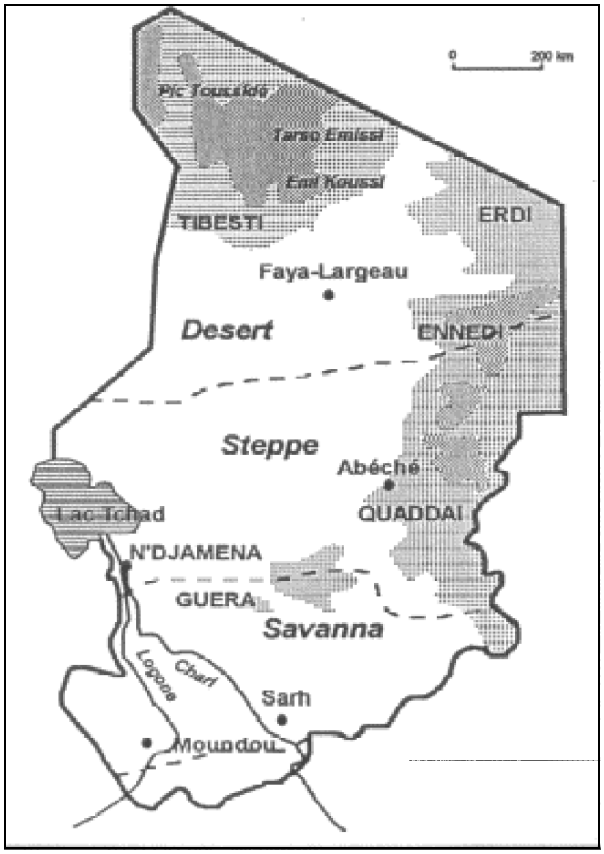

Figure 1. Biomes and Major Features of Chad (Adapted from Géographic du Tchad. EDICF. Paris. 48 pp.)

prefectures of Borkou, Ennedi, and Tibesti.

Northern Chad possessed a number of exceptional mammals, many of which were rare elsewhere, such as wild ass *(Equus asinus)*, addax *(Addax nasomaculatus)*, scimitar-horned oryx (*Oryx dammah)*, and Barbary sheep *(Ammotragus lervia)*. The oryx was so common in the north in 1960 that the government of Chad did not place it on the list of protected animals. All of these magnificent animals are now endangered throughout their range (Newby 1980; East 1990; Wilson and Reeder 1993). Le Berre (1990) recorded 37 species of mammals in the arid northern one-third of Chad, including three bats, three primates, five canids, two mustelids, two hyenas, the lion, the hyrax, five ungulates, the camel, twelve rodents, and two hares. Information on the fish of the Borkou Basin (Tibesti/Ennedi drainages) was summarized by Le Berre (1989). He listed 11 species of fish there, of which the majority are endemics.

CENTRAL SHRUB STEPPE

Rainfall in the steppe is unreliable, but averages 200-600 mm annually. The poor sandy soils in the north support only grasses, forbs, and low shrubs. Further south soils are more complex and a typical *Acacia-Balanites* thornbush savanna develops with short grasses and low shrubs such as *Boscia senegalensis, Gueira senegalensis, Capparis decidus*, and *Maerua crassifolia*. These areas are grazing lands for both wild and domestic herbivores; small ruminants are herded throughout this zone by nomadic tribesmen. Increasingly, however, the steppe is being planted to millet at the beginning of the rainy season by resident farmers, and vast areas are now under cultivation or in short-term fallow.

The avifauna of the large Ouadi Rime-Ouadi Achim Faunal Reserve in the steppe was studied by Newby (1979 and 1980). He recorded 267 species of birds in this 77,950 km^2 reserve, which ranges from desert to sub-desert steppe and Sahelian wooded-steppe. The addax and oryx that formerly occurred in this reserve are no longer present (Daboulaye Ban Ymary, pers. comm.). In a recent visit to the Ouadi Rime-Ouadi Achim Faunal Reserve, P. Pfeffer (pers. comm.) saw only a few of the rarer animals, including six dama gazelles *(Gazella dama)*, a few dorcas gazelles *(Gazella dorcas)*, and a few ostriches *(Struthio camelus)*. Other rare gazelles, such as the red-fronted *(Gazella rufifrons)*, and the slender-horned *(Gazella leptoceros)*, are known to use the shrub steppe. We found no information on the status of most smaller mammals that reside there. Brooks et al. (1992) discussed problems created by Sahelian rodents in Chad.

SOUTHERN SAVANNA WOODLANDS

This zone of savanna woodland averages 600-1000 mm of more dependable annual precipitation. It supports a dense human population and produces most of the foodstuffs grown in the country. Vegetation in the northern, drier parts is largely thornbush composed of *Acacia* spp., *Balanites aegyptiaca, Ziziphus spina-christii, Piliostigma reticulata, Sclerocarya birrea, Combretum* spp., *Terminalia* spp., and patches of doum palm *(Hyphaene thebaica)*.

In the south, where the rainfall exceeds 900 mm, the thorny components largely disappear. The climax vegetation was originally a forest savanna with a tall canopy (15 m) of *Isoberlinia doka, Anogeissus leiocarpus, Ternminalia laxifolia, Pterocarpus lucens*, and *Daniellia oliveri*. Clearing for agriculture, and cutting for fuel wood and lumber has converted the area into a broadleaf shrubby savanna where cultivation, fallow, and grazing dominates land use. Some disturbed, but dense stands of trees and shrubs still exist in the south. The Salamat Prefecture, in the southeast adjoining the Central African Republic, and the northern part of the Moyen Chari Prefecture are the least impacted areas in the south and have some of the best wildlife habitat remaining. The Zakouma National Park and the Bahr Salamat Faunal Reserve are in the Bahr Salamat drainage. Much of the country between the Bahr Salamat and the Bahr Aouk drainage, which forms the border

with the Central African Republic, is relatively undisturbed. This area of open woodlands interspersed with grassy wetlands is protected by prolonged seasonal flooding.

Fourteen species of antelopes are present in the south (Thomassey and Newby 1990). An aerial census in 1986 that covered 50,000 km^2 of the Salamat showed good numbers (300 to 3000) of bubal hartebeest *(Alcelaphus buselaphus),* tiang *(Damaliscus lunatus),* roan antelope *(Hippotragus equinus),* elephant, giraffe *(Giraffa camelopardalis),* buffalo, and ostrich. The giant eland exists only in the extreme south of Chad, where populations are probably sustained by individuals from adjacent National Parks in the Central African Republic. If black rhino still occur near Pala in southern Chad, they probably survive only because of protection offered by the Parc National de Bouba Ndjida, which lies in Cameroon just across the Chadian border.

The Sudanese and Guinean savannas that extend across Africa provide the life requirements for diverse kinds and impressive numbers of migrant birds (Morel 1973). About 480 species and subspecies, and perhaps 5 billion individual birds from the palearctic region of Europe and Asia migrate regularly to tropical and southern Africa (Moreau 1972). However, most of those birds winter north of the equator. Examples are members of the warbler family (Sylviidae), such as the whitethroat *(Sylvia communis)* and the willow-warbler *(Phylloscopus trochilus),* and other important groups such as swallows, shrikes, eagles, buzzards, harriers, kestrels, and kites. In addition, over 500 species and subspecies of African birds undertake seasonal migrations within the continent. Many of those afrotropical migrants breed in or move through the savannas of Africa, including those in Chad. As with all animals, it is essential to maintain quality habitat to ensure the continued abundance of these birds.

Some birds have benefited from agricultural expansion in the savanna and are sufficiently common to be a major threat to grain crops. Examples are the redbilled quelea *(Quelea quelea),* golden sparrow *(Passer luteus),* village weaver *(Ploceus cucullatus),* and fire-crowned bishop *(Euplectes hordeaceus).* Quelea breed in dense colonies in thickets of acacia in the Lake Chad basin, and are periodically poisoned with aerial applications of fenthion.

RIVERS AND FLOOD PLAINS

In Chad, the principal rivers arise from watersheds in either the Central African Republic (the Chari and Logone Rivers) or the Salamat flood-plain in Chad, which includes the Bahr Salamat, the Bahr Keita, and the Bahr Aouk (Fig. 2). The Mayo-Kebbi arises near Pala in the south and drains into the Benue and Niger Rivers. Within Chad, all these rivers have extremely flat gradients (except for the Gauthiot Falls on the Mayo-Kebbi) and, as a consequence, have extensive and important flood plains.

Figure 2. Major Rivers, Lakes, and Wetlands of Chad. (Adapted from Géographic du Tchad. EDICF. Paris. 48 pp.)

All other rivers in Chad are seasonal. The largest of these seasonal rivers is the Wadi Azoum, which drains from the Jebel Mara in Sudan. Its waters spill into the Salamat flood plain and fill Lake Iro before eventually entering the Chari River. Another important seasonal river is the Wadi Batha that originates in the Ouaddaï plateau near Abéché and flows west into Lake Fitre. The flood plains of the rivers in Chad are among the most important wetlands in the Sahel region of Africa.

The extensive bars along the river flood plains attract many migrant waders during the Eurasian winter, as well as local black-crowned cranes *(Balearica pavonina),* marabou storks *(Leptoptilus crumeniferus),* herons, egrets, and plovers. The vertical sandy banks are well-suited for nesting colonies of bee-eaters such as the carmine *(Merops nubicus)* and the red-throated *(Merops bulockii),* and also kingfishers, such as the pied kingfisher (*Ceryle rudis*). Lévèque (1967) studied these and other non-passerine birds of the lower Chari River.

In the wide, flat Salamat River drainage and along the Chari, Logone, and Mayo-Kebbi Rivers, the extensive flood plains have a grassy cover consisting primarily of *Hyparrhenia rufa, Elytrophorus spicatus,* and *Vetiveria nigritana*. These flood plains lack trees, but some have shrubs and herbaceous cover. However, they are primarily grasslands and are heavily grazed by livestock. Increasingly, they are being used for growing cereal grains and rice. These grasslands are important feeding areas for wild ungulates and for small migrant passerines before and after they cross the Sahara desert. The annual grass, *Panicum laetum* that invades the flood plains with disturbance by man produces small, round seeds favored by redbilled quelea. The situation is a good example of how grazing and agriculture can create pest problems.

The lakes and permanent rivers of Chad support a considerable fishing industry; the most important being along the lower Chari and Lagone Rivers and in Lake Chad. Some 21 species of fishes from Lake Chad migrate 100 to 150 km up the El Beid and Chari-Logone river systems to the broad and extensive Logomatia Marshes to spawn. Fry return through the marshes to the El Beid River and on to Lake Chad (Kindler et al. 1989). With intensification of agriculture, this spawning area could be altered and degraded by sediments and agrochemical pollution carried in the rivers. Agricultural and grazing use of flood plains already has reduced the value of the areas for fish. In addition, drought (Quensiere 1976) and overfishing (Durand 1979-1980) have seriously depleted fish populations in Lake Chad and the Chari delta. The decimation of crocodile and hippopotamus *(Hippopotamtus aquaticus)* populations through hunting may have adversely influenced fish populations. A principal prey of the crocodile is the catfish *(Clarias gariepensis).* When crocodiles are hunted out, the catfish proliferate and consume the eggs and fry of tilapia and other desirable cichlid fishes. Hippopotami are helpful in maintaining fish stocks as they increase water fertility with their dung and by stirring up the rich sediments.

LAKES

Lake Chad and other wetlands in the Chad Basin (Fig. 2) provide essential resting and feeding habitats both to palearctic and afrotropical waterfowl and to other wetland species. Vielliard (1972) discussed the status of 17 species of waterfowl on Lake Chad. Bands recovered from ducks banded in Europe illustrated the importance of the lake to migrating waterfowl (Ash et al. 1967). During an aerial survey in 1984 over 700,000 waterfowl were seen on Lake Chad, which at that time represented one-half of the West African population of waterfowl (Roux and Jarry 1984). Periodic counts of waterfowl and other species were conducted by the International Waterfowl and Wetlands Research Bureau between 1955 and 1993, but coverage varied between years (Perennou 1991). Seventeen species of waterfowl and 49 other wetland species were recorded from Lake Chad, and total numbers ranged to over I million birds in 1987. Abundance in different years was correlated with the extent of the water surface of Lake Chad and with wetland conditions elsewhere in West Africa.

The river prinia *(Prinia fluviatilis)* occurs in Chad, Niger, and northern Cameroon in the Lake Chad area. This rare species is listed as threatened (Collar and Andrew 1988; Groombridge 1993), but little is known of its range, abundance, or status. Another species listed as threatened worldwide is the marbled teal *(Marmaronetta anigustirostris)* which ranges from the Canary Islands to southeast Asia. The teal is occasionally seen on Lake Chad (Fanshawe and Gretton 1989) and elsewhere in northern Chad (see Newby 1979).

In addition to the large waders and ducks, Lakes Chad and Fitri support vast numbers of smaller palearctic migrants. On Lake Chad, ruffs *(Philomachus pugnax)* are often common and over I million have been seen on the lake at one time (Fanshawe and Gretton 1989). Ash et al. (1967) recorded 230 species of birds (86 passerines and 144 nonpasserines of which perhaps 76 species were palearctic migrants) on and adjacent to Lake Chad in a six-week period during March and April 1967. They recorded flights of 4,000 per minute for yellow wagtails *(Motacilla flava),* 100,000-175,000 per hour for sand martins *(Riparia riparia),* and large flights of whitethroats, either on passage to and from Africa and Europe, or at Lake Chad for the duration of the northern winter.

The lake supports hippopotami, crocodiles, elephants, the swamp-dwelling sitatunga *(Tragelaphus spekei),* and two species of otter — the cape clawless otter *(Aonyx capensis) and* the spotted-necked otter *(Lutra maculicollis).* All of these animals have been severely impacted by drought and by human intrusion (herders, farmers, fishermen, and poachers). Their status at the lake appears precarious, although little is known about their numbers and distribution. In 1979 fair wildlife numbers existed in the Kalamaloue National Park in Cameroon on the south side of the Chari River near its mouth. From 10 to 2,000 individuals of 7 species of antelopes and a few lions (*Panthera leo),* leopards (*Panthera pardus*), elephants, giraffes, crocodiles, and hippopotami were tallied there in April and May (Okula 1979). The larger mammals in Kalamaloue National Park and in other parks in Cameroon along the Chadian border, such as Waza and Bouba Ndjida National Parks, could reestablish themselves in Chad if habitat was allowed to recover and poaching was restricted. For example, Kalamaloue is just across the river from the extremely degraded Mandela Faunal Reserve in Chad.

Lake Fitri has been called a miniature Lake Chad. It, too, is a shallow lake and completely dried up in 1985 after years of drought. The lake can double or triple in size during wet years (420 to 1,300 km^2). At normal levels the lake's depth is only several meters but its waters are not highly saline (Kindler et al. 1989). Counts of four waterfowl species (*Anas quequedula, A. acuta, A. clypeata,* and *Aythya nyroca*) totaled about 17,000 in 1984, 83,000 in 1986, and 22,000 in 1987 (Perennou 1991). Counts of waterbirds of all species have ranged as high as 145,000 (Daboulaye Ban Ymary, pers. comm.). The lake has a productive fishery that is important to the local economy. In 1990 the Government of Chad identified Lake Fitre as a wetland of international importance to be protected under the criteria of the RAMSAR Convention (Perennou 1991). Whether this new status will contribute meaningfully to the preservation of the environment and the associated wildlife is problematical in the face of mounting human pressures and the lack of funds in the government for staff to provide protection and management. There apparently are plans for economic developments at Lake Fitri to be financed by the Islamic Bank for Development (Kindler et al. 1989). As recently as 1990, a small remnant herd of elephants was still present near the lake (Tchad 1991).

White pelicans *(Pelecanus onocrotalus)* that fish in Lake Fitri use the flat top of the 300 m granite peak, Ab Touyour, near Bitkine, as a nesting site (Dragesco 1971). Feeding involves a flight of approximately 120 km in each direction between the colony and the lake. The summit of this pinnacle might accommodate from 200-400 nests.

Lake Léré and Lake de Tréné are located on the Mayo-Kebbi River in the southwest corner of

Chad. Lake Léré is much larger than Lake de Tréné, and covers an area of about 30 km^2. These two lakes are separated from a series of smaller lakes upriver (Lakes Tikem, Fianga, and Kablia) by the Chutes Gauthiot. The lakes and the town of Léré are within the Binder-Léré Faunal Reserve, which centers around the Chutes Gauthiot where roan antelope, bubale hartebeest, and other larger mammals are still present.

The most scientifically important and vulnerable animals in the area are perhaps the landlocked, fresh-water manatees *(Trichecus senegalensis)* in Lake Léré and Lake de Tréné. Little is known of this population, but its numbers have been estimated at between 100 and 150 individuals (Daboulaye Ban Ymary, pers. comm.). The animals are fully protected, but they are poached as they are excellent to eat. It may be that the species still exists primarily because there are few motorized boats on the lakes to facilitate their capture. Waterfowl and other waterbirds use the lakes. Pelicans and other fish-eating birds feed there, as the lake contains an abundance of fishes. The lake supports an important fishery that provides employment and supplies fish to the local markets. Vielliard (1971a) visited Lake Léré in 1970 and noted 158 species of birds, which included 56 aquatic and 102 terrestrial forms.

Near the headwaters of the Mayo-Kebbi, there is a vast plain containing the Touboiris and Loke Marshes. These marshes, when flooded, can flow either north to the Logone River or south to the Mayo-Kebbi River. As a result, fishes of the Chari/Logone and the Mayo-Kebbi drainages are a combination of species found in the Niger River and in the Chad Basin. The Touboiris and Loke Marshes and the adjacent flood plains of the Logone River are extensively planted to rice, some of which is irrigated and treated with insecticides.

Of all the lakes in southern Chad, Lake Iro is the most isolated and, therefore, the most pristine. It has an important fishery and the export of fish largely supports the local village (Anita Mackey, pers. comm.). The lake has been proposed for protected status as a Ramsar site and Biosphere Reserve. It is not expected that agricultural development will impact the lake or the extensive natural habitats nearby. However, because of its uniqueness, its current condition should be protected.

In Tibesti Province, there are several lakes northeast of Faya Largeau: Lake Yoa at Ounianga Kébir and a set of five finger lakes nearby at Ounianga Sérir. All of these lakes are fed by underground aquifers. They are not currently accessible, but they will be important in the future development of tourism in the unique Tibesti/Ennedi region of northern Chad.

Wildlife Management in Chad

Organization and Activities

The Direction of National Parks and Faunal Reserves functions under the Ministry of Tourism and Environment in Chad. M. Daboulaye Ban Ymary was Director in 1993, and in the central office he supervised 36 employees in four Services; Park Management, Ecobiology, Legislation and Contracts, and Personnel and Procurement. In addition, he directed about 200 contract workers and laborers in the field. The Direction's activities are supported by National Ordinances Nos. 14/63 and 16/63 passed in 1963 and Decrees between 1961 and 1983 providing for hunting, the protection of certain animals, and the establishment of National Parks and Faunal Reserves. The National Ordinances are inadequate and antiquated and need to be revised. The Direction had a budget of 25 million CFA in 1993. This amount covered salaries but left virtually no funds for operations and equipment with which to undertake its responsibilities for the protection and management of Parks and Faunal Reserves and the enforcement of regulations protecting fish and wildlife. For the near future, this Directorate must rely on donor assistance for funding of operations. Additional funds are needed for wildlife management, law enforcement, all weather access roads, and education of the rural population on the benefits they can obtain from their wildlife resources.

Civil war and the breakdown of law and order in Chad during the last two decades, coupled with grazing crises arising from two periods of droughts, has caused widespread disruption in the patterns of land occupancy and use. Undisciplined militia and others acquired automatic weapons which enabled them to supplement their needs for meat and cash. National Parks and Fauna Reserves became target areas for hunting, elephant and rhino poaching, and grazing by transhumant herds driven out of their normal migration corridors by war and drought. Existing legislation was unenforceable and was widely disregarded.

The elephant population plummeted from about 16,000 to 2,300 (Tchad 1991) and the black rhinoceros, the addax, and the scimitar-horned oryx probably were exterminated in Chad (Daboulaye Ban Ymary, pers. comm.). Due to worldwide concern for elephants and a need to establish sanctuaries for the remaining animals in Chad, the European Economic Community / Fonds European du Developpement (EEC/FED) sponsored a survey of numbers and distribution of elephants and helped prepare a management plan (Tchad 1991).

The Government of Chad began developing a National Conservation Strategy in 1990, and was proposing a National Strategy for Sustainability. Such documents will certainly be necessary for guidance and direction of future programs and in obtaining funds from international donors. Stuart and Adams (1990) discussed needed conservation activities including rehabilitation of protected areas and surveys of habitats and wildlife species. Chad is a signatory to the Convention Concerning Protection of the World's Cultural and Natural Heritage and to the African Convention of Nature and Natural Resources, but has not ratified the latter (Robinson, 1989). The government also has not ratified the following agreements (Goodman and Meininger 1989): the African Convention for the Conservation and Management of Wildlife and its Habitat, the African Convention of Nature and Natural Resources, the Convention on Wetlands of International Importance Especially as Waterfowl Habitat (RAMSAR Convention), the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES III), and the Convention for the Conservation of Migratory

Species of Wild Animals (Bonn Convention; Boere, 1991).

NATIONAL PARKS AND FAUNAL RESERVES

Some uplands in the Saharan, Sahelian, and Sudanian zones have been designated as protected areas. Chad has two National Parks and 7 Faunal Reserves (Fig. 3; IUCN 1987a). In addition, Lake Fitri is a Biosphere Reserve, and Lake Iro has been nominated for that status.

The Parc National de Zakouma (3000 km^2), established in 1963, has a rich fauna. Protection and management of the park has recently increased. The park was seriously affected by political unrest and poaching from 1975 onwards, but this has now largely been curbed. The large Bahr Salamat Faunal Reserve surrounds the park and offers it some additional protection. There are plans by the European Community to finance the extension of the buffer zone to the west of the park to include the Siniaka-Minia Faunal Reserve.

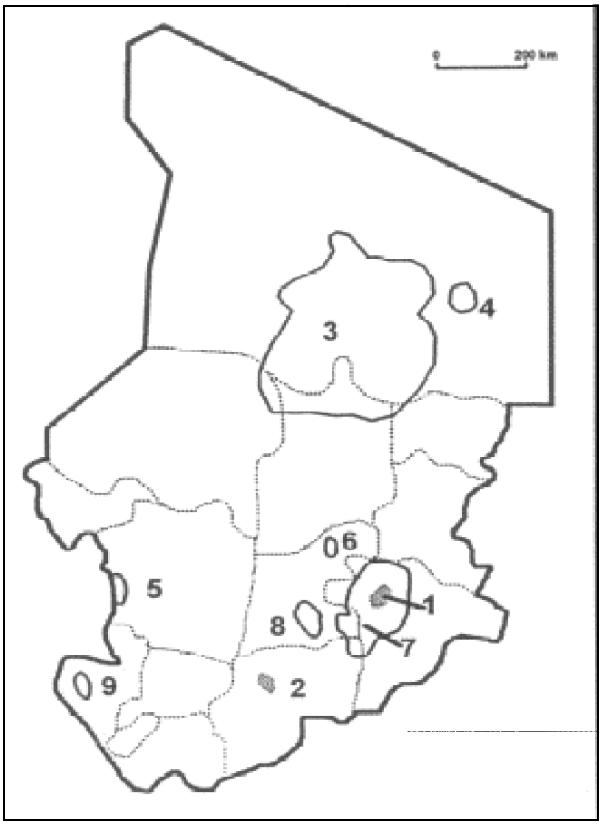

Figure 3. National Parks (1 - Zakouma, 2- Manda); Faunal Reserves (3 - Ouadi Rime Ouadi Achim, 4 - Fada Archei, 5 - Mandelia, 6 - Aboutelfan, 7 - Bahr Salamat, 8 - Siniaka-Minia, 9 - Binder Lèrè) and Boundaries of Prefectures in Chad. (Adapted from Stuart and Adams 1990).

Much of the park and adjacent reserves is flooded during the wet season. Vegetation consists of open, grassy flood plains interspersed with savanna woodlands. The flora and large mammals of the park were studied by Gillet (1969). A total of 47 species of mammals were listed there recently, including buffaloes, giraffes, hippopotami, elephants, cheetahs *(Acinonyx jubatus)*, leopards, lions, 11 species of antelopes, and other smaller mammals (SECA 1992). The park supports large numbers of terrestrial and aquatic birds, and 285 species were recently compiled (SECA 1992). Thiollay (1975) saw 44 diurnal birds of prey in Zakouma National Park and 36 in Manda National Park; of those, 20 species of eagles and vultures comprised 70 percent of the total. The abundance and diversity of birds and mammals is greater in the Park than outside, which reflects the difference in habitat quality between the Park and the degraded savanna areas used by humans.

The EEC/FED has provided funding for two expatriate specialists, game guards, and materials for the rehabilitation of Zakouma National Park. This project has developed management plans and conducted wildlife censuses. There are now game guards in the park, and poaching is minimal. Programs of rural development for villages within the adjacent Bahr Salamat Faunal Reserve have helped relieve human pressures on the park and its resources. Villages were moved from the parks when they were established, and peasants still feel they have rights to the areas. Land is not privately owned in Chad, and tenure is established by previous use.

The Parc National de Manda (1140 km^2) was established in 1965 to protect the rare giant eland, other large ungulates, and the smaller wild animals

that occurred there. All ostrich, bustards, and large mammals are now gone, including the elands, which were shot out during the insurrections of the past two decades. A few bushbuck and common duiker still survive there. The woodland-savanna in the park is in reasonably good condition and continues to support an abundance of the smaller birds and mammals. Cattle still graze in the park, but human intrusion otherwise appears to be minimal. The park is a candidate for rehabilitation. Additional National Parks have been proposed at Aouk and at Goz Beida.

The Faunal Reserves in Chad, with their date of establishment and their size, are Aboutelfan (1983; 1100 km^2), Bahr Salamat (1964; 20,600 km^2), Binder-Léré (1974; 1350 km^2), Fada Archei (1967; 2110 km^2), Mandelia (1983; 1380 km^2), Ouadi Rime-Ouadi Achim (1969; 80,000 km^2), and Siniaka-Minia (1961; 4260 km^2). Their descriptions and current conditions are discussed by Stuart and Adams (1990), Thomassey and Newby (1990), and IUCN (1987b and 1991). There are proposals for new faunal reserves at Bein Amar, Kelo, Larmanaye, Ngam, and Ndam.

Hunting is allowed in the southern one-half of the Bahr Salamat reserve and on the adjacent Siniaka-Minia reserve. The condition of wildlife habitat in these reserves varies, but all could benefit from rehabilitation. With additional protection from human use and hunting, reintroduction of extirpated animals would be possible. Reserves often were established to protect a species or a group of species — the elephant at Mandelia (which is now gone), roan antelope and bubale hartebeest at Binder-Léré, addax and oryx at Ouadi Rime-Ouadi Achim (which are now gone), greater kudu (*Tragelaphus strepsiceros*) at Aboutelfan, and Barbary sheep at Fada Archei.

Human Agricultural Activity

In Chad, 83 percent of the working population is engaged in the production of crops and livestock, primarily for domestic consumption. Only 2 percent of the land in Chad is cultivated, but about 50 percent is grazed (Stuart and Adams 1990). Cereal grains are the main food crops, while beans, corn, rice, and gardens are important in local areas. Cotton and peanuts are the primary cash crops. Traditionally, transhumant livestock herds moved seasonally to utilize forage produced by rainfall that progresses from south to north during the summer. Agricultural expansion has now occupied traditional livestock trails and conflicts have developed between herders and farmers.

Fisheries in the lakes and rivers of southern Chad formerly produced landings comparable to those from coastal waters of Africa. Most fish are consumed fresh, but some are smoked or dried. Over one-half of the catch is from the lower Chari River and Lake Chad.

Forestry provides firewood and lumber for local use, but increased demand has already resulted in over-harvest. To be of continued value to wildlife, forests must be protected from trespass and managed for sustained production. Protection is now minimal and incentives are needed to encourage villagers to replant trees, restrict grazing, and sensibly harvest wooded areas and forest reserves in their area. Villages have long established conventions on use of resources common to people within a village and among neighboring villages. Civil strife, economic stresses, and herder-villager conflicts have compromised the rules for use of common resources and contributed to the over-use of most resources.

Most farming in Chad is now conducted much as it has been for centuries. The main sustenance crops are rain-fed, cultivated and harvested by hand, and grown without the use of fertilizers and other agrochemicals. Farming leads to nutrient depletion, and for every year an area is planted it must be left in fallow for 4 or 5 years to recover. The simple, sustenance farming practiced in Chad today is ecologically stable and sustainable. It is not economically sustainable because of the continuing increase in the human population.

Chad has the potential to greatly increase its production and export of agricultural crops. The southern one-third of Chad has good soils, high rainfall, and a long growing season. Nigeria, which lies immediately to the southwest of Chad, is the most populated country in Africa and is unable to grow sufficient food for its population. Chadian farmers may well strive to increase agricultural production to provide food both for export and for Chad's growing population. Additional land could be cleared and the intensity of management practices, including irrigation and the use of fertilizers, herbicides and insecticides, might increase. Intensification of agriculture would create less stable conditions and certainly would have an adverse effect on wildlife.

The native flora and fauna of an area originally increases and diversifies over time to fully utilize the energy that is available to support life. Humans as hunters and gatherers harvested native plants and animals for food and were themselves a natural part of the diversity within the ecosystem. With the advent of agriculture and livestock, humans began to manage land to force available energy into vegetation and meat for their exclusive consumption. This process ultimately reduced the area, energy, water, and nutrients remaining to support native plants and animals. Management by humans for agriculture will always reduce both biodiversity and the carrying capacity of the land for most species of wildlife. A few species of animals and plants actually benefit from conversion to agriculture, but these organisms

usually come to be regarded as pests (weeds, insects, rodents, and birds). As the intensity of land management for agriculture increases, plant and animal diversity continues to diminish until only a simple, unstable system of soil, air, water, crops, and crop pests remains. This reduction in biodiversity also affects microclimates and soil fertility (World Resources Institute 1992). Such an ecosystem can be maintained temporarily with fertilizers and pesticides, but as has become evident with agriculture in the United States and elsewhere, it can not be indefinitely sustained.

Ecosystems must have a high degree of biodiversity to maintain long-term stability. The checks and balances needed for stability are provided by the competition between producer organisms and the regulation of their numbers by their predators and parasites. Human attempts to channel energy away from natural ecosystems and provide it solely to crops creates an unstable condition that cannot be maintained indefinitely. Likewise, clean farming accomplished by clearing land, and reducing undesirable plant growth with herbicides and undesirable animals with pesticides, eliminates most food and cover for other desirable forms of life, such as natural predators of crop pests, soil decomposers, and wild birds and mammals. The challenge for Chadians, therefore, is to produce sufficient agricultural crops for consumption and market, while maintaining the quality of their environments. Additional programs must be developed to help conserve fish and wildlife diversity and abundance by providing economic incentives to villagers for management and protection of these valuable resources.

Most of Chad's population lives in the southern one-half of the country and especially in the five southern prefectures; it will be there that human activities will have their greatest impact on remaining wildlife and their habitats. The area has the greatest potential for increasing agricultural production and is closest to both domestic and export markets. Natural vegetation within the area has been changed by human activities. Much of the land has been farmed, but more than one-half of the area is in some state of fallow at any given time. Non-farmed areas have been heavily grazed, and remaining forests have been heavily cropped for firewood. There is very little pristine vegetation remaining.

Agricultural Impact on Wildlife

HABITAT ALTERATION THROUGH CLEARING FOR AGRICULTURE

Wildlife effects from agricultural development can be expected as the area used by humans increases. Land will be cleared for agriculture, while increased grazing and cutting for firewood will accelerate destruction of wildlife habitat on the remaining non-crop areas. Such land use would alter habitats, reduce their value for wildlife, and might even eliminate vegetation essential for particular animals, such as *Isoberlinia doka* which is used exclusively by giant eland during certain seasons of the year. Any pressure for agricultural extensification certainly will tend to increase use of parks and faunal reserves for crops, firewood gathering, and grazing, especially since law enforcement is lax.

SHORTENING OF FALLOW CYCLES

If farmers see market demand and have the necessary labor to increase production, they may begin to use fertilizers and reduce the length of time they leave land fallow between cropping cycles. Currently, the proportion of land in different uses in the south is estimated to be as follows: 20 percent is currently in crops, 30 percent is in recent fallow (with coppice regrowth of 1-2 m, and probably out of use for the past 2-3 years), 30 percent is in older fallow (bushy growth over 2 m tall, and probably not cultivated in the past 3 to 15 years), and 20 percent of the area has not been cultivated in recent times, but is grazed and used for woodcutting.

Land that has been fallow for 4 years or more has begun to increase in value for wildlife. Biodiversity has improved as plants, plant litter, soil organisms, insects, other invertebrates, and small vertebrates invade the disturbed sites. Such biotic development will again support birds and rodents that eat insects, plants, and seeds, and will support their predators, such as mongooses, jackals, owls, and raptors. Shorter fallow cycles would tend to reduce the diversity and abundance of wildlife on fallow lands.

INTENSIFICATION OF AGRICULTURAL MANAGEMENT

As markets grow, increased acreage can be expected in cereal grains, peanuts, and manioc in the extensive rainfed farming areas in the southern provinces. Likewise, intensification can be expected in the farming of rice, beans, poie de terre, okra, tomatoes, onions, sorrel, peppers, squash, sesame, tobacco, and sugar cane. Those crops are primarily grown under irrigation or in recessional areas of flood plains and shorelines of lakes. They are relatively high-value crops from which farmers can more readily recoup their costs of land preparation, irrigation, and agrochemical inputs. Increased markets will make intensification more practical and profitable. In southern Chad, vegetable gardens are planted in the rich alluvial soils along streams and around lakes wherever open grassy areas occur. Gardens are important as the produce is sold in local markets and provides a source of cash income. The vegetables are a high-value crop and, therefore, warrant the use of fertilizers and pesticides. Use of agricultural chemicals on gardens would certainly result in the contamination of streams, rivers, and lakes. Gardens are cultivated in the wadis of Abéché, Kanem, and Lac Prefectures; some are irrigated and increased use of agrochemicals can be expected (Matteson 1991 and 1992).

HABITAT ALTERATION DUE TO WATER POLLUTION

Return flow of water from irrigated crops can pollute surface waters. Likewise, runoff and percolation of rain water can pollute nearby lakes and streams (Richards and Baker 1992). Pollutants can be minerals, sediments, organic particulates, fertilizers, herbicides, or insecticides that are either suspended or dissolved in water.

Waste agricultural water has caused severe habitat deterioration in most wetlands of the western United States, where lakes and marshes often lie below agricultural lands in the watersheds. Fertilizers and most herbicides are not highly toxic to wildlife, but over time they can alter aquatic habitats and reduce their carrying capacity for fish and wildlife. Herbicides in waste agricultural water can kill desirable plants. Fertilizers can increase growth of emergent plants and, thereby, reduce the area of open water surface. Water enrichment can support heavy growth of algae that in summer form thick mats over extensive areas of open water. Both algal mats and suspended sediments in water can restrict penetration of sunlight and the production of plants rooted in the bottoms of marshes and lakes. Thus, as the marshes eutrophy they produce inedible cattails and algae, while submergent plants like the various pondweeds favored by waterfowl disappear. Decay of algae reduces the dissolved oxygen content of water and, over time, most fishes and other aquatic organisms that require high levels of dissolved oxygen can be eliminated. Such loss of biodiversity reduces an aquatic ecosystem's ability to absorb pollution, cleanse water, and retain its stability (World Resources Institute 1992).

TOXICITY HAZARDS OF INSECTICIDES

Direct toxicity from insecticides often kills invertebrates, fishes, birds, and mammals. Such mortality can further reduce the abundance and diversity of both vertebrate and invertebrate organisms in wetlands. Concern has been expressed over potential pesticide effects on migratory birds throughout West Africa (Balk and Koeman 1984 and Mullié et al. 1991) and in Egypt (Mullié and Meininger 1985). The insecticides now in use in Chad are highly toxic to wildlife and can be expected to cause mortality. The problem will not be a serious one in the near future as the quantity of pesticides now in use is small. But farmers on irrigated and shoreline farms will use greater amounts of agrochemicals as they become affordable and available. Insecticide use in the future probably will be limited to high-value crops and in the aggregate should not result in severe and widespread direct toxicity to fish and wildlife.

USE OF AGROCHEMICALS IN CHAD

There is no legislation in Chad dealing with either registration of pesticides, food residue tolerances, or pesticide safety. In 1993 the United Nations Development Program (UNDP) and the Netherlands were drafting pesticide legislation for consideration by the Government of Chad. It is not clear where farmers obtain information on pesticides and recommendations for pest control on crops other than cotton. Farmers buy some agrochemicals (the insecticide fenitrothion, the fungicide maneb, and fertilizers) from government agencies. In addition, they purchase synthetic pyrethroids (cypermethrin, cyhalothrin, and deltamethrine) illegally from Nigeria. The products are illegal only because no import duties are paid. Apparently, there is no legal, retail source of agrochemicals in Chad because of high import taxes. Rice farmers use fertilizers and illegally apply the insecticides deltamethrine, malathion, fenitrothion, and an organochlorine, lindane.

The greatest use of insecticides at present is on cotton; these materials are provided to farmers as part of their contract with CotonTchad. Farmers often apply some of the insecticides to vegetables grown in their gardens, even though professional recommendations for pest control — both integrated pest management (IPM) and chemical

— are available only for cotton (CIRAD 1993). In 1993 there were use recommendations in cotton for several synthetic pyrethroids, for several carbamates and organophosphates, and for endosulfan. The pyrethroids and chlorpyriphos (a carbamate) are highly toxic to many aquatic organisms, while endosulfan is a notorious fish killer. Furthermore, endosulfan is a persistent organochlorine insecticide that should be replaced with an alternative compound. Monocrotophos (an organophosphate insecticide used on cotton in Chad) was banned for use on cotton in Arizona and California because it consistently caused serious bird kills. Monocrotophos should be replaced; other effective and safer products are now available for cotton insect control. Use of pesticides on cotton throughout West Africa was reported and discussed in CIRAD (1992).

In summary, agricultural extensification is likely to result in existing wildlife habitats becoming increasingly degraded by greater conversion of non-crop lands to agriculture, reduction of the fallow period on croplands, increased grazing pressure and livestock-wild ungulate competition, greater harvest of trees for firewood and lumber, and increased encroachment of humans into parks and reserves. Agricultural intensification will cause increased use of water for crops, decreased amounts of water available for fish and wildlife habitats, increased water turbidity, increased sedimentation rates, increased pollution of water with agrochemicals, increased eutrophication and reduced levels of dissolved oxygen in wetlands, with resultant degradation of fish and wildlife habitats and increased mortalities. The cumulative impact of all these effects would be overall decreases in the abundance and diversity of wildlife and in the carrying capacity of their habitats within southern Chad. Agricultural intensification and extensification will occur in Chad as increased food production is required for the increasing human population, for additional wealth, and for a higher standard of living. The challenge to Chadians will be to accomplish these changes with minimal impact on fish and wildlife and their habitats. External technical assistance will be needed to meet these goals.

Critical Wildlife Habitats

Habitats that produce essential life requirements are a prerequisite to the maintenance of healthy and abundant wildlife populations. Although a few areas that support wildlife in Chad are in fair-to-good condition, most animal habitats have been severely degraded. Clearing for agriculture, cutting of trees for firewood, and severe overgrazing have seriously reduced the carrying capacity of the land, especially in areas of the southern provinces where human populations are the highest and land use the most intense (IUCN 1991; Tchad 1992). Drought has aggravated this situation in most countries across the Sahel (Warshall 1989).

In the past, Chad had an extremely rich and varied flora and fauna. Chadians will be poorer both culturally and economically if their wild areas are completely degraded and their wild animals are severely decimated or extirpated. Hecht (1993) has argued persuasively that Chad's economy can best be supported by protecting its environment while fully utilizing the productiveness of its natural resources. A healthy environment will enable sustainable production of food crops, livestock, trees, fish, and wildlife. Likewise it enhances the lives and protects the cultural heritage of the human population.

A number of lakes, wetlands, and terrestrial sites in Chad must be protected and managed to ensure their continued value to wildlife. These are designated here as critical habitats and are specific areas in Chad that provide the essential life requirements for larger mammals and other resident and migratory wildlife species. Human activities in these areas should be designed to encourage the coexistence of humans and wild animals by giving the local residents an economic incentive to maintain the quality of fish and wildlife habitats. Methods used to attain such mutual benefits, and examples of successful programs have been presented in recent literature (Wells and Brandon 1992; Steinberg 1993; Cohn 1994) and at recent scientific meetings (International Wildlife Management Congress 1993; McNeely 1993). Exciting examples also exist of current progress in low-input farming that are truly sustainable and environmentally benign (Miller 1992; Bonner 1993). Linden (1993) claimed that sustainable development or even sustainable use can seldom be pursued without exhausting natural resources because, "no matter how good the plan to manage an ecosystem some people will cheat." This probably will be true in many cases and, as he stated, "necessitates the pure preservation of some vital areas."

Future agricultural development in Chad should be concentrated where wildlife habitats have already been severely degraded. Important areas that must be managed to prevent further degradation and to maintain fish and wildlife abundance include the lakes and the savanna wetlands (such as the river flood plains of the Chari/Logone and Bahr Salamat drainages). Habitats in the best condition should be fully protected and managed primarily for fish and wildlife. Such areas include the sites of fish endemism in the Tibesti and Ennedi Mountains, and the more pristine of the National Parks and Faunal Reserves.

LAKES AND SAVANNA WETLANDS

A program to conserve the wetlands of Lake Chad (and those of the more extensive Chad Basin) is needed, but efforts would be costly and would require cooperation between the four countries that share its shoreline (Fanshawe and Gretton 1989). The Lake Chad Basin Commission consisting of members from Chad, Niger, Nigeria, and Cameroon was established in 1964. The member countries adopted an Agreement on Common Regulation of Flora and Fauna at their 24th session

in 1977. This agreement could have facilitated formation of a joint effort in the conservation of Lake Chad, but no such steps were subsequently taken. Tolba (1992) reported that a plan for the management and conservation of Lake Chad had been prepared by the United Nations Environment Program (UNEP) in Nairobi.

Discharges of agrochemicals, sewage, return-flow agricultural water, and sediments are known to have caused wetland degradation throughout the world (Dugan 1993). Lakes Chad and Léré and their flood plains, as well as the entire Bahr Salamat drainage, should be protected from siltation due to soil erosion and from eutrophication as a result of enrichment by fertilizers and human wastes. As the lakes are subject to drainage from agricultural areas, they should be monitored and remedial actions taken, when necessary.

THE TIBESTI AND ENNEDI MOUNTAINS OF THE NORTH

The greatest number of endemic vertebrates in Chad appear to be the fishes that evolved in scattered springs of the Borkou Basin in the northern mountains. These springs should receive absolute protection, and development near them should be prohibited. These fishes are unique in the world and represent a valuable heritage for the people of Chad. Because endemism is not high in Chad, these fishes are of special value. They have been studied by Le Berre (1989).

NATIONAL PARKS AND FAUNAL RESERVES

Protection of habitat from human use and of wildlife from poaching may be possible in the National Parks and Faunal Reserves, but probable not elsewhere. The protection of these areas diminished during the last several decades, and their condition was compromised by drought, poaching, and encroachment of humans. Their condition can be improved by the effective restriction of trespass by poachers, cattle, woodgathers, and farmers (Stuart and Adams 1990). In some cases reintroduction of extirpated species will be necessary. Management and conservation measures for the parks and faunal reserves were outlined by MacKinnon and MacKinnon (1986) and by IUCN reports (1987b; 1992). The objectives of these areas, their present condition, and needed conservation programs are also discussed by Stuart and Adams (1990) and Thomassey and Newby (1990).

Threatened Vertebrates of Chad

Groombridge (1993) listed 20 threatened vertebrates for Chad — 16 mammals, 3 birds, and 1 reptile. He did not list any species as recently becoming extinct in Chad. Other authors have assessed the status of wildlife in Chad (Newby 1980, King 1981, Groombridge 1982, Collar and Andrew 1988, Kindler et al. 1989, Le Berre 1990, Stuart and Adams 1990, Thomassey and Newby 1990, Tchad 1991, and Wilson and Reeder 1993). From these discussions, the following list of threatened species was developed. Threatened species include those that are *E*, endangered; *V*, vulnerable; *R*, rare; and *K*, probably threatened (but insufficient information is available). It should be recognized that the status of animals can differ between countries and that the ability to classify animals is dependent upon current knowledge of their range, their abundance, and threats to their continued existence. Very little such information exists for animals in Chad, and only the larger animals about which the most is known are considered here.

MAMMALS

Fennec fox	*Fennecus zerda*	K
Wild dog	*Lycaon pictus*	E
Pale fox	*Vulpes pallida*	K
Rueppel's fox	*Vulpes rueppli*	K
Cheetah	*Acinonyx jubatus*	V
Lion	*Panthera leo*	V
Leopard	*Panthera pardus*	E
Cape clawless otter	*Aonyx capensis*	K
Spotted-neck otter	*Lutra maculicollis*	K
West African manatee	*Trichecus senegalensis*	V
Elephant	*Loxodonta africana*	V
Wild ass	*Equus asinus*	E*
Black rhinoceros	*Diceros bicornis*	E*
Giraffe	*Giraffa camelopardalis*	V
Dama gazelle	*Gazella dama*	E
Dorcas gazelle	*Gazella dorcas*	V
Red-fronted gazelle	*Gazella ruftfrons*	V
Slender-horned gazelle	*Gazella leptoceros*	E
Buffalo	*Syncerus caffer*	V
Giant eland	*Taurotragus derbianus*	E
Sitatunga	*Tragelaphus spekei*	V
Greater kudu	*Tragelaphus strepsiceros*	V
Barbary sheep	*Ammotragus lervia*	E
Addax	*Addax nasomaculatus*	E*
Scimitar-horned oryx	*Oryx dammah*	E*
Red-flanked duiker	*Cephalopus rufilatus*	R
Yellow-backed duiker	*Cephalopus silvicultor*	K

* May be extinct in Chad

BIRDS

Ostrich	*Struthio camelus*	V
Marbled teal	*Marmaronetta angustirostris*	V
African fish eagle	*Haliaeetus vocifer*	R
Bateleur	*Terathopius ecaudatus*	R
Ayre's hawk eagle	*Hieraaetus ayresii*	R
Martial eagle	*Polemaetus bellicosus*	R
Lesser kestrel	*Falco naumanni*	R
Peregrine falcon	*Falco pereginus*	R
Demoiselle crane	*Grus virgo*	V
Black-crowned crane	*Balearica pavonina*	V
Stanley bustard	*Neotis denhami*	V
Nubian bustard	*Neotis nuba*	V
Arabian bustard	*Ardeotis arabs*	V
White-bellied bustard	*Eupodotis senegalensis*	V
Black-bellied bustard	*Eupodotis melanogaster*	V
Senegal parrot	*Poicephalus senegalus*	V
Abyssinian ground	*Bucorvus abyssinicus*	V

hornbill			Nile crocodile	*Crocodylus niloticus*	V
River prinia	*Prinia fluviatilis*	R	Slender-snouted crocodile	*Crocodylus cataphractus*	V

REPTILES

			Water monitor lizard	*Varanus niloticus*	K
African spurred tortoise	*Geochelone sulcata*	K	African rock python	*Python sebae*	K

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