# Organisation pour la Mise en Valeur du Fleuve Sénégal (O. M. V. S.)

## ASSESSMENT OF ENVIRONMENTAL EFFECTS of Proposed Developments IN THE SENEGAL RIVER BASIN

Partial Report
for
Mammalogy and Herpetology

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Dakar Sénégal

# MAMMALOGY AND HERPETOLOGY

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# CHAPTER A

## INTRODUCTION

The past two decades have witnessed a decline in wildlife throughout much of West Africa (Myers, 1976). Drought and man-made perturbations are primary factors in this decline. The Sénégal River basin project is designed to increase the value of the river as a resource to man. Benefits to wildlife species have not been included in initial planning, although some may occur. Adverse impacts (e.g. permanent habitat loss) will definitely take place where land is cleared or inundated. This environmental assessment attempts to characterize present conditions, identify project impacts on wildlife and produce feasible methods for mitigating harmful impacts.

Wildlife habitats within the project area are largely determined by variations in topography and rainfall, which influence the distribution and diversity of vegetation types (Olaniyan, 1968). Average annual rainfall is highest in the upper valley, becoming progressively less in the middle valley and lower valley. Hence a more lush savanna type is present in the upper valley than occurs in the lower sections of the project area. Topographic relief is also greatest in the upper valley with escarpments and talus slopes along the borders of broad plateaux and mesas; whereas the middle and lower valleys are generally flat with gentle terraces and scattered bodies of standing water (e.g., Lac de Guiers, marigots). The Sénégal River and associated marigots together with Lac de Guiers provide habitat for important animal species. The Sénégal River manatee and Nile crocodile are endangered species which survive within the region only in these areas. Illegal hunting and fishing practices have had a detrimental effect on populations of both species and have eliminated them from much of their former ranges.

Land use practices also influence the present wildlife species composition within the project area. Much of the delta and the middle valley in the vicinity of the river is populated by man. The upper valley along the Bafing River above Mahina is less populated. Dieri farming has caused the removal of indigenous vegetative cover and provided new habitats for some species; especially rodents. Several rodent species are known to increase in areas of grain production. The removal of gallery forests to provide firewood and charcoal has substantially diminished this important wildlife habitat. Savanna vegetation is heavily grazed by

sheep, goats and cattle, thus reducing the habitat and forage available for native herbivorous mammals.

Agricultural practices directly affect species such as warthog, baboon and hippopotamus which are crop pests. Species (e.g. lion) which prey upon livestock are also affected. The lion has been eliminated from most, if not all, of the lower and middle valleys in the past few decades because of the menace it poses to livestock. The reports of Service d'Elevage for the Kenieba section of the Kayes region, Mali, for 1976 and 1977 indicate that 37 hyaenas, two lions, three jackals and 23 dogs were killed while attacking livestock. Quantitative data from other portions of the project area are unavailable.

The upper valley is more sparsely populated than the lower and middle valleys. Dieri cropping is limited, and a narrow band of riparian forest is present along much of the river above Mahina. This forest provides habitat essential for several of the larger mammals such as bushbuck, defassa waterbuck and duikers. Persistent burning of the savanna occurs throughout much of the upper valley. This practice is generally detrimental to many species by destroying forage and cover, and by directly destroying individuals which are unable to escape the flames. From the foregoing description it can be deduced that the entire project region is already highly disturbed by the activities of man, and indirectly by his domesticated animals. This disturbance is superimposed on the climatic and topographic characteristics of the region to produce the present conditions.

Many of the larger species of reptiles and mammals have been drastically reduced in numbers or eliminated from the area altogether. Some rodent pests (e.g. Arvicanthis, Rattus and Mastomys) are thriving in areas of human habitation, particularly where grain crops are produced. Still other species are receiving both negative and positive impacts from different aspects of man's presence. The introduction of livestock has increased available food, but man has extirpated lions in much of their former range to prevent livestock losses. The hippopotamus occasionally raids cropland near the river, but man's presence and hunting practices have considerably reduced its range in the project area.

Subsequent sections will provide a more detailed description of wildlife species in the project area. Special emphasis is placed on species which are considered important. The interrelationships (e.g. predator-prey) among these species and other components of the environment will also be discussed.

# CHAPTER B

# OBJECTIVES, SCOPE AND ORGANIZATION

## B.1. Objectives

The ultimate purposes of this study are to accumulate sufficient baseline data to provide a useful (and reasonably reliable) assessment of the impact of the proposed project on wildlife, and to develop realistic mitigative measures for harmful impacts. Because of existing constraints imposed on the project, the acquisition of baseline data has relied heavily on existing literature and contacts with regional authorities. These sources have been supplemented by field surveys as outlined in the procedures section which follows.

The objectives of field surveys were:

1. To determine presence, distribution and habitat affinities of major animal species which may be affected by the project and,

2. To verify information obtained from literature and during interviews.

B.2. Scope and Organization

The basic approach to accumulating wildlife data was first to consult available literature sources in order to determine data sufficiency. After a preliminary literature evaluation, regional wildlife experts were identified and the field sampling program design was adjusted to fill gaps in data required. Examinations of the literature and early contacts with regional authorities revealed the presence of wildlife collections in Sénégal and the United States of specimens from the project area. Field studies were conducted in conjunction with interviews of regional experts in order to obtain adequate data for each habitat, subdivision and important species within the project area.

Existing literature was reviewed at the O.M.V.S. Documentation Center in Saint-Louis and at the Institut Fondamental d'Afrique Noire (IFAN) and the Office de la Recherche Scientifique et Technique Outre Mer (ORSTOM) libraries in Dakar, Senegal. Additional literature, unavailable in the riparian states, was surveyed at the Carnegie Museum library, University of Pittsburgh library, Cornell University library, University of New Mexico library and the Mammalogy and Herpetology Division libraries at the United States National Museum. All relevant books and articles were either reviewed at these institutions, or were obtained for subsequent evaluation and use.

Personnel of the Service des Eaux et Forêts within the project area in Sénégal and Mali were interviewed and current data on the distribution of important species were discussed. Copies of the regulations protecting and regulating the species for hunting were obtained from appropriate offices in Dakar, Bamako, Kayes, Rosso and Nouakchott. Wildlife experts at ORSTOM and IFAN in Senegal, the Unites States National Museum and Carnegie Musuem in the Unites States and at the Museum Alexander Koehig in West Germany were also consulted.

Meetings were held in Morges, Switzerland, during November, 1978, with biologists from the World Wildlife Fund (WWF) and the International Union for the Conservation of Nature and Natural Resources (IUCN)- Information on the status of important animal species was obtained. Potential impacts and suggested mitigation measures were discussed.

Contacts were also made with villagers, particularly hunters, to obtain specific data on important species occurrence and to verify questionable distributions presented in the literature. The information obtained, much of which was subsequently verified by field studies, is felt to be generally reliable.

Museum collections of mammals, reptiles and amphibians were examined to obtain data on species distributions not available in published literature. Mammal collections at ORSTOM in Dakar and at the United States National Museum were visited. Amphibian and reptile records and specimens at the United States National Museum, ORSTOM in Richard Toll and at IFAN in Dakar were also examined.

Aerial surveys were conducted on February 18, 1978, to the upper valley (Bafoulabé) to a point several kilometers south of Bamafélé on the Bafing River, and on October 14, 1978, to the delta and all of the middle valley (Saint-Louis to Matam). These aerial surveys have been undertaken in order to obtain data on the distribution (e.g. extent of standing water, location of gallery forest) and present condition (e.g. degree of disturbance) of wildlife habitats in the project area.

Field surveys were conducted throughout the project area (Table B.2-1). Because of logistic constraints, including impassable roads during the rainy season, complete surveys of the study area were not made at each visit. Surveys were conducted at the end of the dry season (June and July, 1977) in the middle valley, throughout the project area at the end of the wet season (November-December, 1977) and the length of the project area again in the middle of the dry season (February, 1978). General reconnaissance was made during the June-July and November-December visits. Selective sampling was performed during all field trips.

TABLE B.2-1

Field Surveys for Mammals, Reptiles and Amphibians

| | |
|---|---|
| June 28 - July 1, 1977 | Saint-Louis, Diama, Richard Toll, Lac de Guiers (Mbane) |
| July 6 - 15, 1977 | Saint-Louis, Richard Toll, Dagana, Podor, Ndioum, Mbiddi, Matam, Odober |
| November 18 - 23, 1977 | Saint-Louis, Diama, Richard Toll, Lac de Guiers (Mbane Nieti-Yone) |
| November 26 - December 10, 1977 | Keniekenieko, Soukoutali, Manantali, Mahina, Bafoulabé, Tinntila, Kayes, Bakel, Ndioum, Lac de Guiers, (Nieti-Yone), Diama, Saint-Louis |
| February 18 - 25, 1978 | Soukoutali, Manantali, Mahina, Bafoulabé, Tinntila, Kayes, Bakel, Lac de Guiers (Nieti-Yone), Saint-Louis |
| October 14, 1978 | Saint-Louis to Matam (aerial survey) |

B.2.1. Mammals

Standard sampling techniques were employed to obtain data on mammals throughout the basin. Although information was obtained on all major mammalian groups (e.g. carnivores, ungulates, bats, rodents, etc.) sampling efforts concentrated on larger species and on species of special concern (e.g. endangered game). Sampling trips were conducted in June, July, November and December of 1977 and February and March of 1978.

Small mammal trapping was conducted at several locations and in all major habitat types in the basin. Although a variety of traps were used, most sampling employed Museum Special snap traps. Traps were baited with peanut butter and placed at selected locations within the various habitat types. In some locations larger traps (Victor rat traps) were employed. Two sizes of live traps, Sherman three by three by nine-inch traps and Woodstream six by six by eighteen-inch traps were also used.

Mist netting for bats was attempted at Podor. Only three bats were collected and it became apparent that the technique was of marginal value. Discussions with mammalogists at the United States National Museum (Drs. Setzer, Robbins and Wilson) indicated that mist netting in Africa is difficult, and that other techniques (e.g. shotguns) are more successful. Sufficient recent literature (Adam and Hubert, 1976; Rosevear, 1965) is available so that adequate baseline characterization and evaluation of impacts could be assessed without additional sampling for bats.

Occasional wildlife observations were made during aerial surveys, but habitat conditions and low population densities precluded the acquisition of data on crocodile, hippopotamus and manatee distributions, as had been originally planned.

Records were taken on the habitat association and location of mammals seen while driving in the project area. Population levels of ungulates were too low to provide data on the abundance of these species. Ungulates were rarely observed because of their scarcity; therefore road-strip censuses were not conducted. Data on general abundance, habitat association, and distribution of ungulates was obtained during contacts with regional experts and villagers, from existing literature, and from random observations.

Voucher specimens of selected species were preserved in ten percent formalin solution. A tag was attached to each with the data and location where the specimen was found. Records were kept on all sampling results and miscellaneous observations. Photographic records were made of species too large to be prepared as voucher specimens.

### B.2.2. Amphibians and Reptiles

General searches were conducted in all major habitat types throughout the project area. Diurnal searches were made in rocky areas near buildings and in wooded areas to locate duirnal snakes and lizards. Limited night surveys around buildings and baobabs were also made to locate nocturnal species such as geckos.

Double-ended funnel traps for aquatic turtles were employed at the commencement of the project, but were later set aside. It was found to be more efficient to enlist the assistance of villagers in securing representative specimens. Arrangements were made with villagers in Diama (vicinity of Diama dam site) and Soukoutali (in the area to be inundated above the Manantali dam) to collect local species. Although the results were limited, useful data was obtained.

The use of a boat was not feasible for investigating crocodile distributions. Contacts with villagers along the river and near Lac de Guiers, and from personnel of the Service des Eaux et Forêts in Senegal and Mali indicated that crocodiles no longer exist in much of the basin. One night lighting survey was conducted along the Taoué *marigot* and adjacent portions of Lac de Guiers during the November 1977 field trip.

# CHAPTER C

# INVENTORY

## C.1. Mammals

As a group, mammals play an important role in the structure and function of ecosystems within the project region. Much of the energy flow through these ecosystems involves mammals at different trophic levels. Species such as ungulates and rodents are herbivorous and feed on vegetation (e.g. grass, grain, fruit, etc.). Bats are common and are primarily insectivorous, but some species are frugivorous. There is also an abundance of carnivorous species throughout the region (e.g. common jackal, serval, lion, etc.).

Some species (e.g. Senegal River manatee) are now considered endangered in the region, primarily because of increased pressures and habitat disturbance resulting from the presence of man. Other species are not endangered, but are important to man as crop and livestock pests. The subsequent sections describe the present status of mammals in the project area. The discussions of mammals will not cover domesticated species which are considered elsewhere in this report.

### C.1.1. General Distribution

The distribution and abundance of mammals in the Sénégal River basin have undergone substantial changes in the past few decades. A list of larger mammals and representative small mammals with their present probable distribution is presented in Table C.1-1.

Recent data exists for small species (e.g. rodents and bats) in the lower and middle valleys. In the upper valley information is spotty and descriptions in the literature are correspondingly vague. Because of the sparse populations and patchy distribution of many larger species (e.g. red-fronted gazelle, bushbuck), most information on them was obtained from the literature, supplemented with interviews and direct field observations.

Many species inhabit a variety of habitats and are found throughout the project area. Several species, however, have more specific habitat requirements and are restricted to particular portions of the river basin. The present distribution of mammals in the three subdivisions of the project area are presented in Table C.1-1.

Species which occur throughout Sénégal in the Sahelian and Sudanian vegetation zones (Laboratoire de Zoologie Appliquée, Centre ORSTOM de Dakar, 1974) and inhabit similar habitat throughout the project region include:

Rodents:

*Heliosciurus gambianus* (Gambian sun squirrel)
*Euxerus erythropus* (striped ground squirrel)
*Arvicanthus niloticus*
*Mastomys erythroleucus*
*Hystrix cristata* (crested porcupine)

Carnivores:

*Ictonyx striatus* (zorilla)
*Mellivora capensis* (ratel)
*Viverra civetta* (African civette)
*Ichneumia albacauda* (white-tailed mongoose)
*Felis lybica* (African wildcat)
*Felis serval* (serval)

Primates:

*Erythrocebus patas* (patas monkey)

A few of the species listed in the ORSTOM study are not common along the Sénégal River and have not been included in the foregoing list.

TABLE C.1-1

Mammal Species Which Occur in the Senégal River Basin

| Common Name[2] | Scientific Name[2] | Lower Valley[3] | Middle Valley[3] | Upper Valley[3] |
|---|---|---|---|---|
| Order: INSECTIVORA | | | | |
| * | | | | |
| *White-bellied Hedgehog | Atelerix albiventris | X | X | X |
| *Shrews | Crocidura spp. | X | X | X |
| Order: CHIROPTERA | | | | |
| *Straw-colored Fruit Bat | Eidolon helvum | X | X | ? |
| *Gambian Epaulet Bat | Epamophorus gambianus | X | X | |
| *Egyptian Tom Bat | Taphozous perforatus | X | X | ? |
| *Common African Leaf-nosed Bat | Hipposideros cafer | X | X | |
| *Slit-faced Bats | Nycteris spp. | X | X | ? |
| *Abyssian Horseshoe Bat | Rhinolophus fumigatus | X | X | |
| *Gambian Free-tailed Bat | Tadarida gambiana | X | X | X |
| *Schreber's Brown Bat | Scotophilus nigrita | X | X | |
| *Ruppells Pipistrelle | Pipistrellus rueppelli | X | X | ? |
| Order: LAGAOMORPHA | | | | |
| *African Hare | Lepus capenis | X | X | X |
| Order: RODENTIA | | | | |
| Gambian Sun Squirrel | Helioscirus gambianus | X | X | X |
| *Striped Ground Squirrel | Euxerus erythropus | X | X | X |
| *Giant Rat | Cricetomys gambianus | X | X | |
| Cane Rat | Thryonomys swinderianus | | | X |

TABLE C.1-1 (cont)

| Common Name[2] | Scientific Name[2] | Lower Valley[3] | Middle Valley[3] | Upper Valley[3] |
|---|---|---|---|---|
| * | Felovia vae | X | X | X |
| *Crested Porcupine | Hystrix cristata | X | X | X |
| * | Graphiuris huetti | X | | |
| * | Rattus rattus | X | | |
| * | Arvicanthis niloticus | X | X | X |
| * | Mastomys spp. | X | X | X |
| * | Mus spp. | X | X | X |
| * | Acomys spp. | X | X | |
| * | Tetera spp. | X | X | |
| * | Taterillus spp. | X | X | |
| | Desmodilliscus spp. | X | X | |
| Order: PHOLIDOTA | | | | |
| +Giant Pangolin | Manis gigantea | | | X |
| Order: PRIMATES | | | | |
| *Lesser Galago | Galagoosenegalensis | X | X | X |
| *Western Baboon | Papio papio | | | X |
| *Patas Monkey | Erythrocebus patas | X | X | X |
| *Vervet Monkey | Cercopithecus aethiops | X | X | X |
| +Chimpanzee | Pan troglodytes | | | X |
| Order: CARNIVORA | | | | |
| *Common Jackal | Canis aureus | X | X | X |
| *Pallid Fox | Vulpes pallide | X | X | X |
| +Wild Dog | Lycaon pictus | | | X |
| *Zorilla | Ictonyx striatus | X | X | X |

TABLE C.1-1 (cont)

| Common Name[2] | Scientific Name[2] | Lower Valley[3] | Middle Valley[3] | Upper Valley[3] |
|---|---|---|---|---|
| *Ratel | Mellivora capensis | X | X | X |
| *Cape Clawless Otter | Aonyx capensis | X | X | X |
| *African Civet | Viverra civetta | X | X | X |
| *Common Genet | Genetta genetta | X | X | X |
| *White tailed Mongoose | Ichneumia albicauda | X | X | X |
| Marsh Mongoose | Atilax paludinosus | X | X | X |
| +Egyptian Mongoose | Herpestes icheumon | X | X | X |
| *Slender Mongoose | Herpestes sanguinineus | X | X | X |
| Banded Mongoose | Mungo mungo | X | X | X |
| +Spotted Hyaena | Crocuta crocuta | | | X |
| Striped Hyaena | Hyaeba hyaena | X | | X |
| *African wildcat | Felis libyca | X | X | X |
| *Serval | Felis serval | X | X | X |
| *Caracal | Felis caracal | X | X | X |
| *Lion | Panthera leo | | | X |
| Leopard | Panthera pardus | | | X |
| Order: SIRENIA | | | | |
| *African Manatee | Trichechus senegalensis | X | X | |
| Order: TUBULIDENTATA | | | | |
| *Aardvark | Orycteropus afer | | X | X |
| Order: HYRACOIDEA | | | | |
| Rock Dassie | Procavia capensis | | | X |

TABLE C.1-1 (cont)

| Common Name[2] | Scientific Name[2] | Lower Valley[3] | Middle Valley[3] | Upper Valley[3] |
|---|---|---|---|---|
| Order: PROBOSCIDEA | | | | |
| +African Elephant | Loxondona africana | | X | X |
| Order: ARTIODACTYLA | | | | |
| *Hyppopotamus | Hippopotamus amphibius | | | X |
| *Warthog | Phacocheerus aethiopicus | X | X | X |
| *Bushbuck | Tragelaphus scriptus | X | X | X |
| +Roan antilope | Hippotragus equinus | | | X |
| +Topi | Damaliscus korrigum | | | X |
| *Defassa Waterbuck | Kobus defassa | | | X |
| +Kob | Kobus kob | | | X |
| *Bohor Reedbuck | Redunca redunca | X | | X |
| *Dorcas Gazelle | Gazella dorcas | X | X | |
| Dama Gazelle | Gazella dama | X | X | X |
| *Red-fronted Gazelle | Gazella rufifrons | X | X | X |
| Red-flanked Duiker | Cephalus rufilatus | | | X |
| Grimm's Duiker | Sylvicapra grimma | | | X |
| *Oribi | Ourebia ourebi | | | X |

[1]Species distributions compiled from Bouliere, Morel, and Galat (1976) Dekeyser (1955); Happold (1973); Dorst and Dandelot (1969); and the Ministère du Developpement Rural et de l'Hydraulique (1976).

[2]Nomenclature follows Meester and Setzer (1971).

[3]A description of each portion of the Sénégal River Basin is provided in the Rivers and Estuary Report.

*Species documented as present in recent times within the basin, based on museum records (ORSTOM), Dakar; IFAN Dakar; U.S. National Museum, U.S.A.), direct observation or sign during field studies, or recently published reports.

+Presence based on verbal information provided by reliable sources (e.g., regional personnel of the Service des Eaux et Forêts).

The order INSECTIVORA is distributed throughout the basin. The white-bellied hedgehog (Atelerix albiventris) and shrews (genus Crocidura) inhabit the Sahelian and Sudanian vegetation types. Although they are ubiquitous in the region, their functional role in area ecosystems is apparently minor.

The order CHIROPTERA is diverse and widely distributed throughout the project area (Adam and Hubert, 1976; Adam and Hubert, 1972; Rosevear, 1965). Fruit bats (e.g. Epomophorus and Eidolon) are common in the Sahelian and Sudanian zones (Dekeyser, 1955). Insectivorous species (e.g. Tadarida and Pipistrellus) are numerous and are relatively important insect predators in ecosystems of the region.

The order LAGOMORPHA is represented in the region by the African hare, Lepus capensis. The species is locally common and occurs in most habitats within the project area. The taxonomy of this species in the Sénégal River Basin is under revision.

The order RODENTIA contains many species of ecological and economic importance in the region (Hubert et al, 1973; Rosevear, 1969). The striped ground squirrel (Euxerus erythropus) is abundant throughout the basin as are cricetid and murid rodents (typical rats and mice). They are ecologically important as primary consumers of vegetation (e.g. seeds and grass) and because they are preyed upon by secondary consumers (e.g. raptorial birds, jackels, snakes, etc.). A large number of carnivorous species depend on rodents as a primary food source. Many rodent species affect the health and welfare of the human population in the basin by competing with man for grain crops, serving as disease vectors for human and domestic animal diseases (see Public Health). Important genera found throughout the basin include Arvicanthis, Mastomys, and Mus.

The order PHOLIDOTA has one species, the giant pangolin, (Manus gigantea) inhabiting the project area. It has been reported from the upper valley, but is probably rare in the area. The species is discussed further in Section C.1.2. Important Species.

The order PRIMATES is represented by five species which inhabit the study area. The lesser galago (Galago senegalensis) occurs where trees are present along the river and in savannas throughout the upper, middle and lower valleys. Galagos are nocturnal, arboreal and insectivorous, and are not a conspicuous part of regional ecosystems.

The Western baboon (Papio papio) is limited to the upper valley, particularly in savanna areas where rocky outcrops are present. Baboons are crop pests in the project area from Kayes to the upper Bafing. A more detailed discussion of their life history and importance is provided in Section C.1.2.

The patas monkey (Erythrocebus patas) is duirnal and more terrestrial. They are the fastest of all primates, running at speeds in excess of 50 kilometers per hour (Dorst and Dandelot, 1969). The species is common in all parts of the study area. Patas monkeys feed on grass, fruit, and seeds and are considered crop pests in some portions of the basin.

The vervet monkey (Ceropithecus aethiops) is widely distributed and common throughout the project area. In the upper valley, the species inhabits the Sudanian woodland and narrow band of forest along the Bafing and upper Senegal Rivers. In the lower and middle valleys it is apparently confined to gallery forests close to the Senegal River and associated marigots. They are mainly vegetarians, but also eat some insects. They also are considered crop pests in some portions of the basin. The species is preyed upon by the leopards, serval, caracal and large raptorial birds; thus they play an intermediate role in energy flow through natural ecosystems of the region.

The chimpanzee (Pan troglodytes) has been reported as an occasional visitor to the upper Bafing in the area to be inundated by the Manantali dam (personal communication with villagers at Soukoutali). The occurrence of this species is probably rare and not likely to be affected by the proposed project.

The order CARNIVORA contains species which are both of ecological and economic importance. Several genera of mongoose (Mungo, Herpestes, Ichneumia), the African civet (Viverra civetta), common jackal (Canis aureus), ratel and caracal (Felis caracal) are common species distributed in major habitat types of the region. They function in regional ecosystems as secondary consumers, eating rodents, reptiles, amphibians and some insects.

Most carnivores are nocturnal hunters while some species, notably the lion, are frequently active during the day. Most species are also solitary, but a few of the larger species (e.g. hyaenas, lions) are social and associate in family groups (prides), pairs, or small packs (Wlaker, 1975). The leopard (Panthera pardus) is limited to remote areas of the upper valley, and is apparently not common even there (Mr. Songo, personal communication; interviews with villagers at Soukoutali). It is a potential livestock predator. A more detailed discussion of some carnivore species in given in Section C.1.2. Important Species.

The order SIRENIA is represented in the project area by the Senegal River manatee (Trichechus senegalensis). The species is in a state of decline within the basin and is apparently confined to the lower and middle valleys. A more detailed discussion of the species is presented in Section C.1.2. Important Species.

The order TUBULIDENTATA contains a single species, the aardvark (Orycteropus afer). The species feeds almost entirely on termites and ants which they obtain by tearing apart termite mounds and exposing ant nests with their powerful claws and lapping up the insects with a protractile tongue. It is not found in the lower valley, and is apparently uncommon in the middle and upper valley. No individuals were located during field studies, and interviews with regional personnel of Eaux et Forêts in Senegal and Mali indicated that they were present, but not common.

The order HYRACOIDEA has one species, the rock dassie (Procavia capensis) which probably occurs in the upper valley. None were seen during field surveys, but the published range includes the project area (upper valley) where suitable habitat (rocky areas in scrubby savannas) is present (Dorst and Dandelot, 1969).

The order PROBOSCIDIA is also represented in the region by a single species, the African elephant (Loxodonta africana). A small herd reportedly occurs along the river in Senegal and Mauritania in the area east of Matam (Mr. Faye, personal communication).

The order ARTIODACTYLA is comprised of the even-toed ungulates and includes several species considered ecologically and/or economically important. Members of this order are herbivores, and as such are primary consumers. They also play a functional role in area ecosystems by serving as prey for larger carnivores.

The order is represented in project area by the hippoptomus (Hippoptamus amphibius), warthog (Phacochoerus aethiopicus), and several species of antlopes, gazelles, and duikers.

Nearly twice as many species are likely to inhabit the upper valley than in the lower and middle valleys (Table C.1-1). There are two basic reasons for this difference: 1) suitable habitat for more species (wooded Sudan savanna and riparian forest) is present and, 2) habitats in the lower and middle valleys are highly disturbed by the presence of man and his domesticated animals.

Confirmation of the presence of some species was made during contacts with local villagers in the vicinity of Manantali and by observing the hides of animals recently killed in the area. A more detailed discussion of important species in this order is presented in the following section.

C.1.2. Important Species

For purposes of assessing environmental impacts resulting from development and operation of the proposed project, a species is considered important if it is:

- Designated as threatened or endangered.
- Economically important in the project area (e.g. game species, crop pest).
- A major component of ecosystems in the region.

The consideration of a species as threatened or endangered is based on designations of the governments of countries involved and of international organizations. The category of threatened and endangered includes those species which are completely protected in countries within the project area. Economically important species are identified by consulting the regulations for hunting and by interviews with personnel of Eaux et Forêts of each country in the project area. Determination of a species as important as a major component of ecosystems in the region is based on analysis of all available data, and is somewhat arbitrary. Mammal species determined as important are listed in Table C.1-2 and discussed in the subsections which follow.

Rodents are important throughout the project area as disease agents (human and domesticated animals), as crop pests, and as primary consumers in natural ecosystems.

Small Mammals are listed as small game species in Senegal. Crawshay's hare and the striped ground squirrel are the most abundant and widely distributed species, occurring in savanna habitats throughout the project area. No quantitative data are available, but recent literature, museum records, interviews, and direct observation verify this conclusion.

The Giant Pangolin reaches a total length up to 150cm, and is the only species of scaly anteater in the project area. It is slow moving, nocturnal, and entirely terrestrial. The species lives in rocky areas in savanna habitat and feeds on ants and termites. It obtains the latter by digging into mounds and lapping up the termites with its long tongue.

Pangolins are probably rare throughout their range (Walker, 1975), and are completely protected in Senegal and Mali (République du Sénégal, 1973; Ministère de la Production République du Mali, 1963). The species has been reported as occurring in the Ferlo south of the Senegal River along the Bafing River in the vicinity of Manantali.

The Lesser Galago attains a body length of 20cm, and is the only galago inhabiting the project area. It has very large ears, a long thin tail, and a soft woolly coat of gray fur. Galagos (bush-babies) are nocturnal, arboreal, and very active. In spite of its small size, the

lesser galago can jump distances up to three meters (Dorst and Dandelot, 1969). The species is primarily insectivorous, but consumes fruit, leaves, and tree gum.

TABLE C.1-2

Important Mammal Species Which Inhabit the Project Area

| COMMON NAME[1] | IMPORTANCE DESIGNATION |
|---|---|
| Rodents[2] | crop pest, disease agents (human and domestic animals), ecologically important |
| Small Mammals (mouse, squirrel, etc.) | small game species (Sénégal) |
| Giant Pangolin | protected (Mali, Sénégal, Mauritania) |
| Lesser Galago | protected (Sénégal, Mauritania) |
| Western Baboon | crop pest, ecologically important |
| Chimpanzee | protected (Mali, Sénégal) |
| Common Jackal | ecologically important |
| Small Carnivores (Serval, caracal, African Wildcat, Civette, Genet, Zorilla, Otter) | game species (Sénégal), ecologically important |
| Lion[3] | livestock pest, game species (Mali, Sénégal) |
| Leopard | protected (Sénégal), game species (Mali) |
| Senegal River Manatee | protected (Mali, Sénégal), Endangered (IUCN, U.S.) |
| Aardvark | protected (Mali, Sénégal, Mauritania) |
| African Elephant | protected (Mali, Sénégal, Mauritania) |
| Hippopotamus[4] | game species (Mali, Sénégal) |
| Warthog | crop pest, game species (Mali, Senegal) |
| Bushbuck | game species (Mali, Sénégal) |
| Roan Antelope | game species (Mali, Sénégal) |
| Defassa Waterbuck | game species (Mali, Sénégal) |
| Kob | game species (Mali, Sénégal) |

TABLE C.1-2 (cont)

| COMMON NAME | IMPORTANCE DESIGNATION |
|---|---|
| Bohor Reedbuck | game species (Mali, Sénégal) |
| Topi | game species (Mali) |
| Dorcas Gazelle | game species (Mali) |
| Dama Gazelle | protected (Mali, Sénégal, Mauritania) |
| Red-fronted Gazelle | game species (Mali, Sénégal) |
| Red-flanked Duiker | protected (Mali), game species (Sénégal) |
| Grimms Duiker | game species (Sénégal) |
| Oribi | game species (Mali, Sénégal) |

[1]See Table C.1-1 for scientific names and distributions.

[2]Rodents are discussed in detail in Public Health Report.

[3]Hunting permits in Sénégal must be authorized by the President of the Republic.

[4]Hunting permits in Mali must be authorized by the chief of the Forest Service. Hunting permits in Sénégal must be authorized by the President of the Republic.

The lesser galago has been collected in the middle valley near Kaskas (USNM specimen 378069), and occurs in wooded areas throughout the upper valley. It is considered uncommon in Sénégal where it is fully protected.

The Western Baboon is a relatively small species (body length of 75 centimeters) olive-rufous in color. The species is diurnal, social and omnivorous.

Distribution in the project area is limited to the upper valley. The species is common throughout this area and is considered as a crop pest, raiding and damaging village gardens. Several bands of 6 to 100+ individuals were seen within the basin from Manantali to the vicinity of Bakel during project field surveys.

The Chimpanzee is terrestrial and arboreal, diurnal, and primarily vegetarian. Some insects and eggs are also included in their diet. The species is probably only an occasional visitor to the project area. Villagers at Soukoutali, within the area to be inundated, report rare sightings in the area up river (south). Marginal habitat is present in the upper portion of the upper valley of the Bafing River. The species is protected in Sénégal and Mali (Table C.1-2).

The Common Jackal attains a height of 50 centimeters at the shoulder. The species is usually nocturnal, feeding on small mammals, insects, and some vegetation. It is also ecologically important as a scavenger on garbage and animal carcasses.

The common jackal occurs throughout the project area from Saint-Louis to the upper Bafing River south of Manantali. Published reports (Happold, 1973), interview with regional experts, and observations made during field studies all indicate that it is common throughout the region.

Several species of Small Carnivores which are considered game species in Sénégal are also ecologically important as predators of rodents, birds, and other small animals. By preying on rodents, they help regulate population of these species. Small carnivores listed as game animals in Senegal are: serval, caracal, African wildcat, civet, genet, zorilla and otter.

All species are generally distributed in all major habitats within the project area, with the exception of the otter. Little is known about their abundance because of their nocturnal secretive habits, but none of the species are considered rare in the area.

The Lion is probably the best known predator in Africa. Until the past few decades, it ranged throughout the project area. Because it was (and is) a predator on livestock, it has been extirpated by man in the lower and middle valleys where livestock production is concentrated. Lions still

occur in the upper basin from Bakel throughout the Senegal and Bafing portions of the project area. Recent accounts provided by Service des Eaux et Forets of Senegal and Mali indicate that it still preys on livestock throughout the upper valley.

Lions hunt by sight and sound, relying little on smell. They usually live and hunt in prides. The average number of kills per individual is sometimes as low as 20 per year (Dorst and Dandelot, 1969).

In West Africa, the Sahel and Sudan savannas are preferred lion habitat (Rosevear, 1974). Lions usually drink large quantities of water after feeding, and require open water for drinking throughout the year. The river and adjacent savanna provide these conditions.

No specific data is available on population levels in the region but the species doesn't seem to be declining precipitously at present. The lion is designated as a game species in Senegal and Mali. In Senegal, permits to hunt lions must be authorized by the President of the Republic.

The Leopard occurs in the upper portion of the upper valley. Like the lion, it is a large cat whose appearance is well known and unmistakable. Leopards are solitary and hunt at night. They prey on a variety of large native mammals including warthogs, gazelles, monkeys and baboons. Leopards are also known to take domesticated species such as poultry, cattle, goats and sheep.

The species has been reported in the study area. Because of the apparent low population density it is not considered a livestock pest, and is probably not a significant factor in ecosystems within the region.

In much of Africa, populations of small and medium-sized wild herbivores continue to decline. The adaptability of the leopard to other food sources allows it to survive in a variety of habitats, some of which are not readily accessible to human disturbances. The increased development and progressive decline in game is likely to lead to a reduced population density, rather than eradication of the species (Myers, 1976).

The Senegal River Manatee is of special interest because of its status as an endangered and protected species (U.S. Department of the Interior, 1976; République du Sénégal, 1973; Ministère de la Production, République du Mali, 1963; IUCN, 1976) and because of the potential direct impact of the proposed project on the species. The species is distributed in freshwater lakes and rivers, and in coastal lagoons of West Africa from the Senegal River in the north (16° N latitude) south to the Quanaga River in Angola (10° S latitude) (Best, 1971). It also occurs in the Lake Chad drainage (Walker, 1975).

Like all manatees, the species is air-breathing, but entirely aquatic. They have a rounded body, small head, and small eyes. They may attain a length of over three meters and a weight in excess of 360 kilograms. One young is born at a time and receives maternal care for over a year. They are diurnally active, but feed mostly at night. Little specific life history information is known, although it is presumed to be similar to the American manatee.

Like all manatee, this species is completely herbivorous, (Bertram, 1974). Aquatic species such as Polygonum sp. and Vossia sp. (both of which occur in the project area) are eaten (Husar, 1978). It has been estimated that a free-ranging adult may consume about 8,000 kilograms per year (Husar, 1978). The species has been considered for control of aquatic weeds in other parts of Africa.

Manatees are seriously threatened throughout their range (Dorst and Dandelot, 1969). In many areas they are slaughtered for their highly prized meat, even though they are protected by law. Interviews with personnel of Service Eaux et Forêts in Senegal and Mali indicate that although manatees are occasionally taken illegaly for food, other factors are contributing to their apparent decline in the Senegal River. Recent drought conditions have lowered water levels and dried up marigots and ponds which are normally filled by annual flooding of the river. Reduction in flood levels has caused some of these to dry up, trapping some manatees which perish. Two such cases have been reported for the area between Matam and Bakel, but documentation could not be obtained. It has also been reported that manatees become ensnared in fishermens gill nets and drown. Cadenat (1957) reports similar problems with shark nets placed in coastal waters. It is illegal to place a gill net across the river which would impede manatee movements and increase ensnarlment, but illegal nets have been observed in the channel near Richard Toll and elsewhere along the river during project field surveys.

The species inhabits the lower and middle valleys, but no reliable reports were obtained of its presence upriver from Bakel. It is known that manatees move through the channelized Taoué marigot between the river and Lac de Guiers when the river is high and the gates at Richard Toll are open. The manatees have been observed moving out of Lac de Guiers into the river against the current in July. They probably return to the lake in November before the gates are closed (Bourlière et al, 1976). One manatee was observed in the Garak marigot northeast of Rosso, Mauritania in 1977.

Estimates of the present population vary between 50 and 300 individuals, but there is no hard data. The species is apparently reproducing in Lac de Guiers (Bourliere et al, 1976), but there are no indications as to its success elsewhere in the river. Based on these fragmentary data, a knowledge of the life history of the American mana-

tee (Hartman, 1971), and the fact that the Senegal River manatee occurs in the Lake Chad basin, it seems evident that manatees do not need to visit brackish or ocean waters in order to complete their life cycle.

The Aardvark is the single representative of the order Tubulidentata and is endemic to Africa. It reaches a height of 60 centimeters at the shoulder and may weigh nearly 70 kilograms. It is generally pig-shaped with an arched back, tube-shaped snout, and long pointed ears. Aardvarks are active burrowers and build large tunnel systems, sometimes covering an area of 500 meters (Dorst and Dandelot, 1969).

The species is listed as a game animal in Mali and Senegal. Hunting permits in Mali must be authorized by the Chief of the Forest Service, and in Senegal by the President of the Republic.

The Warthog is a common and conspicuous inhabitant of Sahel and Sudan savannas throughout the project area. Particularly dense concentrations are present in the delta region of the lower valley.

Warthogs reach a height of 75 centimeters at the shoulder and may weigh over 100 kilograms. The species is pig-like with unusual tusks which turn upward, outward, and then inward. It is gregarious in family groups. It is a grazer, feeding on grass and other herbaceaus vegetation. Because of its abundance in the region it is also a crop pest, destroying grain crops and village gardens. According to the interviews obtained with regional Eaux et Forêts personnel in Senegal and Mali, damage is greatest in the upper valley.

The species is designated a game species in Senegal and Mali and is hunted for sport, particularly in the Senegal delta. Although the flesh is edible, the species is not heavily hunted by villagers in the river basin who are predominantly Moslem and do not eat pig. This restriction probably accounts for the abundance of warthogs in the project area.

The Bushbuck is a medium-sized antelope (85 centimeters at the shoulder) sparsely distributed throughout the project area. It is game species in Senegal and Mali; is nocturnal, somewhat solitary, and a browser. The species prefers dense brushy areas close to water. Bushbucks were reported and one hide seen from the area to be inundated by the proposed Manantali dam at Soukoutali.

The Roan Antelope is a larger antelope (150 centimeters at shoulder) which is designated a game species in Mali and Senegal. It is mainly a grazer and prefers open or sparsely wooded savanna near water. The species does not occur in the lower valley portion of the project area but is present in the Ferlo south of the middle valley portion. Little

is known about its abundance, but the species probably is not common.

The Defassa Waterbuck (shoulder height 130 centimeters) is a game species in Mali and Senegal. The species prefers wooded areas with adjacent water and savanna habitat, and may even inhabit areas with rocky hills. It is a grazer, which lives in small herds (5 to 25), and drinks freely (Dorst and Dandelot, 1969). Presence in the Manantali area has been documented by observing hides and talking with local villagers. The species is probably not uncommon in the upper portion of the upper valley.

The Kob is considered one of the commonest African antelopes (Dorst and Dandelot, 1969). The species is medium-sized, a grazer and usually associates in herds. None were observed during field studies, and little is known about their abundance in the area. It is a game species in Mali and Senegal.

The Bohor Reedbuck is a medium-sized antelope inhabiting grasslands near water. The species is a grazer, nocturnal, and generally secretive. It is a game species in Mali and Senegal. No data is available on its abundance in the project area.

The Topi is a larger species inhabiting dry grassland savanna. It has been reported from the upper valley, but specific data was not obtained on its abundance in the project area.

The Dorcas Gazelle is adapted for desert conditions and inhabits semi-desert areas mostly north of the Senegal River in the lower and middle valleys. It is a game species in Mali. The species was introduced from Mauritania into the Djoudj National Bird Park in 1974 (Bourliere et al, 1976). Thirty to forty individuals are now present there, and are reproducing successfully (Dupuy, personnal communication).

The Dama Gazelle is protected in Mali and Senegal. Within the project area, it is limited to the sahelian savanna. It is apparently rare in the area.

The Red-fronted Gazelle is a medium sized gazelle (height 70 centimeters at shoulder) which occurs throughout the project area. The species inhabits the Sahel and bordering areas of the Sudan savanna. It is a game species in both Senegal and Mali. Reliable reports of species occurrence were obtained for the lower, middle, and upper valleys at some distance from the river. No specific data on abundance is available, but the species is apparently not common in much of the project area. Seventeen individuals have been introduced at Djoudj National Park and are reproducing successfully (Dupuy, personal communication).

The Red-flanked Duiker is the single species of forest duiker (genus Cephalophus) found in the project area. They typically have a hunched back and glossy coat, and are confined to areas of dense bush such as occurs along the Bafing River. Its abundance in the area is not known. The species is designated as game in Senegal, but is completely protected in Mali.

Grimm's Duiker is a bush duiker (genus Sylvicapra), and is distinguished from the forest duikers by having a straight back and grizzled coat. It is listed as a game species in Senegal, but its abundance in the project area is not known.

The Oribi is a small antelope (height at shoulder 60 centimeters) which inhabits grassy savanna habitat in the vicinity of water. It is a grazer. This species was observed in the vicinity of Manantali during field surveys. Its abundance in the project area is not known, but it is not presumed to be common.

## C.2. Amphibians and Reptiles: General Description

The classes Reptilia and Amphibia are traditionally considered together, although their basic life histories and functional role in regional ecosystems are very different. Amphibia are represented in the project area by species in the order ANURA (frogs and toads) which are restricted to aquatic habitats and terrestrial habitats in the vicinity of water. Reptiles are more diverse in the area and are represented by species in the orders LORICATA (crocodiles), CHELONIA (turtles), and SQUAMATA (lizards and snakes). Reptiles occur in all habitats in the project area.

The distribution and abundance of amphibians and reptiles in the region have not received much attention in recent times. General distributions and habitat affinities of some species are known (Villiers, 1950; Villiers, 1958; Loveridge, 1941), but there are many taxonomic problems among the species described (Böhme, personal communication), and little detailed information on even basic aspects of life history for many of the more secretive species.

Considered together, amphibians and reptiles are less important in the structure and function of regional ecosystems than are mammals or birds. Amphibians and reptiles are also of relatively little economic importance. Most species which occur in the region are widely distributed in similar habitat elsewhere in Africa. Although they are prey species for many carnivores, they seldom comprise an essential part of carnivore diets.

### C.2.1. Amphibians

The order ANURA includes all members of the class Amphibia which are known to inhabit the project area. Common species typically found throughout the basin include *Bufo pentoni*, *Bufo regularis* and *Dicroglossus occipitalis*.

The two toad species (genus *Bufo*) are adapted to prevent rapid water loss and are found in terrestrial habitats some distance from standing water. They are more active at night when water stress is less, and seek shelter in cool moist locations during the day. Toads are most active during the rainy season (July through September). With the onset of the dry season, many individuals aestivate in the immediate vicinity of the river, in dried pools. Toads were found at locations in the upper, middle and lower valleys during project field surveys.

The large ranid frog *Dicroglossus occipitalis* was encountered at several locations throughout the project area. Böhme (personal communication) considers it the commonest and most important frog in the region. Böhme also notes that the species tolerates brackish water. *Dicroglossus* is of some economic importance as food; the legs are eaten by local villagers in some parts of the region, and are sold in a few local restaurants.

All of the common anuran species reproduce by depositing eggs in slow moving water. Tadpoles emerge and function as herbivores (primary consumers) in the aquatic ecosystems. The tadpoles also serve as food for fish and other secondary consumers. As they undergo metamorphosis to the adult stage, anurans become insectivorous (secondary consumers). Thus, anurans at different stages in their life cycles perform different ecological functions in different habitats.

C.2.2. Reptiles

Three orders of reptile inhabit the Senegal River basin. The order CHELONIA contains several species of turtles which occur in the project area. Species in the group display various adaptations to available habitats from totally terrestrial species (e.g. Geochelone sulcata) to aquatic species (e.g. Trionyx triunguis).

The Emydid turtle, Clemmys caspica, is an aquatic form reported as occurring in the region (Villiers, 1958). No specimens were observed during project field studies and none were collected by Böhme (personal communication) in his surveys of the lower and middle valleys. It feeds on fish.

Two species in the family Tesudinidae (tortoises) inhabit the region; Geochelone sulcata and Kinixyz belliana. Both occur in terrestrial habitats, but have somewhat different distributions. G. sulcata occurs along the river in upper, middle and lower valleys in the Sahel and Sudan savannas in Mauritania, Mali and Senegal. The species is apparently rare near the river but more common further land, particularly in the Ferlo region and in Mauritania. This species is the largest tortoise in Africa and is herbivorous.

K. belliana is limited to the Sudan savanna and probably occurs in the upper valley. One unconfirmed report was obtained in the Manantali region. This species has the unusual feature of movable hinged posterior carapace (upper shell). It is also herbivorous.

The family Trionychidae is the most aquatic group of turtles occurring in the basin. They eat both vegetation and animal material. There is one specimen of Cyclanorbis senegalensis from Ogo (near Matam) in the collection of the United States National Museum. Little is known of their distribution in the region.

The family Pelomedusidae is represented in the project area by three species: Pelomedus subrufa, Pelusios subniger and Pelusios adansone. These species are carnivorous, but also consume fruit and vegetation. They are semi-aquatic and will come out of the water to bask. Ratels, jackals, eagles and man all prey upon them.

Pelomedus subrufa occurs throughout the project area. The species was observed at several locations in the basin including Lac de Guiers, the Senegal River at Richard Toll and Soukoutali (upriver from Manantali). It appears to be common, but not abundant over most of the area.

Pelusios subniger and P. adansoni have been collected by Böhme in the lower and middle valleys, but their distribution in the upper valley is not known. There are no present indications that they are rare in the area.

Turtles are completely protected as a group in Senegal, but there is no apparent enforcement. Turtles are frequently caught in gill nets and are retained as food items by the fishermen. Interviews with personnel of the Service des Eaux et Forêts and local villagers indicated that the practice is widespread.

Sea turtles may enter the estuary of the river, but are not regular residents of the project area and are not likely to be greatly affected by the project. They are of economic importance in Senegal as food and are sold in markets near the coast.

The order Squamata is diverse in the region. Many families of lizards and snakes are present, but only a few are abundant enough to merit discussion.

Geckos are common throughout the project area. They are most often found in and around village dwellings and in the large baobabs in the upper valley. They have also been observed in rocky areas in the upper portion of the upper valley. Geckos are nocturnal and insectivorous. Species known from the project area include Hemidactylus brookii, Tarentola ephippiata and Hemitheconyx caudicinctus. All species are well adapted for climbing on vertical surfaces.

The rainbow lizard (Agama agama) is the most conspicuous, if not the most common lizard in the project area. The species was observed at numerous locations in all subdivisions of the region. Böhme (personal communication) has also observed it to be very common and points out that in this region it is not restricted to dwellings. The species was frequently observed foraging in trees some distance from settlements. Mebuya perroteti is also common in the region, but is mainly a ground dweller. Both species are diurnal insectivores.

The largest lizard present in the region is the Nile monitor (Varanus niloticus). Large specimens reach a length of nearly two meters. It is found in or near water throughout the project area, and is particularly common in the lower and middle valleys. The species is largely carnivorous and catches fish. It is also known to eat carrion and some vegetation.

Nile monitors were observed in Lac de Guiers, at Diama, Richard Toll, Podor, Matam and at Manantali during field surveys. A closely related, but smaller species, V. exanthematicus, is common and ubiquitous in the lower and middle valley. It has been reported by Morel as an important bird predator, mainly on the golden sparrow Auripasser luteus (Böhme, personal communication).

Relatively few snake species have been reported from the project area, but certain common species have been identified. The colubrid snake Psammophis sibilans was

observed in all portions of the project area. More than one species is probably included in this "species", which is presently being taxonomically revised (Böhme, personal communication). A closely related species, Psammophis elegans was also observed in the three subdivisions of the project area. Both species are common, and both are opisthoglyphs (possessing venomous fangs on the posterior portion of the maxillary bone).

Another opisthoglyphous colubrid, Crotaphopeltis hotamboeis was observed in the upper valley. It is apparently distributed throughout the project area (Villiers, 1950).

Three members of the family Boidae are found in the project area. Python sebae is a large species (length up to eight meters) in the Sahel and Sudan savanna. One specimen was seen in the middle valley near the river during field surveys. Interviews with the Service des Eaux et Forêts personnel indicate that it occurs in the savanna zone south of the river. Python regius, also a large species, is limited to the Sudan savanna and probably occurs in the upper valley. Both species are hunted and killed for their hides which are made into leather goods or sold outright in markets in Senegal and Mali. Reports obtained during surveys indicate that both species are becoming uncommon in the area as a result of this constant hunting pressure.

One small species, Eryx muelleri, inhabits the study area. A single specimen was collected near the village of Nieti Yone, northwest of Lac de Guiers in an area of sandy soil. The species is fossorial and inhabits similar areas in the Sahel and Sudan savannas (Villiers, 1975) and probably is distributed throughout the project area.

Three species in the family Elapidae have distributions which include the project area (Villiers, 1975). Only the spitting cobra (Naja nigricollis) appears to be common. Interviews in all parts of the project indicate its presence. The species is dangerous to man; the bite is fatal and the venom can be spit into the eyes where it causes extreme irritation and blindness. The venom can enter the body through the moist membranes of the eyes and cause additional harm (Cansdale, 1961; United States Department of Navy, 1962). Recent encounters have been reported from Richard Toll.

Several species in the family Viperidae inhabit the project region. Two are relatively common and deserve mention. The puff adder (Bitis arietans) occurs commonly in the lower, middle and upper valleys. The species was reported from Richard Toll, Matam, Bakel and Kayes. Two individuals were observed near Matam during field surveys. This thick-bodied snake has very large fangs (up to three centimeters in length) and its venom is highly toxic. The species is slow moving and predominantly nocturnal (Cansdale, 1961). The saw-scaled viper (Echis carinatus)

also inhabits much of the project area, but is probably more common in the Sahel in Senegal and southern Mauritania.

The order LORICATA contains one species, the Nile crocodile (Crocodylus niloticus) found in the project area. The species is considered important because of the rapid decline in population levels and decreasing distribution throughout most of its former range. The Nile crocodile will be discussed in detail in the following section.

C.2.3. Important Species.

Although certain anurans (e.g. Dicroglossus occipitalis) and several turtle species are used for food, they are of little economic importance. The single important species within the project area is the Nile crocodile. Two other crocodilians, the narrow-nosed crocodile (Crocodylus cataphractus) and the dwarf crocodile (Osteolaemus tetraspis) could potentially occur in the upper Bafing River (Cissé, personal communication). Field studies and interviews indicated that neither species is likely to be present in the project area.

The Nile crocodile is probably the best known reptile in Africa. It is distributed throughout sub-Saharan Africa and along the Nile River. It has a widespread and well documented reputation as a man-eater (Guggisberg, 1972). The species was formerly abundant throughout much of its range, but most populations have either been exterminated or are in precipitous decline. Two principal factors, both related to the presence of man, are responsible:

1) Destruction of natural habitat,

2) The slaughter of individuals for hides (Cott, 1961).

Recent drought conditions have decreased the area of surface waters, drying ponds and shrinking the size of other waterways in the project area. This has further reduced available habitat and forced crocodiles in to more open waterways where they are more exposed to hunting. Although the species is protected in Senegal and Mali, and hunting in Mali is legally restricted, paoching is known to occur.

There is little direct evidence and much conflicting information on the distribution of crocodiles in the project area. Cott and Pooley (1972) report that the Nile crocodile is still generally distributed along the Senegal and Falémé Rivers. The concensus of opinion and available data obtained during this study indicate that the Nile crocodile is present in the Djoudj National Bird Park, in the Taoué marigot and irrigation canals of the sugar cane fields at Richard Toll and in Lac de Guiers. There are unconfirmed reports of crocodiles in marigots and small lakes along the Senegal River between Matam and Bakel, and in the Doué marigot of the lower and middle valleys. There are also scattered reports for the Senegal River near Kayes, and on the lower Bafing River. Field surveys and interviews with villagers indicate that crocodiles are scarce or absent from the Bafing River in the vicinity of Manantali. Nine crocodiles are present in Djoudj National Bird Park; the largest is about three meters in length (Dupuy, personal communication). It is hoped that these individuals will reproduce and become successfully established in the park.

The skulls of three recently killed crocodiles (C. niloticus) between one and two meters in length were seen and photographed in villages near the northern shore of Lac de Guiers. Villagers in the area report that most of those in the region are small, but one specimen over four meters in length was seen during project field surveys.

Because of its sparse populations, the Nile crocodile is not now important in ecosystems of the region. Studies conducted elsewhere in Africa have detailed the functional role of this species in relationship to other species present in the basin. The species is largely aquatic, inhabiting slow moving portions of rivers, marigots, lakes and temporary pools. In the dry season, crocodiles will move from marginal locations to larger bodies of water.

The species is primarily carnivorous, but is also an important scavenger in inland waters. Cott (1961) in a study on Nile crocodiles in central Africa, found that insects, fish and mammals are major components in the diet. In small specimens, insects predominate. As they reach intermediate size (1.5 - 2.5 meters) insects decline in importance and fish become the major food items. A few mammals are also taken. In specimens exceeding three meters, mammals are important, fish are less important and insects minor. Thus, the role in regional ecosystems changes with the size classes of crocodiles present.

The Nile crocodile is at the top of the food chain, and has no natural enemies other than man. The species includes several reptiles in its diet. Among these are turtles (genus Pelusios ) and the Nile monitor (Varanus niloticus). Several fish found in the Senegal River are likewise included in the crocodiles' diet. Clarius, Alestes, Labeo and Syndontis were found in crocodiles in Uganda below Murchison Falls (Cott, 1961). Bushbuck were also found in larger adults.

Reproduction and parental care in the Nile crocodile has been examined by Cott (1971) and Villiers (1958). The eggs are deposited on land, buried in the sand near water and are guarded by the female prior to hatching. It has been reported that the female helps unearth the young as they hatch, but Neill (1971) states that no one has actually observed this behavior. The female usually stays with the young for several weeks after hatching.

The eggs may be preyed upon by a number of predators found in the study area. Among those identified are: baboon, Nile monitor, palm nut vulture, ratel, white-tailed mongoose, spotted hyaena, serval and gray heron (Cott, 1971). Young crocodiles also have many predators: West African river eagle, black bite, ground hornbill, pied crow, civet, Egyptian mongoose and even catfish of the genus Clarius (Cott, 1971; Neill, 1971).

An interesting symbiotic relationship exists between this species and the crocodile bird (Pluvianus aegyptius). The bird walks about on basking crocodiles and obtains food by removing external parasites and by entering the open mouths of crocodiles to remove debris between their teeth.

From the aforementioned predator-prey interrelationships it can be seen that crocodiles have a direct relationship with other vertebrates, and play a pivotal role within ecosystems in which they are common.

In addition to sufficient water, good crocodile habitat includes areas with marginal swamps and emergent aquatic vegetation. This provides hiding places for the young, and nesting locations less vulnerable to disturbance and predation. Although fish are taken, crocodiles are not detrimental to fishing interests (Cott, 1961). They do, however, occasionally damage the gill nets of fishermen. Because of declining populations, the species is no longer considered a serious threat to man.

# CHAPTER D

## ENVIRONMENTAL IMPACTS

Development of the Senegal River basin project will produce both negative and positive impacts on wildlife. The factors creating impacts can be identified, but the complex interactions between factors and the variety of wildlife species concerned make assessment difficult. Quantitative data on population densities and seasonal movements, necessary for adequate impact analysis, are unavailable. Even the presence of some potentially important species (e.g. chimpanzee) within the project area cannot be verified.

Another problem is the lack of detailed post-impoundment wildlife studies for similar projects. Pre-impoundment surveys have been conducted for most large reservoirs throughout the world, but follow-up studies have been either superficial or totally lacking (Seaman, 1973). Because of insufficient data and lack of predictive models, changes in ecosystem components (e.g. terrestrial wildlife) frequently fall into the category of unforeseen side effects (Bardach and Dussart, 1973), rather than predictable results. In spite of the aforementioned problems, it is possible (and necessary) to predict major wildlife impacts. Quantification, however, is frequently impossible.

The following discussion is organized according to the factors creating impacts. For instance, where a combination of factors combine to produce an impact or a single factor produces multiple impacts, appropriate cross-references are indicated. The Diama and Manantali impoundments are expected to exert the most significant impacts on wildlife and are therefore considered first.

## D.1. Diama Impoundment

### D.1.1. Negative Impacts

During the first several years of operation, the impoundment will be filled to a level of 1.5 meters IGN, and cover a surface area of about 235 square kilometers. There is a possibility that at a later date the reservoir's pool level may be increased to 2.5 meters IGN. In that case a total area of 433 square kilometers would be inundated. The loss of existing terrestrial habitat will be approximately equal to the area inundated. Behind the Diama dam, the habitat loss will be 130 square kilometers and 318 square kilometers depending on the future reservoir water level. Annual water level fluctuations will lead to the formation of extensive marshlands, characterized by emergent vegetation (see Aquatic Vegetation). Heavily grazed savanna and approximately 1,100 hectares of gonakié forest will be lost.

The areas of terrestrial habitat lost will reduce populations of animal species proportionately. Important species which will be adversely affected include: warthog, jackal, rodents and several small carnivores (e.g. serval, civette, genet, etc.). No quantitative population data is presently available.

Individuals displaced from the impoundment area by rising water rarely survive long because of overcrowding and/or competition with resident members of the same species (Trefethen, 1973). As waters rise during initial flooding individuals of less mobile species will seek refuge in shrubs, trees and on high ground. As the reservoir fills, animals will move to higher ground or into trees. Those incapable of swimming for sustained distances will become trapped on islands which gradually diminish in size and eventually disappear beneath the rising water. Individuals of smaller species will become increasingly exposed to predation as they are forced into these areas. Remaining individuals will eventually drown. Most species within the area are adapted to seasonal flooding, and substantial losses are not anticipated.

Three other bodies of water will be affected as a result of the Diama impoundment. Lake R'Kiz and the Aftout es Sahel in Mauritania contain little water during most years, but become inundated on a larger scale about once in ten years. Lac de Guiers contains some water in all years; but will increase in size as a result of Diama. Loss of terrestrial wildlife habitat will be proportioned to the area inundated. At certain times the area inundated in Lac R'Kiz will increase to 120 square kilometers. Savanna and shrublands will be lost, and wildlife impacts will be the same as those described for the Diama impoundment. Lock and dam construction will restrict manatee movements between the estuary and the impoundment.

D.1.2. Positive Impacts

Creation of the Diama impoundment will create primary and secondary impacts which are likely to benefit two important wildlife species, the Senegal River manatee and the Nile crocodile. The main primary effects are the increased volume and surface area of water. Shoreline increases are beneficial but are less important. The subsequent establishment of emergent and floating aquatic vegetation is a significant secondary effect of the impoundment (see section 1, Aquatic Vegetation).

Fixed floating aquatic plants will become established in shallow waters which will be too deep to be affected by annual drawdown. *Typha australis* (cattails) and *Nymphaea* spp. (water lotuses) will develop in calm shallow water. These species provide cover for crocodiles which are expected eventually to colonize the impoundment. Present crocodile populations in Djoudj National Bird Park and near Lac de Guiers may be the sources for this colonization. It will take several years after the impoundment formation before aquatic weeds are established and crocodiles invade the area.

Aquatic weeds (e.g. *Vossia cuspidata*) are also beneficial to manatees which consume them in large quantities. The presence of expanded areas of shallow water which are vegetated and available for foraging during high water should benefit the remaining Senegal River manatee population. Other factors are involved in determining the ultimate changes which will result. The existing population level and degree of disturbance by river traffic are important parameters to be considered. If sufficient animals remain the population could increase.

Seasonal movements and other basic life history information have not been obtained for the Senegal River manatee. The presence of manatees in the Lake Chad basin (entirely freshwater) suggests that movement into brackish or saline water is not required for successful propagation (see C.1.2. Important Wildlife Species). Information needed to determine the magnitude and possibly even the direction of impacts of the Diama impoundment on manatee is presently unavailable.

Lac R'Kiz and the Aftout es Sahel, both in Mauritania, and the Lac de Guiers on the Senegal side of the river will receive additional water as water is backed up.

Lac R'Kiz and the Aftout es Sahel presently receive water about once in a ten year period. Both areas subsequantly dry up and remain so for long periods. With the buildup of water behind Diama dam, water will be present throughout the year in both areas. Aquatic vegetation will be present in both areas, but water depths will be relatively shallow

Manatees could forage during part of the year in both places, but would return to marigots (or the Diama impoundment) during the dry season. Crocodiles could likewise use the areas during the wet season, but would need to return to deeper water as the areas decreased in depth during the dry season. The Aftout es Sahel presents an additional problem for wildlife in that water salinity increases to a point where wildlife cannot drink it.

Lac de Guiers has water in it during all of Lac de Guiers' seasons. With inundation behind Diama dam, the average surface area will increase from 273 square kilometers (at present) to 321 square kilometers. The water level should remain more consistent because of flow regulation at the Diama and Manantali dams. Emergent vegetation at the shoreline and floating aquatic vegetation will be similar to what is now present, but over a greater area. Species of Polygonum and Vossia, which will be present in the lake, are consumed by the Senegal River manatee (Husar, 1978). The expansion of water volume and surface area, and the expected increase in forage should afford an increase in the manatee population using the lake.

The continual presence of freshwater in Lac R'Kiz and above Diama dam will provide additional water sources for terrestrial wildlife and permit them to exploit areas not formerly available to them. Vegetation along the shoreline will provide cover and forage. Populations of species considered agricultural pests (e.g. warthog, rodents) are among those which will increase in numbers.

## D.2. Manantali Impoundment

### D.2.1. Negative Impacts

When filled to capacity, the impoundment will cover 450 to 500 square kilometers of savanna woodland and riparian fringe forest. The loss of terrestrial habitat will be approximately equal to the maximum area inundated. The annual fluctuation in water levels (ten meters plus) will prevent all but annual grasses from becoming established within the boarder zone. This loss of habitat in the impoundment and along the shoreline will result in the permanent loss of wildlife production within the area, and a corresponding reduction in the size of wildlife populations in the region.

The fringe forest along the Bafing River and its tributaries is important to several species of wildlife, especially small game ungulates (hooved mammals). The oribi, bushbuck and red-flanked duiker require dense vegetation for cover, although they may forage for browse in the surrounding savanna. Fringe forests along 123 kilometers of the Bafing River will be harvested prior to flooding the impoundment, driving wildlife into adjacent areas or into the surrounding savanna. No population density figures for these important species are available, but several species are considered relatively common.

The fluctuation of water levels in the impoundment will prevent fringe forests from becoming established anywhere along the shoreline of the impoundment. The reservoir will, therefore, create a 123 kilometer hiatus between the fringe forest north of Manantali and the fringe forest and Guinea savanna south of the impoundment. This will reduce or eliminate movement between these areas, thus isolating wildlife north of the dam from the more extensive populations south of it.

Individuals forced from the impoundment area by forest clearing and subsequent inundation rarely survive for long in competition with resident members of the same species (Trefethen, 1973). No quantitative population data is available but at least some displaced individuals should survive. Those which move into surrounding savanna are more likely to perish.

Important mammals which may become trapped include the cats (e.g. lion, serval, etc.), hyaenas, warthog, oribi, red-flanked duiker and bushbuck. Smaller mammals (e.g. lesser galago, red monkey, green monkey, rodents, etc.) will also be affected

Lizards and snake populations will suffer substantial losses. Many individuals will either drown or move to higher ground and be exposed to increased predation.

Individuals of aquatic species (e.g. turtles and crocodiles) may suffer some initial losses because of displacement from former habitats, but the populations should benefit. Crocodiles (if any are present) will also be exposed to hunting during the period of initial flooding and the early stages of lake stabilization.

### D.2.2. Positive Impacts

Wildlife benefits resulting from the construction and operation of the Manantali impoundment are even more difficult to assess than negative impacts. During initial flooding predators will be able to take advantage of the increased concentrations of prey species. Those predators which are able to avoid becoming stranded on temporary islands or in trees will probably not be lost immediately from regional populations. This is a transitory and relatively minor benefit.

The hippopotamus population within and downriver from the impoundment will be variously affected, but the net results are expected to be a population increase. During the period of initial inundation, water levels below the dam will decrease substantially and hippos will become confined to the deeper remaining pools. Upriver from the dam, rising waters will drive hippos from the river channel and toward the shoreline of the newly formed lake. The inundation of tributaries will increase the shoreline from approximately 120 kilometers along the river to 450 kilometers in the lake. Much of the lake shoreline will be too steep for use by the hippos, but gently sloping areas inside valleys and in the upper reaches of the lake should provide easy access for hippos which graze on shore. The creation of Lake Kariba led to an increase in the hippopotamus population (Setzer, personal communication), and a similar increase may be expected at Manantali.

Wetland habitat (marshes and swamps) may be formed in some of the broad tributary valleys and near the upper end of the impoundment. These wetlands would be formed in the zone between maximum inundation and the normal annual low; a range of ten to twelve meters.

The detailed topographic maps, necessary to determine the location and extent of such areas (if any) is unavailable at present. Creation of wetlands would benefit wildlife, particularly the Nile crocodile.

The lake inundation will extend permanent water several kilometers into tributary valleys. This should improve the habitat of species such as the roan antelope, defassa waterbuck and bohor reedbuck. These species prefer open woodland savanna habitat near water.

## D.3. Agricultural Development

### D.3.1. Negative Impacts

The principal impact of development on wildlife will be loss of indigenous vegetation converted to irrigated perimeters and associated facilities. By the end of the 50 years of development, 255,000 hectares of land will be in irrigated perimeters. At the present time, an annual average of 100,000 hectares is used for recession farming. This land is within the area designated for perimeter development, leaving about 155,000 hectares of natural lands which will ultimately be lost. Detailed vegetation and perimeter development data is unavailable, but most of the land to be committed is heavily grazed Sahel savanna. Portions of the gallery (gonakié) forest near the river will also be cleared and converted to agriculture. Wildlife use of the savanna habitat near the river is already limited because of man-made and livestock disturbance. Forest areas are less disturbed and provide suitable habitat for several important species such as warthog, small carnivores, rodents and monkeys. Loss of forests may result in proportionately larger losses of wildlife since certain species require extensive forest areas in order for populations to survive. If only small patches of forest remain, they may not be sufficient to support wildlife populations.

Agricultural development according to Natural Resource Units, called Unités Naturelles d'Equipement (see Agricultural Development Report, Chapter C, subsection C.2.2., General Description of Soils.), will not take over classified forests. However all unclassified forests within the U.N.E.s will be taken over for irrigated perimeters.

### D.3.2. Positive Impacts

As irrigated perimeters are developed, small bodies of open water will be created. This new habitat will benefit amphibians such as the frog *Dicroglossus occipitalis*. The species has been observed to be abundant in irrigated perimeters throughout the middle and upper valleys, and the same situation is likely in newly planned perimeters. This relatively large species is of economic value as food and could provide a local supplementary protein source. Frog culturing could be promoted in storage reservoirs and drainage sumps if proper pesticide use is controlled to prevent concentration of toxic substances in frog flesh.

The additional crops will benefit species which are crop pests (e.g. warthog). Eventual control measures should make this a marginal benefit to wildlife, and a relatively insignificant harmful impact on man and his crops.

## D.4. Navigation

### D.4.1. Negative Impacts

The principal aspect of river navigation which will adversely affect wildlife will be dredging and disposal of dredge déblais spoils. Dredging of the river channel will take place in several localized segments of the middle and upper river valleys (see Report IV - Navigation). The spoils will be placed on land above the level susceptible to flooding. Sahelian savanna and gonakié forest will be affected. The result will be a relatively small amount of lost habitat. Natural vegetation may eventually reclaim some areas, but the quality of habitat is not likely to be restored to its present value. This is particularly true for forest areas which will not be restored to forest vegetation.

Manatee injuries and mortalities may result from collisions with boats due to increased river traffic. Manatees breath air and frequently float near the surface. When water levels are at their lowest annual levels, individuals may become concentrated in the river channel where collisions would occur. Sufficient data on manatee populations are not available at present, so the likelihood and possible significance of this impact cannot be adequately assessed. Manatee injuries resulting from collisions with boats have been reported from other parts of the world.

### D.4.2.1. Positive Impacts

No wildlife benefits resulting from navigation are anticipated.

## D.5. Population Resettlement

### D.5.1. Negative Impacts

Major population shifts will take place in the Manantali area. Approximately 10,000 people will be moved from the area of inundation behind Manantali dam. Two resettlement locations are planned; one east of the Manantali impoundment and the other downriver between Manantali and Mahina. Most of these people (possibly 7,000) will settle in the latter location, with the rest scattered over a more extensive area east of the impoundment.

The people settling below Manantali will exert the greatest adverse influence on wildlife. Many individuals of fringe forest species displaced from the impoundment area during clearing and inundation (see Chapter D.2. - Manantali Impoundment) will move into this area. Villagers established along the river will clear land, reducing available habitat. Competition from domestic animals and increased hunter pressure will further reduce populations. As in the case of other impacts, no quantitative evaluation of losses is possible. However, the combination of resettlement and impoundment in the Manantali area will directly affect 255 kilometers of fringe forest habitat and its resident wildlife along the Bafing, and exert an adverse influence for several kilometers beyond this because of the overcrowding of wildlife displaced by clearing and inundation.

Perimeter development and related industries will result in population resettlement and growth primarily in the middle and lower valleys. Because of present and past habitat disturbances by man and livestock and because of habitat lost during perimeter construction, little additional losses are expected from population shifts in these areas.

### D.5.2. Positive Impacts

No wildlife benefits resulting from population shifts are anticipated.

## D.6. Minor Factors

Other impacts are anticipated, but their importance is relatively minor. All of these are generally adverse. The impacts are as follows:

- Dike construction will create barriers to flooding, causing loss of some gonakié habitat and a resultant loss of resident wildlife.

- Changes in flood patterns will result in forest losses through permanent flooding or prevention of annual flooding. This will also cause loss of forest habitat and a reduction in wildlife numbers.

# CHAPTER E

# MITIGATING MEASURES

## E.1. Introduction

Adverse impacts on wildlife will be partially offset by the benefits which are expected to result from project development. For example, creation of the Diama impoundment will eliminate large areas of terrestrial habitat but may provide additional aquatic habitat for the Senegal River manatee and Nile crocodile. Mitigation measures will be necessary in order to adequately compensate for the loss of wildlife and wildlife habitat resulting from full project implementation.

It is not possible to quantify the extent of mitigation needed for the following reasons:

- Almost no quantitative data are available on populations of important species within the project area,
- Predictive models and post-impoundment wildlife studies have not been conducted on similar projects and
- The value of an important (e.g. endangered) species cannot be expressed in terms of biomass, productivity or money.

The following discussion considers alternative mitigation measures and provides a technical and economic evaluation of each.

## E.2. Loss of Wildlife Habitat

The most pervasive of all the adverse impacts will be the destruction of wildlife habitat. All major aspects of development (e.g. Diama impoundment, Manantali impoundment, irrigated perimeters, resettlement) will result in the removal or degradation of important habitats bordering the Senegal and Bafing Rivers. Of the 27 mammal and one reptile species designated as important in the project area, only three are likely to benefit from project development (see section C.1.2. - Important Species).

E.2.1. Mitigation Alternatives.

Several methods of mitigating habitat losses are possible. Alternatives which have been considered are discussed in the following paragraphs.

- Equivalent sized areas of habitat similar to those which will be lost could be established near each of the proposed impoundments. At Manantali this would require that 123 kilometers of fringe forest along the Bafing River be set aside as a wildlife preserve.

- Resettlement along the Bafing River between Bingassi and Mahina could be prohibited in order to prevent habitat destruction in that area. Resettlement could take place in areas away from the fringe forest habitat.

- The complete protection of some or all important species could be implemented. This would potentially lead to an increase in populations of game species which have been declining because of hunting pressure.

- Personnel and equipment of the Service des Eaux et Forêts in each of the riparian states could be substantially increased. This would enable each country to effectively enforce its game laws, thus reducing wildlife losses resulting from poaching and illegal hunting.

- Existing national parks (e.g. Djoudj National Bird Park) could be expanded and new national parks could be established. This would provide areas of complete protection for wildlife and would permit habitat management, thus optimizing conditions for several important species (Heinzenknecht and Paterson, 1978).

- A research program could be instituted to obtain basic data on the current population, distribution, movements, and other pertinent life history information on the Senegal River manatee. These data are needed in order to provide adequate management and protection for the species.

- Wildlife specialists could survey the areas to be affected to obtain data on population levels and carrying capacities for important species. This would provide quantitative information to be used in assessing impacts and designing appropriate mitigation measures.

- The dike and gate system at Djoudj National Bird Park could be repaired to prevent habitat destruction when the Diama impoundment is flooded. Additional diking could be created north of the present park to prevent habitat disruption from irrigated perimeters near the park.

- A final possibility would be to consider adverse impacts to be minor, and not implement any mitigative measures.

## E.2.2. Technical Evaluation of Alternatives

Setting aside equivalent sized areas of similar habitat is an impractical approach for several reasons. Suitable areas of equivalent habitat are difficult to define within the project area. To effect this change, it might be necessary to initiate extensive resettlement and land reclamation programs. In addition, it is likely that future land use needs and planned development would compete directly with such large areas.

Prohibiting resettlement below the Manantali dam would create logistic and social problems for the people involved. Living away from the river would require drilling wells and a change in the methods used to obtain and store water. Much of the land between Bingassi and Mahina has been somewhat modified by agricultural use and by burning. Logistic problems created by this alternative overshadow the potential benefits to wildlife.

Legislating the complete protection of important species is possible. Enforcement, however, is a problem. The Services des Eaux et Forêts in each of the riparian states are presently understaffed. A substantial increase in personnel and equipment would be required in order to effectively enforce protective legislation. This would require additional training and proper deployment which would be logistically cumbersome and technically less desirable than other possible mitigation procedures.

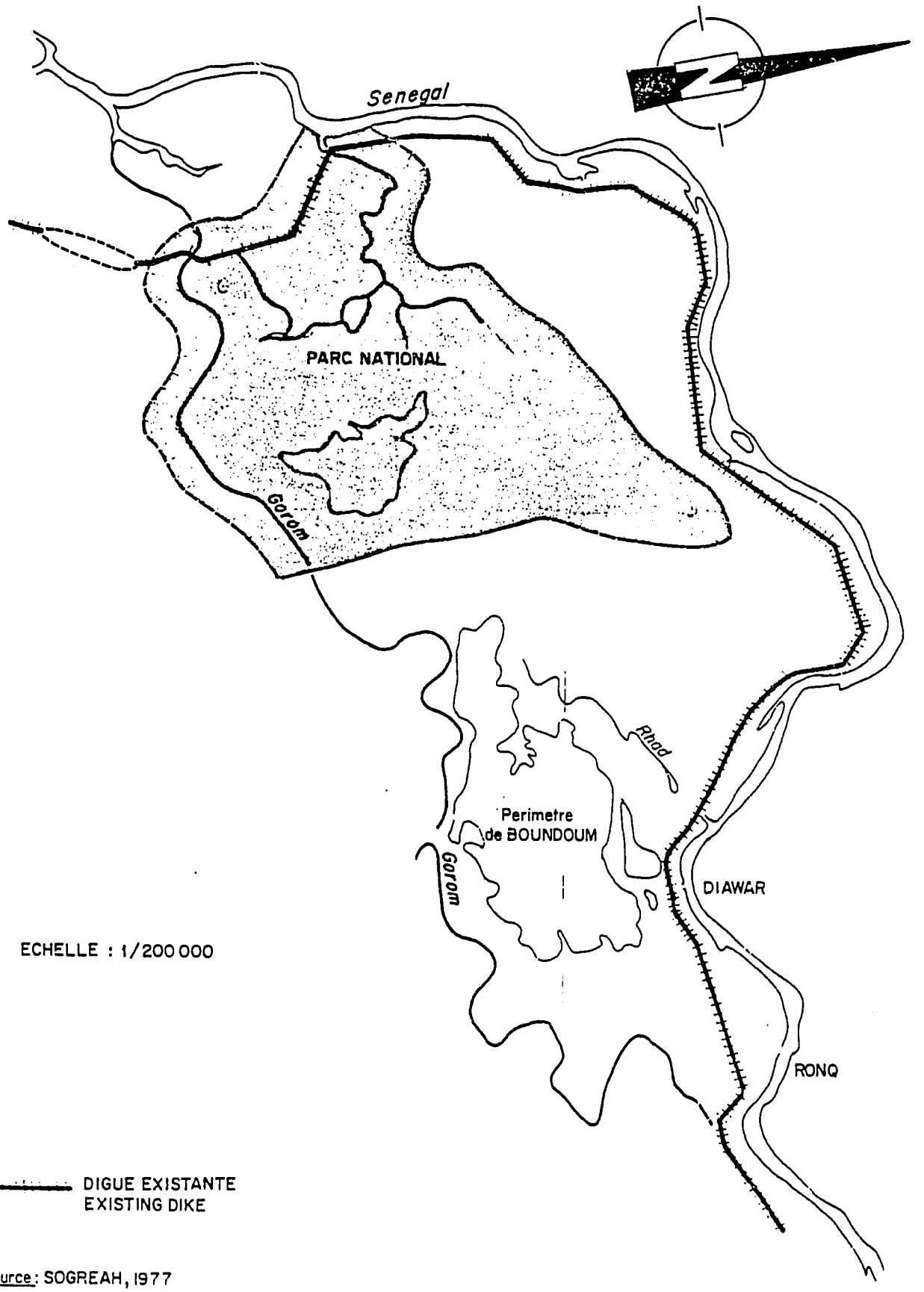
Concentrating enforcement efforts in selected locations and moderate increases in wildlife personnel are technically feasible and are in keeping with accepted wildlife management principles.

Expanding existing national parks and creating new ones is technically feasible and is a very effective method of mitigating the loss of wildlife habitat. Larger mammal species require large areas of habitat in order to maintain their populations (see Chapter D). Suitable land is available, and there are no technical difficulties involved in the acquisition and management of the new parks. Creation of new park areas would protect these lands from heavy grazing, the harvesting of forests and game hunting. Protection would improve the habitat quality for wildlife species and permit populations of important species to increase. The most desirable locations for park areas are:

Senegal - approximately 5,000 hectares of land immediately east of Djoudj National Bird Park and adjacent to the Gorom Marigot, and an area north of the Gorom Marigot, west of the Senegal River and adjacent to the park. See Figure E.2-1.

Figure: E.2-1

# CARTE DU PARC NATIONAL DE DJOUDJ
# MAP OF THE DJOUDJ NATIONAL PARK




Source: SOGREAH, 1977

Mauritania - approximately 30,000 hectares of land opposite Djoudj National Bird Park, extending from the Senegal River to the Atlantic Ocean and including brackish water areas.

Mali - two choices: establish a new national park (40,000 hectares) along the Bafing River above the proposed Manantali impoundment and including 45 kilometers of fringe forest habitat, or add approximately 40,000 hectares to the existing Parc National de la Boucle de Baoulé near Bamako.

The areas of land recommended for national park status are suitable for development with minimal disruption of human settlements, and are not within the region of planned industrial or agricultural use.

Basic life history and distribution information on the Senegal River manatee is absolutely necessary in order to gauge impacts and design effective mitigation measures. So little is presently known about the species that only general inferences can be made about its social structure, reproductive requirements and movements. The Senegal River supports the northernmost population of this species. If the population disappears, natural re-establishment would be impossible because of the lock and dam at Diama.

If a self-sustaining population of manatees remains in the river after construction of the Diama dam, the resulting impoundment may ultimately benefit the species. Estimates of the number of manatees in the river at present range from fewer than 50 to 300, with most sources indicating less than 100 individuals. Basic information on population size is urgently needed. A research program designed to obtain fundamental information is feasible. The species is of international concern, and international expertise should be available to assist in the planning and execution of such a study. Similar projects on a more limited scale have been successfully undertaken (Hartman, 1971).

Surveys of wildlife populations and carrying capacities of affected habitats could be conducted. Population densities of several important species are so low that ordinary census techniques would probably be ineffective. Several years of research would be needed in order to obtain meaningful data. This approach is marginally feasible from a technical standpoint.

Dike repair and gate replacement at Djoudj is an obvious and technically feasible mitigation measure. The four gates, each of which is 2.5 meters wide, are in an advanced state of disrepair. With the anticipated increase in water levels above the Diama impoundment, an adequate dike and gate system would be needed in order to control the timing and amount of water available within the park.

Unless flows are properly regulated, habitat loss and wildlife destruction could occur. The placement of an additional dike north and east of the park would further protect the park from the influence of irrigated perimeters upstream.

Nonimplementation of mitigation measures is certainly feasible, but is an environmentally unsatisfactory alternative. A review of the nature and extent of possible adverse impacts indicates that this approach is unwarrented. Potential wildlife losses, and extensive impacts on wildlife habitats will not be offset by anticipated beneficial impacts, thus mitigation measures will be needed. Positive impacts discussed in Chapter D will partially compensate for adverse impacts. The most noteworthy of these are the possible population increases for the Senegal River manatee and Nile crocodile in the areas inundated above Diama dam. Without effective control of hunting and fishing, these benefits may not exist.

### E.2.3. Economic Evaluation of Alternatives

Assessment of alternative mitigation measures as disucssed herein will consider only those which are technically reasonable (Section E.2.2.). The following measures therefore will not be evaluated:

- Establishment of equivalent sized areas of similar habitat,
- Prohibition of resettlement along the Bafing River below Manantali,
- Complete protection of all important species,
- Conduct detailed wildlife surveys in all areas to be affected,
- Nonimplementation of mitigation procedures.

Four alternatives remain. Because of the inherent complexity of biological systems, an approach which combines different mitigative procedures into a coordinated program is more technically desirable and economically efficient than separate implementation. The following economic assessments will, however, consider the measures as separate entities.

Gate replacement and dike construction at Djoudj National Bird Park should be included in the construction costs for the Diama project because the diking system is an integral part of the project design. If these costs have not been included, some provisions should be made. A benefit per cost analysis based on the assumption that nonrepair will result in the total loss of income to the park, follows (Dupuy, 1978). Estimated park income in good years approaches 100,000,000 CFA. By 1980, annual average income should at least reach this figure. The benefit per cost ratio can be calculated as:

Assumptions: Discount rate = 12%
Time of planning horizon = 50 years

Benefits:

Annual income = 100,000,000 CFA
Present worth = 100,000,000 x 8.304 = 830,400,000 CFA

Costs:

Construction and repair of dikes = 400,000,000 CFA
gate replacement 20,000,000 CFA
Maintenance of gates and dikes at 1% of construction cost = 4,200,000 CFA/year
Present worth = 4,200,000 x 8.304 = 34,880,000 CFA
TOTAL COSTS 458,880,000 CFA

$$\text{Benefit/cost ratio} = \frac{830.400.000}{454.880.000} = 1.81$$

From a financial standpoint, dike and gate repair are highly desirable. The additional benefits to wildlife cannot be expressed in monetary terms, but are substantial. The park preserves a unique segment of undisturbed habitat of international concern (République du Sénégal, undated) supporting a variety of important species. In addition to the 3,000,000 birds which visit the park annually, the Nile crocodile, Senegal River manatee, red-fronted gazelle, and Dorcas gazelle also find refuge within the park.

A life history study of the Senégal River manatee can be undertaken at reasonable costs which would depend on the amount of detail sought. A minimum study of two years is envisioned. The cost of such a study is estimated at 35,000,000 francs CFA.*

Planning assistance and partial funding may be available from international wildlife organizations working in cooperation with O.M.V.S. The alternative to this study may be the extermination of the Senegal River manatee in the Senegal River. No cost benefit analysis for such a result is possible.

Procurement or designation of additional lands as wildlife reserves is a highly effective mitigation measure. Land acquisition and population resettlement are problems which should be addressed through detailed, specific studies.

These studies should be designed to investigate the economic value of these parks as reservoirs for game species ranging outside of the parks and as refuges for endangered species.

Increasing the staffs of the Service des Eaux et Forêts in each country would be prohibitively expensive. Dozens of additional trained individuals would be required in order for this increase to be effective throughout each of the riparian states. Annual costs per country could be expected to exceed 200,000,000 CFA. An increase in personnel would undoubtedly benefit wildlife, but insufficient data is available to permit a quantitative analysis.

*Costs of such a study could vary widely depending on the national counterpart participation in personnel and equipment.

## E.3. Destruction of Wildlife by Inundation

The second serious adverse impact on terrestrial wildlife will be the direct loss of individuals caused by the initial flooding behind Manantali and Diama dams. Losses above Diama are not expected to be great because of the limited amounts of forest habitat affected. Many of the species inhabiting the land adjacent to Lac de Guiers and along the river below Rosso are adapted to withstand flooding and would not perish.

At Manantali the topography is varied. Fringe forest and woodland savanna occupy much of the land to be inundated. Although it has been recommended that fringe forests be cleared prior to flooding (see Forestry Report), substantial portions may remain. These areas harbor a variety of larger mammal species (e.g. duikers, oribi, defassa waterbuck, bushbuck, etc.). Meager information on hunting pressure and present population level suggest that populations in surrounding areas may not be at carrying capacity, and that animals displaced from the zone of inundation may survive.

### E.3.1. Mitigation Alternatives

Several mitigation procedures may be considered. The most reasonable measures are those which attempt to diminish wildlife losses rather than those which merely compensate for them. Potentially viable alternatives include the following:

- All harvestable trees could be cut, and the area cleared. These activities should be organized so that wildlife would be progressively driven toward areas of suitable forest upstream of the impoundment. The effort would be considerable above Manatali, but minor in the area above Diama dam.

- Animal rescue efforts could be conducted during the period of initial inundation above Manantali. Motorized boats, specialized collecting and communications equipment, and trained personnel would be needed.

- Nonimplementation of mitigative procedures is a possible alternative. It could be argued that the loss of individuals of terrestrial species would be compensated for by providing additional habitat for aquatic species such as the hippopotamus.

- Other potential mitigation measures are discussed in Section E.2.2 and E.2.3.

### E.3.2. Technical Evaluation of Alternatives

Harvesting the fringe forest and woodland savanna at Manantali is technically feasible. Estimates of manpower and equipment are discussed in detail in Forestry Sections E.5 and E.6. Manpower is available and the anticipated time frame is such that 36,000 hectares of woodland could be harvested. This is approximately 72 percent of the forest area to be inundated. The remaining area is considered unharvestable because of the terrain or the sparse distribution of trees. Wildlife could become concentrated in remaining areas or leave the area altogether. This would substantially reduce the number of individuals exposed to flooding and facilite recovery efforts.

Effective rescue operations could be implemented. Logistically this would require 6 to 10 people experienced in handling larger animals, two to four boats, and suitable transport equipment. The operation might require as little as two months, assuming adequate rains during the first year of flooding. No insurmountable technical problems are envisioned.

It is, of course, possible to ignore potential losses from populations of important species and choose not to mitigate. This approach is inadvisable because of the ease with which satisfactory mitigation can be achieved.

Technically feasible mitigation measures discussed in Section E.2.2 could compensate for individuals destroyed during initial inundation. Implementation of forest clearing and animal rescue would reduce losses.

### E.3.3. Economic Evaluation of Alternatives

Alternative mitigative procedures discussed herein are limited to those which are 1) technically feasible and 2) have not been previously discussed.

Cutting and harvesting trees have been economically evaluated (see forestry Section G.6. The benefit cost ratio, based on firewood value, is 2.1 - 2.5/1. Benefits to wildlife cannot be quantified, but this alternative is economically and environmentally attractive. Harvesting would require 200 man years, thus boosting the economy of the region during the harvesting period. Additional manpower would be needed for hauling and marketing the timber. Harvesting the 1,000+ hectares of trees in the area above Diama would be relatively simple and also cost-effective (see Forestry Section G.6).

Animal rescue efforts would involve the commitment of manpower and equipment for a period of two to six months, depending on seasonal flooding. Total costs would range from 40,000,000 to 50,000,000 francs CFA. With forest clearing, costs would be reduced by as much as 50 percent. Partial funding and advice would probably be available from international wildlife organizations. Costs could be built into project design specifications.

Nonmitigation would involve no costs, but wildlife losses would undoubtedly take place.

## E.4. Minor Adverse Impacts

Several relatively monor negative impacts might result from project development. Those identified are:

- Manatee damage as a result of collisions with increased river traffic.

- Manatee casualties downriver from Diama because of the presence of the lock and dam.

This impact is difficult to evaluate and almost impossible to mitigate. Expected habitat improvement for manatees upriver from Diama should at least partially compensate for these impacts. It has also been suggested that manatees could be placed in drainage canals of large irrigated perimeters. This would protect the manatees and provide the additional benefit of controlling weeds in these canals.

# CHAPTER F

## PLAN OF ACTION

Proposed mitigation measures can be integrated into a two-part plan of action. Different approaches are needed to compensate for lost habitat than the measures proposed to reduce the destruction of wildlife. The two programs are discussed in the following sections.

## F.1. Mitigation of Habitat Losses

Four technically feasible and economically sound methods for mitigation were discussed in Sections E.2.3 and E.2.4. They can be efficiently combined into a single program in the following way:

1) A single member of the environmental staff of O.M.V.S. should be responsible for the implementation of the program.

2) The program should begin at the earliest possible date; preferably, before construction of the Diama dam.

3) The program should begin by defining (in consultation with appropriate national park services) lands to be set aside as wildlife preserves and/ or national parks near Diama and above Manantali.

4) The manatee life history study should be developed and begun two years prior to the impoundment of Diama. One or more members of the survey team should be a member of the park service or Service des Eaux et Forêts who would be trained to continue monitoring the population and managing it in the Senegal River.

5) The O.M.V.S. official would see to it that dikes and gates at Djoudj were repaired and modified to protect the park. Gates should be designed to open and close with a vertical rather than horizontal opening (Dupuy, 1978).

6) Following land acquisition, a program for obtaining additional equipment and implementing any resettlement would be needed.

7) Contact with international wildlife organizations (e.g. World Wildlife Fund and International Union for the Conservation of Nature and Natural Resources) should be initiated immediately to obtain expertise and possibly some funding for portions of the program.

8) New national park officers should receive two years training in wildlife management.

F.1.1. Infrastructure

An O.M.V.S. staff member should be appointed prior to the commencement of dam construction. Minimum qualifications for the position are:

- Four years training in wildlife management (B.S. degree or equivalent). This would require training obtained outside of the member countries.

- Two years of field and administrative experience.

- Preferably a citizen of one of the O.M.V.S. member countries.

The primary responsibilities will be to implement the mitigation measures already discussed, and combine them into a coordinated program. Priority should be given to the establishment of wildlife preserves and instituting a manatee research program. The manatee research team should be comprised of a senior mammalogist (presumably an expatriate) and a wildlife biologist (two years training) from one of the O.M.V.S. countries. The latter person would be trained during the study to continue monitoring the population and supervise management efforts following the termination of the original study.

It would also be the responsibility of the O.M.V.S. conservation officer to provide training for the new national park officers and appropriate parties in wildlife management techniques. This training would supplement training normally provided to park service employees, and would be necessary for coping with the unique problems to be encountered.

The officer should have the additional responsibilities of liaison between O.M.V.S. and the international wildlife organizations. The organizations could provide assistance in various aspects of program implementation. Coordination with them would be particularly helpful in designing the manatee study and in organization of the animal rescue efforts in the Manantali area.

A committee should be established within O.M.V.S. to make recommendations to the member countries on the extent and location of proposed national parks. Members of the national park service in each country should be represented. The committee should exist until final decisions have been made and authority then turned over to the appropriate agencies. Committee activities could take one to three years to conclude.

F.1.2. Costs

Anticipated costs for various portions of the program are as follows:

-Labor

| | |
|---|---|
| O.M.V.S. staff position | 2,400,000 CFA/Year |
| Manatee survey staff | 20,000,000 CFA |
| Wildlife training outside O.M.V.S. countries | 8,000,000 CFA |
| National park officers training | 9,000,000 CFA |

Additional funds will be required to realize the national park improvement and enlargement program described in Section E.2.2.

## F.2. Mitigation of Wildlife Losses

Some unavoidable wildlife destruction will occur as a result of project development. Major potential losses are expected during inundation behind the Manantali dam. An animal rescue effort would substantially reduce anticipated losses.

### F.2.1. Infrastructure

The O.M.V.S. conservation officer will need assistance to plan and execute a recovery effort during the initial one or two years of inundation at Manantali. Wildlife authorities with appropriate experiences should be temporarily hired to conduct the effort. The program should include personnel from the Malian Service des Eaux et Forêts.

In addition to the O.M.V.S. conservation officer, the following personnel would be required:

- One or two international wildlife rescue experts. Qualifications should include an advanced degree (M.S. or PhD) in animal ecology or wildlife biology, experience with African wildlife (particularly large animals), and previous experience in project organization.

- Two or more Malian conservation officers. Qualifications should include: wildlife management training and experience with African wildlife.

F.2.2. Costs

Project costs will vary, depending on the techniques to be used and the level of effort required. A minimum program is costed as follows:

| | |
|---|---|
| -Labor | |
| 2 wildlife experts for 4 months | 5,200,000 CFA |
| 3 Malian conservation officers | 2,200,000 CFA |
| 2 support staff | 900,000 CFA |
| -Direct Costs | |
| Field meals and lodging | 2,000,000 CFA |
| Plane rental | 2,100,000 CFA |
| Vehicle purchase (truck & car) | 5,000,000 CFA |
| Collecting & Transporting equipment | 1,200,000 CFA |
| Maintenance & miscellaneous costs | 800,000 CFA |
| 2 motorized boats | 850,000 CFA |

# CHAPTER G

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