A SURVEY OF THE VEGETATION AND UNGULATE POPULATIONS IN PARK W, NIGER

by

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A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Department of Fisheries and Wildlife

1981

ABSTRACT

The vegetation of Park W, Niger, West Africa is typical of the Sudan Wooded Savannah vegetation zone, and is dominated by trees and shrubs of the Combretacease family. The four major plant communities which characterize the vegetation are riparian, Combretaceous woodland, Combretaceous shrubland, and grassland. Woodland associations are most frequently used by wildlife. Fires, used to facilitate game-viewing and to create fire breaks, burn most of the park annually and result in the formation of fire-tolerant subclimax woodlands. Excessive annual burning has increased woody vegetation and deteriorated perennial grass cover in many areas.

The most abundant ungulates are the buffalo, elephant, Grimm's duiker, warthog, bushbuck, and oribi. Lions are the only common large carnivore in the park. Distribution, movements, group size, sex and age structure, food habits, and habitat preferences are described for each of the larger ungulates. Elephant numbers appear to be excessive in relation to the area occupied by this species in the park.

Illegal hunting and livestock grazing are serious problems along the major rivers, and both are difficult to control. In areas where cattle and sheep are grazed regularly, wildlife is almost totally absent.

Waterhole development projects have been successful in improving game distribution and thus facilitating tourist viewing. Habitat damage adjacent to waterholes has been minimal thus far, but monitoring of these sites is recommended.

ACKNOWLEDGEMENTS

This study was made possible through the support of the United States Peace Corps program in Niger and the Waters and Forest Service of the Niger Government. Special thanks goes to Benjy Kaghan, whose support and understanding and shared experiences will never be forgotten. I wish to thank former park directors Albichir Mohammed and Elmanseur Seyleman for their cooperation and support. I also wish to thank those in Peace Corps, Niamey, especially Richard Poche who provided timely support and advice, and game guards Humbo, Garba, Danderae, and Boubacar Ali and to former volunteers Jeff Towner and Dave Maercklein for their many hours of help in the field.

Finally, I wish to thank Dr. G. Petrides for his many hours of help on the manuscript and my committee members Drs. R. Baker and S. Zarnoch for their advice and support.

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INTRODUCTION

Ecological wildlife studies have been few in West Africa. This study is intended to provide the descriptive framework for management and for future, more quantitative investigations into the ecology of Park W. What we know of African wildlife comes almost entirely from observations made in eastern or southern Africa. Observations made there may not always be applicable in West Africa.

Although Park W wildlife resources cannot compare with those of East African parks, they are nonetheless unique and valuable. Park W is Niger's only national park, and one of only a few in West Africa representing the Sudan Savannah biome. For many plant, mammal, and bird species, the park represents their northernmost range because of habitat, climatic, and human factors. More than 42 plant species collected in the park have not been found anywhere else in Niger, and one of the largest concentrations of buffalo and elephants in West Africa is found here.

GENERAL DESCRIPTION

Location

Park W is an international park, with boundaries in Niger, Benin, and Upper Volta. The total area is over 10,000 km^2 with about half in Benin and one-quarter in each of the other countries. The Niger portion lies on the right bank of the Niger river in the southwest corner of the nation. It lies between latitudes $11^{o}50'$ and $12^{o}35'$, and longitudes $2^{o}5'$ and $2^{o}50'$, and covers approximately 2200 hectares. Topographically, the area comprises a peneplain 250 meters above sea level. On the south, it is bounded by the Mekrou river, on the west by the Upper Volta border, to the north by the Tapoa River, and to the east by the Niger river. Niamey, the capital city, lies 150 km to the north, and is connected to the park by an all-weather gravel road.

History

Earliest records of the area date to 1591-1593, when conflicts between local tribes and Moroccan invaders from the north pushed many of the inhabitants south into present-day Nigeria. Gradually however, nomadic, hunting, and fishing tribes resettled the area. This region was never densely populated, and had fewer than five persons per square kilometer

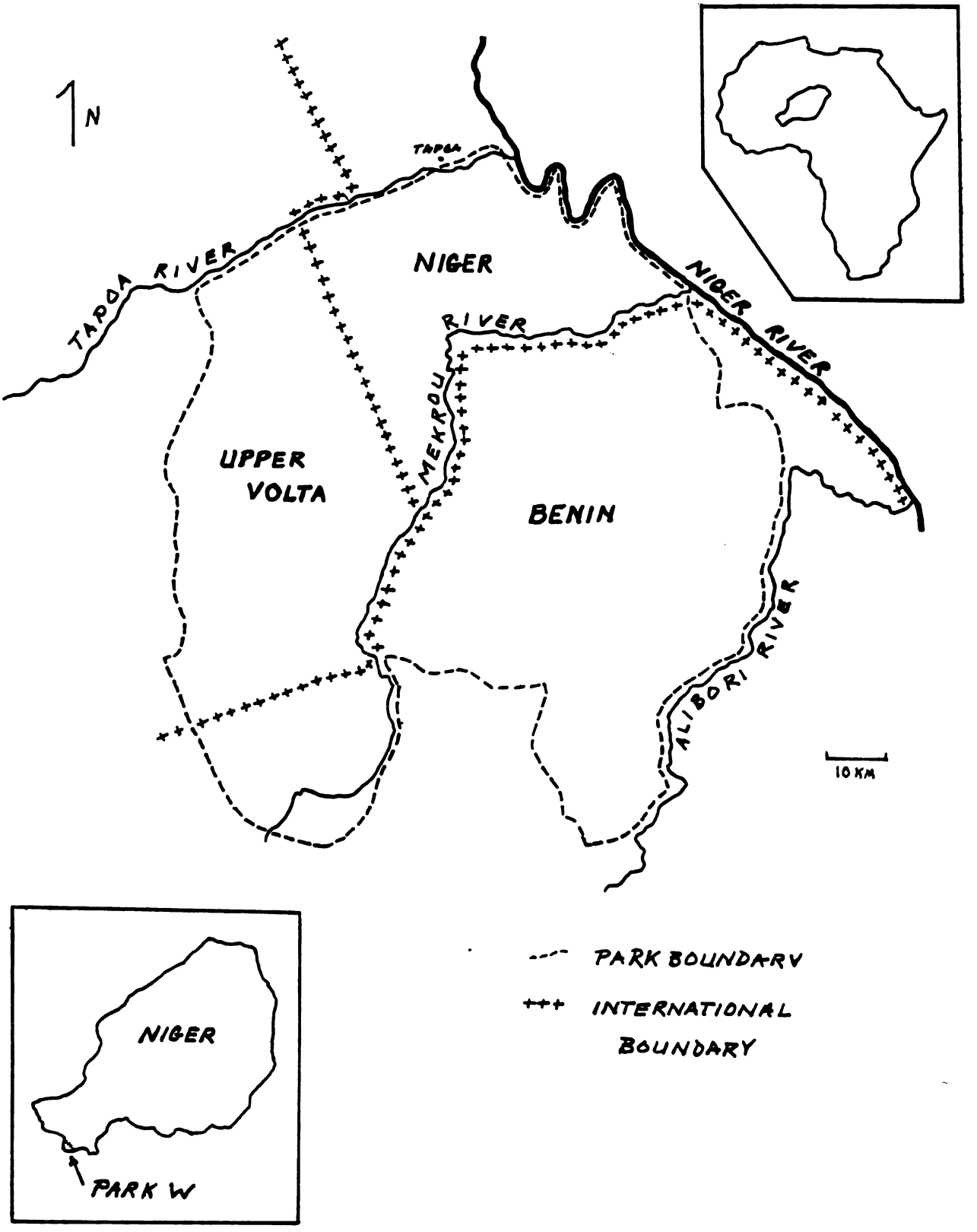

Figure 1. Park W lies in three West African countries: Benin, Upper Volta, and Niger. The Niger portion is situated in the southwest corner of that country.

as recently as 1950 (Roure 1956). Poor soils, prolonged dry seasons, diseases affecting both humans and livestock, and frequent tribal conflicts partially explain the low human population densities.

Seven tribal groups developed in the area including Djerma, Housa, Peul or Fulani, Dendi, Sonrai, Gourmantchi, and Bariba. Today, these last two are more numerous in Upper Volta. Gourmantchi tribes are traditionally hunter-gatherer groups and are the main contestants for lands now comprising Park W. The Peul are herders and for centuries have grazed their cattle. sheep, and goats throughout the area. Livestock numbers are believed to have been small then because of their susceptability to trypanosomiasis carried by tsetse flies (Glosina morsitans and G. tachinoides). River-blindness of humans carried by black flies (Simulium sp.) was and still is prevalent in the area, and may have contributed to the low human population density.

Almost nothing is known about the history of wildlife in the area. Scattered accounts of early explorers reported fair numbers of game, notably buffalo and elephants (Roure 1956). When questioned, old residents in the region stated that game populations have not changed significantly in the past 50 years. Antelope numbers, they advised, may have declined slightly, but buffalo and elephant populations have increased.

Park W was first declared a game reserve in 1925 by the territorial governor of French West Africa. His decree called for hunting regulations and the protection of wildlife but none were actually carried out at that time. Permanent establishment of the park began after 1936, following the International Convention on Wildlife in London. During 1936-1937 Dr. Faisson, a medical doctor and veterinarian, explored the region and identified game-viewing and scenic areas within the park. On November 13, 1937, the reserve officially became a national park and, by a decree of the territorial governor, all hunting and exploitation was forbidden within the designated boundaries. The reserve was named Park W because of the natural formation of that letter by the Niger river (Figures 1 and 2).

Nothing more was done until 1950, when roads, guard posts, and tourist facility construction began. Although several had been relocated, twelve villages were allowed to remain in the park. These settlements involved several hundred inhabitants, and had been scattered along the major watercourses. By 1955, the villages of hunters, fishermen, herders, and subsistance farmers had been relocated outside the park boundaries, mainly along the Niger and Tapoa rivers. Between 1969 and 1978 development projects in Niger's portion of Park W included road construction, waterhole development, and tourist facilities. The park now has a visitor center, twelve artificial waterholes, and more than 475 km of roads.

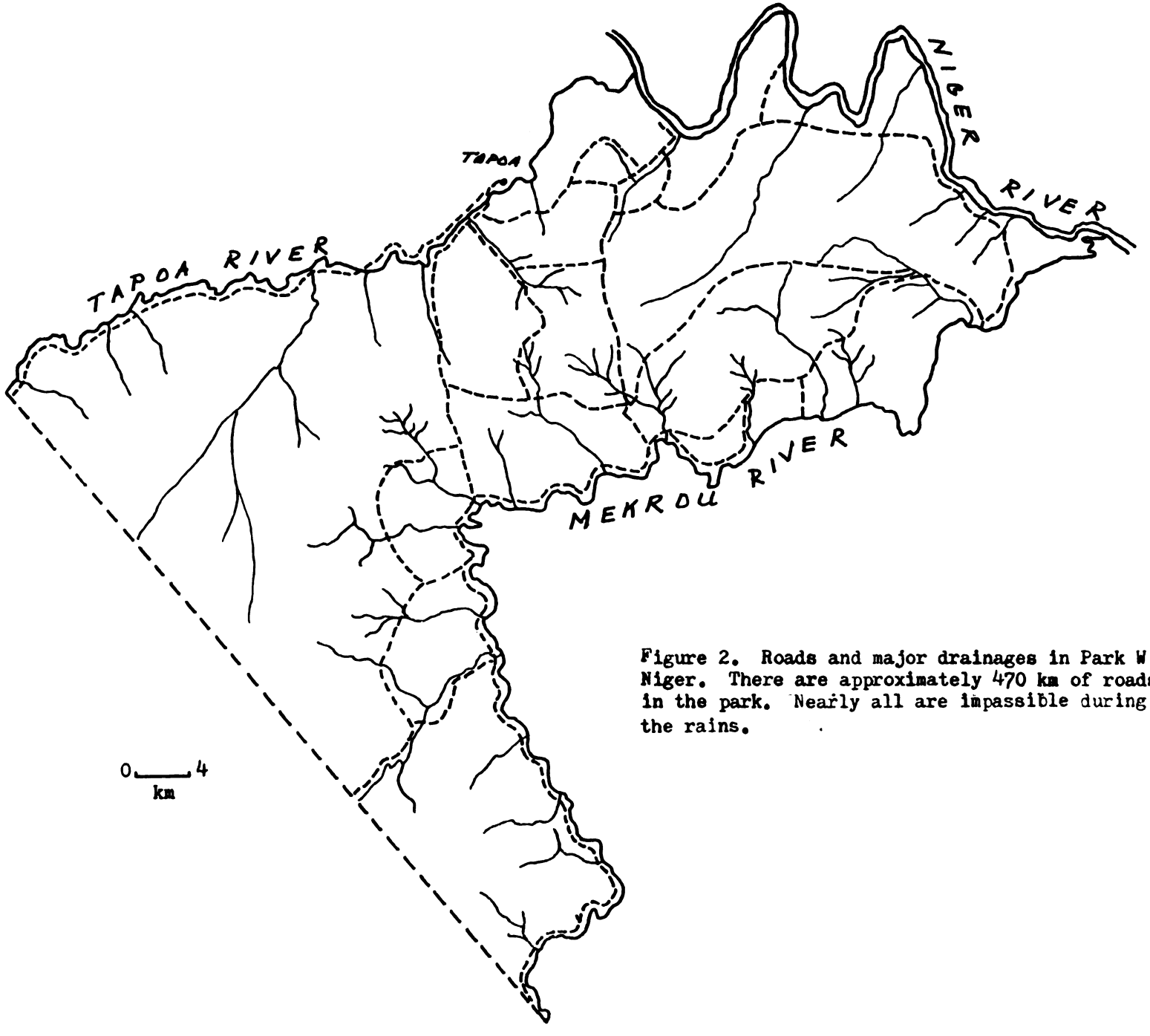

Figure 2. Roads and major drainages in Park W, Niger. There are approximately 470 km of roads in the park. Nearly all are impassible during the rains.

THE PHYSICAL ENVIRONMENT

Climate

The park lies within the 700-800 mm isohyets. Rains (Figure 3) normally begin in mid-May, but may come as early as late April or as late as June. Rainfall amounts increase gradually through August, the wettest month, then decrease and end during September or early October. High temperatures during the rains average 33°C. Following the rains, the hot humid season extends into November. The cool dry season lasts until mid- to late February. This pleasant period supports high temperatures of 30-32°C and lows of 12-14°C. The following hot dry season lasts until the rains begin. Hot season temperatures (Figure 4) of 40-42°C are not unusual, while hot season lows may reach 24-26°C.

During the hot dry season, characterisitc harmattan winds carry dust from northern latitudes and, at times, visibility is significantly reduced.

Geology and Soils

Surface rocks and soils have revealed (Roure 1956) that the region lies within a zone formed during the Precambian and Tertiary periods. Surface features include deposits of sand, gravel, shales, stony rock wastes, lithosols, and

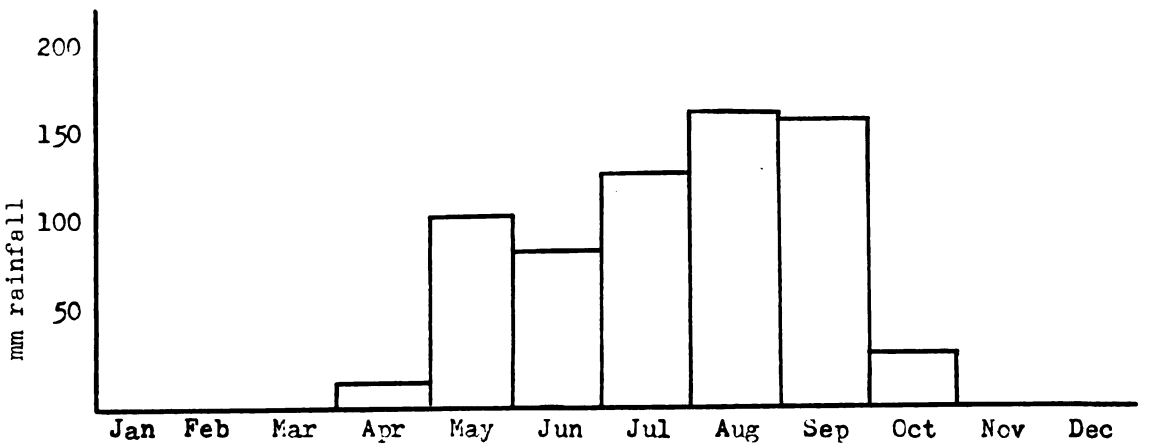

Figure 3. Mean monthly rainfall at Tapoa, Park W, Niger, 1973 through 1976, in millimeters. Scattered rainfall occurs during March and April but is localized and seldom recorded.

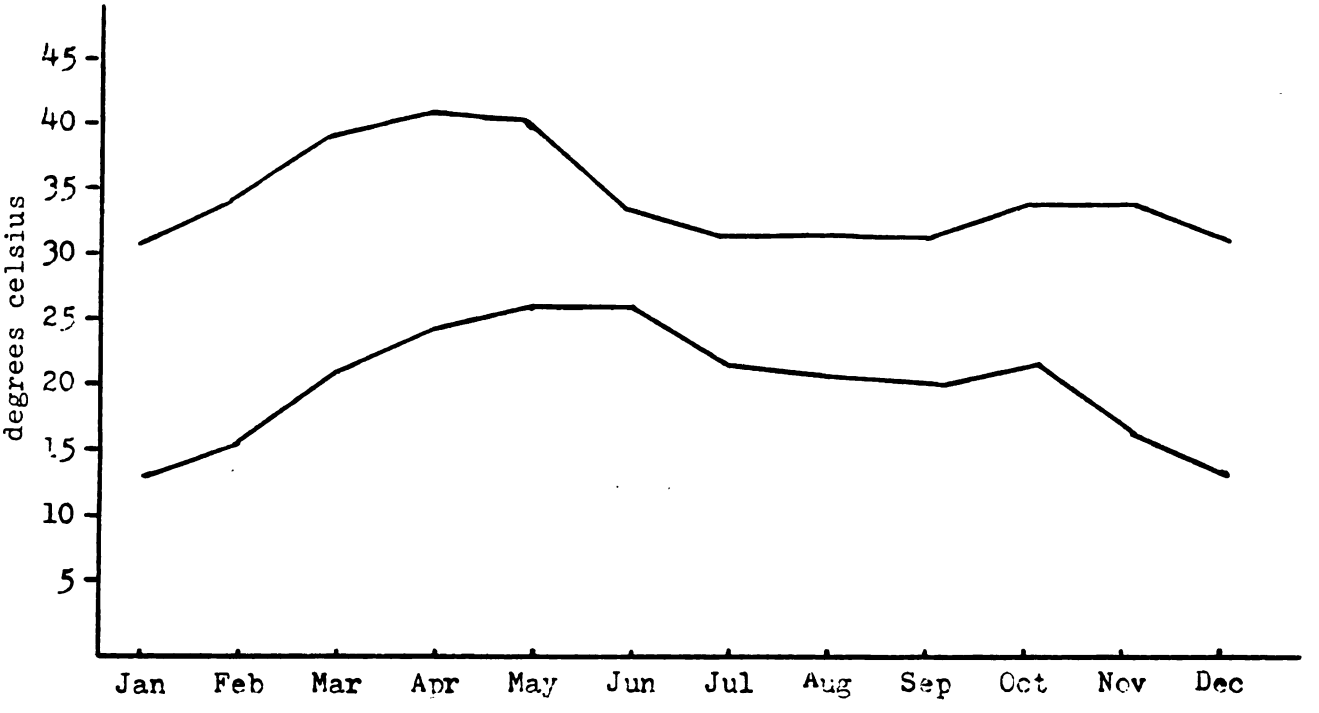

Figure 4. Mean monthly high and low temperatures recorded at Tapoa, Park W, Niger, in degrees celsius. Temperatures were recorded from 1973 to 1977.

metamorphic rocks consisting of schists, gneisses, granites, and quartzites. In addition, there are extensive ironstone sheets. In several areas, the Tapoa and Mekrou rivers have cut through 30-60 meters of rocks, exposing layers of quartzites and muscovites. Most geologic formations follow the directions NE-SW or NNE-SSW (Roure 1956).

There are two principal soil catenas within the park. The first is associated with exposed weathered rock formations which lie adjacent to the three major rivers, and are composed of quartzes, schists, and gneisses. On the outcrops, soils are thin and poor, but deepen toward the outcrop bases, and there form a mixture of sandy clay loams and sandy loams. In some areas, especially along the Mekrou river, rock outcrops are highly weathered and occur as plateaus with scattered boulders on the surface, and with very thin soils. Adjacent to the rivers, colluvial soils integrate with alluvial soils to form flood plains from a few to several hundred meters wide. Floodplain soils are often sandy but deep loams form in frequently inundated areas. On outcrops facing away from the rivers, soils gradually deepen, but usually are stony or very sandy, especially along the Niger river. Higher clay contents are normally found only in stream basins and poorly drained soils.

Most of the park's interior is comprised of upland soils with a high iron content. These are infertile soils termed ironpan formations. Some are several meters thick and extend

over many square kilometers. They grade into gently-sloping deeper sandy loams and sandy-clay loams. Stream basins and depressions have deeper soils which are generally fertile. They cover entire drainage basins in flat areas. Scattered throughout the park are flat-topped outcrops of ironstone. The outcrops, sometimes reaching 50 meters, have poorly developed soils with scattered ironstone boulders on the slopes, and pea-sized ironstone nodules toward the base. These well-drained soils support only shrubby vegetation and sparse grass cover. Deeper soils tend to support woodlands.

Hydrology

The Niger river drains the entire region and flows throughout the year. Two principal tributaries drain the park but flow only seasonally. The Mekrou is the larger and reaches a depth of more than 2 meters during August and September. By December, flow diminishes and stops, but numerous pools remain throughout the dry season. The Tapoa River is considerably smaller, attaining a depth of less than 1 meter during the rains, and ceases to flow by December. It has only two waterholes which persist throughout the dry season.

More than 50 seasonal drainages of varying sizes empty into the three main rivers during the rainy season. Nearly all cease to flow soon after the last rains. Several of the larger seasonal streams contain pools late into the dry season, and in some years they persist until the next rains. At least six streams have springs along their banks which feed pools,

but only two are known to maintain a flow throughout the dry season.

METHODS

Vegetation

Vegetation studies were carried out during the latter portion of August through October 1977, when woody plants were fully leaved and most grasses were identifiable. Preliminary surveys were conducted to determine the general vegetation types present. Each type was sampled to determine floristic composition by making traverses of at least five transects in each major type.

The point-center-quarter method (Cottam and Curtis 1956) was employed to determine tree and shrub composition, density, and dominant species. Each transect consisted of at least 10 sample points, with 20 meters between each point. All trees and shrubs taller than 1 meter were included in the survey, and heights of each were recorded. Canopy cover was estimated according to the method developed by Emlen (1967). Presence or absence of canopy directly above the observer was recorded at 3 meter intervals.

Grass composition was determined from transects of 100 sample points each. A metal rod was placed at the end of the samplers shoe at two pace (2 meter) intervals, and the second-closest grass plant to the rod was recorded at each point. If the rod tip fell within the diameter of a perennial grass tussock, it was recorded as such, and the number of points provided a percentage of perennial grass basal cover.

Classification of vegetation follows that of Pratt (1966) for rangeland in East Africa and of Geerling (1972) for vegetation in Nigeria. In this study, vegetation was considered mainly as wildlife habitat. Classification was intended to separate plant associations into those which could be easily recognized by park personnel with a minimum of experience.

Fauna

Ungulates were tallied on the basis of more than 1100 km walked and 6000 km driven. The majority of observations were made during the dry months since poor road conditions and dense vegetation made travel and observations difficult during the rainy period.

Population estimates of ungulates in Park W are based on a comprehensive survey made during January and February, 1978, in which 62 compass-line transects totalling 650 km were walked, mainly by four teams of two individuals each. Transects were traversed between the hours of 0700 and 1100, but occasional transects were not completed until early afternoon. Transect lengths were between 6 and 12 km, usually 10 km, with a minimum of 1 km between each. These lengths were measured from landmarks on topographic maps and by pacing.

The mean visibility method described and tested by Hirst (1969) in South Africa was used to estimate ungulate populations densities. Mean disappearing distances were estimated for each species and based on measurements of actual distances determined by pacing or with a range finder.

Because some areas were inaccessible and only one vehicle and limited fuel were available, complete randomization of transects was not possible. It was necessary to begin transects along park roads. Bias in transect placement was minimized by randomly selecting the first transect along a route and beginning the remainder at 3 km intervals along the route. This permitted a fairly complete and systematic coverage of the park with maximum fuel-time-efficiency.

Hirst (1969) found that disappearing distances provided good estimates of mean strip widths, where random distribution can be assumed to prevail. It was apparent in Park W, however, that animals were not randomly distributed. Many species formed herds, and were clumped near surface water. Therefore only rough approximations of total numbers were possible. Other censuses in this park carried out by landrover and helicopter, however, gave similar results (Koster, unpublished reports).

The buffalo population occurred in large breeding herds, and was determined by finding the total number of herds in the park and repeatedly counting each herd. Elephant numbers were determined from an aerial survey carried out during February, 1977 (Koster 1977). Population density estimates for each species were calculated only for the estimated areas occupied at the time of the survey. It was felt that this was the most meaningful procedure since most species were not found throughout the park, and several had a very restricted distribution.

VEGETATION

General Description

Stebbing (1937) stated that woodlands which characterize Park W and much of the central portion in West Africa are often misnamed as savanna. He described this region as dry mixed deciduous forest which would become deciduous and evergreen forest with protection from fires, grazing and agriculture depending on site and soil moisture conditions. Other observers, however, refer to this region as Sudan or Sudanese Wooded Savannah (Aubreville 1948; Hutchinson 1958). The presence of many species characteristic of the more southerly Guinea Savanna such as Afzelia africana, Burkea africana, and Isoberlinia doka suggests that the park lies within a transition zone between the Suban and Guinea Savannas. But these species rarely occur in large stands and are usually mixed with species of the genus Combretum. The overwhelming dominace of the Combretaceae family throughout the park reinforces classification as Sudan Savanna. The park may best be described as Combretum Wooded Savanna which supports a more diverse vegetation where better soil conditions exist.

Within the park, three characteristic vegetation types can be identified: riparian, woodland, and shrubland. The riparian is most distinctive, while the latter two often

integrate so that separation is sometimes difficult. These characteristic types can be further classified into subtypes.

I. Riparian Vegetation

Riparian (riverine) vegetation was highly variable with separable associations ranging in life form from grassland and marsh to gallery forests. This variability is attributable to variations in soil quality, moisture, and depth, and the topography.

A. Evergreen forests.

The most common vegetation along the major watercourses was evergreen forest which forms a narrow band, 10 to 50 meters wide. High soil moisture and infrequent fire permits growth of a wide variety of plant species, many of which are normally found much farther south of Park W. Most of the park was burned annually, but because of the lack of fuel and the moist conditions, fires seldom penetrated riparian forests. Included within the riparian vegetation type are four subtypes: evergreen forest, woodland, grassland, and seasonal streams vegetation.

Riparian evergreen forests are characterized by trees growing to 30 m and a nearly closed canopy. Common trees are Diospyros mespiliformes, Anogeissus leocarpus, Ficus sp. Kegelia africana, and Daniellia oliveri on drier soils and on moist and inundated soils, Mitragyna inermis and Cola laurafolia are abundant. Common shrubs are Mimosa pigra, Combretum micranthum, Acacia atataxacantha and Acacia

erythrocalyx. Other species were abundant in forests and are listed in Appendix A.

In some areas, especially along the Tapoa river, Mitragyna inermis is the dominant species and with Vitex chrysocarpa, forms a narrow band along the banks. In other areas, mainly along the lower Mekrou and Niger rivers, Borassus aethiopum is common.

Grass cover is usally sparse, with the shade-tolerant species Panicum pilger, Paspalum orbiculare, and Pennisetum pedicellatum most common. Basal cover of perennial grasses is low (0-1%) except immediately along stream banks where Andropogon gayanus, Vetivera nigritana, and Sporobilis pyramidalis are found.

B. Riparian woodland.

Floodplain evergreen forests grade into mixed woodlands 25-30 m tall. Species composition is similar to that of evergreen forests but canopy cover is reduced to 50-80%, and ground cover density also is less. These woodlands are found intermittently along the three major rivers and involve a relatively small portion of the park. Common trees are Diospyros mespiliformes, Daniellia oliveri, Anogeissus leocarpus, Prosopis africana, Pterocarpus erinaceous, Terminalia avicennioides, Tamarindis indica, Combretum micrathum, C. nigricans, and C. glutinosum. Grass cover is generally well developed but varies with the amount of canopy cover and soil moisture conditions. Andropogon gayanus, Hyparrhenia involucrata, and Pennisetum pedicellatum are common species.

C. Riparian grasslands.

Perennial grasslands occur on seasonally inundated colluvial loamy floodplain soils. During the dry season (December-March), heavy rains upstream causes the Niger River to flood, inundating the 2-200 m floodplain along its banks. Grasses often form dense mats and grow to 3 m. Common species are Jardinia congoensis, Sacciolepsis africana, Sporobolis pyramidalis, Vetivera nigratana, Fibristylis dicotoma, and sedges Cyperus sp. Mimosa pigra shrubs are common along the floodplain, and often form dense stands or are interspersed with grasses.

Seasonally inundated grasslands grade into drier floodplain grasslands in some areas. Soils on these sites are sandy loams and often of poor quality, as evidenced by their sparse grass cover. Grass cover is commonly less than 1 m, and includes Eragrostis atrovirens and Vetivera nigrantana on heavier soils and Chlorus pilosa, Ctenium newtonii, and Schoenfeldia gracillis on drier sandy soils. The occurrence of the last two species indicates heavy grazing pressure.

D. Seasonal Streams.

More than 50 seasonal streams of 10 km or longer empty into the three major rivers. Most contain water only during and after heavy rainstorms, but soil moisture near them is high enough to support floodplain vegetation similar to that of the major rivers. These streams and their narrow floodplains are characterized by narrow bands of woody vegetation

and are of special interest because the provide shade, cover, and corridors into otherwise inaccesible areas for many animal species. Many of these smaller streams too contain pools late into the dry season. Seasonal stream vegetation follows a general pattern from outlet to source. Nearest the outlet, sometimes for several kilometers, the vegetation closely resembles the evergreen forest, but is usually a narrower strip. These forests gradually become more open, closely resembling the riparian woodland but with greater shrub density. Plant diversity gradually decreases toward the stream's source. Anogeissus becomes increasingly common and often forms pure stands of several hectares of more. Large Daniellia oliveri and Kaya senegalensis trees provide ample shade along the banks. Other common trees are Mitragyna inermis and Combretum nigricans and the shrubs Securinega virosa, Acacia ataxacantha, and Combretum micranthum are most abundant. Grass cover is variable, becoming better developed toward the source. Common grasses are Pennisetum pedicelatum, Panicum pilger, and Andropogon gayanus. Canopy cover ranges from 50% to 90% and basal cover of perennial grasses gradually increases from less than 1% near the outlet to 7% near the source. Adjacent to many of the streams, Mitragyna inermis forms a narrow band of vegetation. Stream origins are usually basins or valleys of open woodland consisting of Combretum and Terminalia species on moderately deep soils.

II. Woodlands

This vegetation type is the most important to wildlife since it covers extensive areas near streams and supports plant life favorable to many ungulates.

A. Combretum woodland.

This is the most extensive woodland type and the most variable. It is found on soil types ranging from shallow and eroded ironpan to well-developed alluvial soils. Trees grow to 15 m, occasionally to 20 m. On more moist soils, combretum woodlands integrate with riparian woodlands and, in some areas, extend to the evergreen forest edge. Characteristic tree species are Combretum nigricans, C. glutinosum, C. hypopilinum, Crossopteryx febrifuga, Piliostigma reticulatum, Anogeissus leocarpus, and Terminalia avicennioides, and common shrubs are C. micranthum and Guiera senegalensis. Canopy cover ranges between 20% and 60%, averaging 35%. Canopy height averages 7.5 m for trees and 1.7 m for shrubs. Grass cover is dominated by annuals Hyparrhenia involoucrata, Loudetia togoensis, Andropogon pseudapricus, A. fastiagiatus and the perennial Andropogon gayanus. Basal cover of perennial grasses ranges from 3% to 7%, averaging 3.9%.

On shallow soils such as erosion areas, ironpan soils, sand, and rocky slopes, the combretum woodland is more shrub-like with a canopy height 6 m to 8 m high. Common trees on these dry soils are the same as those previously described with the addition of Detarium microcarpum and Dichrostachys

glomerata which are common in some areas. Loudetia togoensis is the characteristic grass of infertile ironpan soils. Other common grasses are H. involucrata and A. gayanus, and Diheteropogon hagerupii. Perennial grass basal cover is usually poor, between 2% and 3%.

There are many distinguishable smaller plant associations in the Combretum woodland. As site conditions change, various non-Combretum plants become increasingly common, but in most cases, Combretum species remain dominant. These associations are:

1. Combretum-Burkea africana woodlands on well drained soils, usually sandy or sandy loams.
2. Combretum-Afzelia africana woodlands on deeper, poorly drained soils, usually clay-loams.
3. Combretum-Terminalia woodlands on a wide variety of soils. This could be considered a separate type, but usually one of the two species is dominant.

Adansonia digitata, Pseudocedrella kotschyi, and Bombax constatum also occur in isolated woodlands but comprise an insignificant portion of the park's vegetation.

B. Terminalia woodland.

This woodland type often integrates with the combretum and riparian woodlands on deep soils. Trees grow to 15 m on moderately deep soils, and to 20 m on deeper soils. Dominant tree species are Terminalia avicennioides, Butryospermum paradoxum, Daniellia oliveri, Combretum glutinosum,

and C. hypopilinum, and common shrubs are Ximinia americana, Gardinia sokotensis, and Securinega virosa. Average tree canopy height is 9.1 m and 2.1 m for shrubs, and average canopy cover is 35%. Grass cover is well developed, often to 3 m, with annuals Hyparrhenia involucrata and Andropogon pseudapricus and perennial A. gayanus the dominant species. On sandy soils, Diheteropogon haguperii is also common. Basal cover varies significantly, ranging from 2% to 10%.

A second distinct Terminalia woodland is prominent in some areas in which T. macroptera is the dominant species. This species is slightly taller than T. avicennioides and occurs in 2 to 5 hectare open park-like stands on flat, poorly drained soils. Other trees in this type are Daniellia oliveri, Pterocarpus erinaceous, Crossopteryx febrifuga, Combretum glutinosum, C. hypopilinum, and shrubs Ximinia americana and Securinega virosa.

C. Combretum-Detarium woodland.

This occurs mainly on rocky soils along the Mekrou river. Soils are thin and poor, and support more open vegetation. Canopy height ranges between 4 and 6 m and canopy cover is from 20% to 40%. Characteristic species are Detarium microcarpum, Combretum glutinosum, C. nigricans, Terminalia avicennioides. Grass cover is not well developed, and includes Loudetia togoensis, Diheteropogon haguperii, and Hyparrhenia involucrata. Perennial basal cover is less than 2%.

D. Combretum-Balanites woodland.

This consists of Balanites aegyptiaca mixed with Combretum and Acacia species on well-drained sandy loam soils. This type occurs mainly on the Niger River floodplain, but also along the Tapoa and Mekrou Rivers. Trees are small, to 7 m, and canopy cover is usually less than 25%. Other trees in this type are C. glutinosum and C. nigricans, with shrubs C. aculeatum, Acacia ataxacantha, Zizephus mucronata, and Dichrostachys glomerata.

III. Combretum savanna shrubland

Shrub savanna occurs mainly on infertile porous soils in upland areas, and covers extensive areas of the park's interior. On flat ironpan plateaus common shrubs are Combretum micranthum, C. nigricans, Dicrostachys glomerata, and Guiera senegalensis. C. glutinosum and several other species which normally occur as trees on moist soils, but appear here as shrubs. Canopy height is 2 to 4 m with emergent trees such as Burkea africana and Anogeissus leocarpus growing to 10 m. Canopy cover averages 28%, and the basal cover averages 1.6%, reflecting the poor soil quality.

On eroded slopes and rocky soil, Guiera senegalensis, Dichrostachys glomerata, Combretum nigricans, C. glutinosum, and Securinega virosa are common shrubs, and some Terminalia trees also occur. Common grasses are Loudetia togoensis, L. annua, Ctenium newtonii, and Hyparrhenia involucrata.

Andropogon gayanus is one of the few perennial species in shrublands, and grows mainly in the shade of trees and shrubs.

IV. Grassland

Scattered throughout the park are isolated openings in shrublands and woodlands. These occur mainly on shallow flat ironpan soils in upland areas. Grasses are mainly annuals including Loudetia togoensis, Microchloa indica, Andropogon fastigiatus, and A. pseudapricus. The first two species are the most common, but are avoided by most ungulates. They dry quickly after that rains and burn nearly every dry season. A few scattered low-growing shrubs persist on these sites, including Combretum nigricans, C. glutinosum, and Acacia ataxacantha. These grasslands range in size from several hectares to 2 km^2. Canopy cover is less than 10% and perennial grasses are uncommon.

A second grassland type occurs on seasonally inundated alluvial soils. Grasslands located in the beds of seasonal streams are often 150 m wide and some extend more than 1 km in length. Grass species are mainly perennials including Andropogon gayanus, Hyparrhenia cyanescens, Vetivera nigratana, and Sporobolis pyramidalis. On moist soils with high water tables, Jardinia congoensis sometimes forms dense stands growing to 3 m. These impede drainage and maintain moist soil conditions during the dry season.

Other grasslands occur in heavy clay soils along the major rivers and may better be termed marshes. They are

usually less than 4 hectares in extent and retain standing water 1 to 3 months following the rains. Common grasses are those described for moist-soil grasslands.

Patterns of vegetation growth

Plant growth is limited almost entirely to the rainy season. Grasses grow and mature at varying rates, but the majority fruit near the end of the rains during September and October. Some upland grass species such as Loudetia togoensis mature in late August, and are the first to dessicate. In heavy soils next to streams, rivers and marshes, grasses may remain green from one to two months following the last rains. Perennial grass species are normally the last to mature and dry.

All grasses become dormant during the dry season except those in very moist soils. Deciduous trees and shrubs also become dormant, and shed their leaves usually between December and March. Leaf-fall may occur much earlier if the grass cover has been burned. New leaves sprout during the hot dry season prior to the rains, and many species also bear fruit before or during the leaf-growth period.

Perennial grasses normally sprout following early dry-season fires, but some growth may occur following later fires provided that soil moisture is sufficient. Growth can reach between 5 cm and 10 cm in height in drier soils and up to 20 cm in moist soils. Many ungulate species, however, have been observed grazing on this regrowth or flush, and it seldom reaches more than a few centimeters before being consumed.

Patterns of habitat use by ungulates

Researchers in East Africa (Bell 1971; Pratt and Gwynne 1978) have described grazing mosaics or grazing successions which are sequences of grazing by a spectrum of ungulate species. Larger hoofed animals utilize the tall course grasses which then opens the way for smaller species. Successional grazing patterns occur to some extent in Park W but are not well developed. In areas along the Mekrou River where buffalo and elephant are most abundant, the grass sward is sufficiently reduced to encourage use by kob, waterbuck, oribi, and other species. But over most of the park, ungulates are too few to affect the vegetation markedly. Further, grass grows very rapidly, particularly during August, at which time the larger ungulates are most widely dispersed.

Most grazing species utilize a wide variety of habitat types (Table 1). Woodlands of low to moderate tree and shrub density on moderately deep soils are favored by the majority of ungulate species. Presumably, this is because soil quality and consequently forage nutrients and diversity are better on these sites.

The habitats used least by ungulates are the dense shrublands and grasslands on ironpan soils. One of the dominant grass species on these areas is Loudetia togoensis which is avoided by most species. These sites are characterized by low plant diversity and infertile soil conditions. Unfortunately, they cover extensive areas of the park, and

Table 1. Relative frequencies in percentages of sightings of ungulate species in habitat types for Park W, Niger from 1975 to 1978.

Species	Habitat types							
	Evergreen forest	Riparian woodland	Riparian grassland	Seasonal streams	Combretum woodland	Terminalia woodland	Shrub-land	Upland grassland
Kob	6.2	6.3	20.8	0.5	26.1	16.9	22.2	1.0
Waterbuck	2.3	6.8	2.3	0.6	32.4	42.1	12.5	1.1
Roan antelope	1.4	11.3	2.8	4.2	32.4	15.5	31.7	0.7
Hartebeest	0.0	11.3	2.3	0.0	31.8	11.3	38.6	4.6
Warthog	7.5	6.3	13.8	3.1	33.8	16.9	14.4	4.4
Buffalo	2.8	5.6	8.5	2.1	35.2	22.5	20.4	2.8
Elephant	18.5	8.7	14.6	5.8	11.7	14.6	24.3	1.9
Reedbuck	13.6	17.0	18.6	8.5	22.0	8.5	11.9	0.0
Buchbuck	21.3	19.2	14.9	17.0	8.5	6.4	12.8	0.0
Grimm's duiker	1.7	8.5	1.7	1.7	27.1	3.5	40.7	5.1
Oribi	0.0	6.4	2.1	1.1	38.3	13.8	33.0	5.3
Red-fronted gazelle	0.0	7.1	0.0	0.0	21.4	14.3	21.4	35.7
Topi	0.0	14.3	7.1	0.0	14.3	21.4	14.3	7.1
Red-flanked duiker	46.7	20.0	6.7	20.0	6.7	0.0	0.0	0.0
Hippopotamus	0.0	28.5	42.9	0.0	14.3	14.3	0.0	0.0

probably are largely responsible for the small ungulate populations in the park.

Fire and vegetation

Fire plays a major role in the formation and maintenance of plant communities and has long been recognized as an important tool for maintaining or modifying wildlife habitat (Komarek 1963, 1969). In Park W, fire has perhaps the most important influence on the plant communities of any factor. It offers one of the most important management tools available.

The principle objectives of burning in Park W were to improve visibility for game viewing and to destroy combustible materials which could support more serious fires later in the dry season. Fires were set after the rains as soon as vegetation would burn. Shrublands and dry grasslands could usually be burned within two weeks after the rains, but dense woodlands often required one to two months to dry. Individual fires frequently burned for several days, and often covered more than 100 km^2. In addition to fires set by park personnel, local herders and hunters illegally started fires in the more remote regions of the park. As a result, more than 70% of the park's total area was burned annually.

Early dry-season fires were considered desirable because they were slow, incomplete, damaged few trees, left a mosaic of burned and unburned areas, and stimulated growth of perennial grasses which provided green forage for ungulates during the dry season. There is some evidence, however,

that early dry-season fires can be detrimental, and the buring policy in Park W should be carefully examined.

Kennen (1972) for example, found that annual burning in the thornveld of Rhodesia (1957-1971) caused severe deterioration of perennial grass cover. This was accompanied by a gradual replacement of perennials by annuals. This may possibly explain the low percentages of basal cover reported in this study. There was also evidence that burning at the end of the growing season can damage partially-green perennial grasses because food reserves have not fully transferred from the leaves to the roots (Rains 1963). If the grasses then resprout, they do so at the expense of partially-replenished root reserves. If the resulting growth is grazed, root reserves are further depleted, and plants can die within a few years.

There is also reason to believe that the present burning policy has resulted in an increase in woody vegetation in recent years. Local residents have indicated that the densities of trees and shrubs have gradually increased, and fire may have caused this. Experimental early dry-season burns in Ivory Coast and northern Ghana resulted in marked increases in woody vegetation (Innes 1972). This occurred largely because the relatively cool fires did not seriously damage seedlings or small trees of species adapted to withstand fires. Glover (1968) found that many species of Combretum have extensive underground stems which can regenerate quickly.

In the absence of hot fires for two to three years, they can become large enough to be safe from fire. Many examples of this can be seen of this in Park W. The most notable fire-resistant species are Combretum glutinosum, C. nigricans and Terminalia avicennioides, and in some areas, literally hundreds of shoots per hectare cover the ground. As a result, the viewing of game animals in the park has become more difficult.

Mid-dry season fires comprised a large percentage of the total area burned each year. These fires were usually set by hunters, herders, or tourists. Fires at this time are undesirable because grazing animals are deprived of their food supply at a critical time of the year; perennial grasses begin growing, but die back due to a lack of moisture (Van Rensburg 1972). These plants are weakened, and are less able to compete with woody vegetation. Although these fires are hot, most trees and shrubs are unaffected since they are dormant.

Management of fire

A controlled-burning plan for Park W should have the following objectives: improve visibility for game viewing, control woody vegetation, improve or maintain grass cover, attract game, remove undesirable accumulations of vegetation, protect the park against unwanted fires, and provide for the specific needs of wildlife species.

Controlled burning schemes are difficult because intended goals can conflict. For example, burning to improve visibility can increase woody vegetation and deteriorate grass cover. Similarly, where early burning stimulates perennial grass growth that may benefit hartebeest, waterbuck, and kob the important dried grass food supply of elephants and buffalo is eliminated. And a conservative burning program early in the dry season exposes the park to fierce fires throughout the dry season.

Studies in other areas have shown that controlled burning during both the early and late dry season may be necessary to achieve management objectives (Rains 1963, Innes 1972, Austen 1972, thomas and Pratt 1967, Ross and Harrington 1968 and 1969). Fires just prior to or soon after the first rains are very hot, and can effectively reduce woody vegetation within a few years and improve basal cover of perennial grasses (Trollope 1972). Trees and shrubs at this time are most sensitive to fire, but grasses are still dormant. Annual burning of this type can open up dense woodland within four to five years (Rains 1963).

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A total of 15 ungulate species was recorded in the park during the survey. They were representative of species found in other West African game reserves, and are widely distributed in Africa (Figure 5). In their West African range, these ungulate species are distributed mainly within the Guinea and Sudan Savanna zones, and the Park W region represents the northern-most range of nearly every species.

Kob

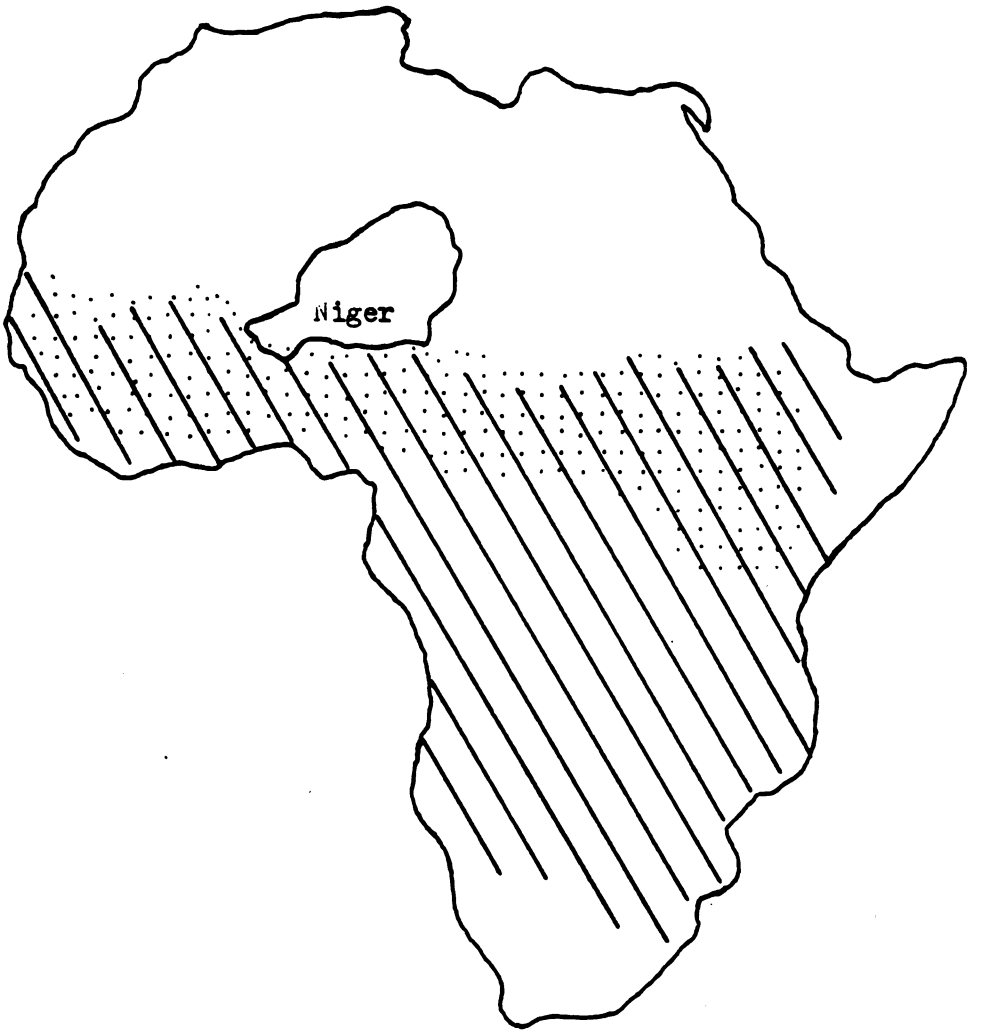
Buechner (1974) noted that the kob (Kobus kob kob Erxleben) is a species of the open savanna, always near water. In Park W, open savanna is scarce, and kob inhabit open shrubland and woodland areas. Forest and dense woodlands and shrublands, however, are mostly avoided. Kob were common only along the Mekrou and portions of the Tapoa Rivers. During the dry season, they were nearly always within 500 m of water and usually were within 300 m. During the rains they range somewhat farther into the savanna, and sometimes several kilometers from the rivers along seasonal streams. Very few were found along the Niger or Upper Topoa Rivers, apparently because of the presence of livestock and hunters.

Kob are almost purely grazers. Grasses observed eaten by kob were Paspalum orbiculare, Andropogon gayanus, Hyparrhenia

involucrata, Pennesetum pedicellatum, and P. polystachion. Sprouts of perennial grasses were heavily grazed after fires. Leaves and twigs of woody species sometimes were eaten late in the dry season when grazing was poor.

An estimated 500 kob occupied approximately 275 km^2 during the dry season. The average density of 2.77 per square kilometer was one of the lowest recorded in Africa (Table 2), suggesting that kob habitat here is marginal, and near the geographical limit of their range.

This species is sedentary as in East Africa, but territorality, mating behavior, and herd structure differ. Buechner (1961, 1974) described the territorial breeding grounds of male Ugandan kob as mainly small fixed territories within a central area of intensive activity, about 200 yards in diameter, and containing 12-15 more or less circular territories. The main activities within these territories was territoral defense and mating. Females entered male territories for the purpose of mating. The central area was surrounded by a zone of more widely spaced male territories, where breeding seldom occurred. This type of breeding territory has been observed in many portions of the kob's range (Leuthold 1967), but did not occur in Park W. Instead, male kob formed single territories similar to those described by Leuthold (1967) for territories in marginal habitat in Uganda. Territories here were side-by-side adjacent to rivers. Territory sizes were not individually measured in Park W, but general



Hartebeest, kob, red-flanked duiker, reedbuck, topi, and waterbuck

Bushbuck, elephant, buffalo, Grimm's duiker, oribi, roan antelope, and warthog

Figure 5. Generalized distribution patterns of ungulates found in Park W, Niger.

observations indicated that they were considerably larger than those reported by Beuchner (1961) and Leuthold (1967). Beuchner (1974) suggested that high population density may be essential for expression of territorial behavior in kob, and in Park W male kob were widely dispersed.

Though the kob is a social species throughout its range, it appeared to be far less so in Park W. The largest group observed was 13, considerably fewer than reported for other areas (Table 2). Poor habitat quality and competition with other grazing species such as waterbuck, may account for this.

Herd structure

The overall herd structure did not change appreciably during the year (Figure 6). Kob bred throughout the year, but a slight decrease in average group size occurred during February, and may have been caused by females leaving their groups to calve. There was a corresponding increase in the percentage of young in March (Figure 7). The adult male: female sex ratio was strongly in favor of females at 28:72. Subadults and young averaged 15% of the population over a three year period.

Male kob were most commonly solitary (85%) while the remaining 15% consisted of an adult male and between 1 and 4 subadults (Table 3). Thirty-three percent of all males observed during the survey were in the company of females.

Females tended to form larger groups than males, although eight-nine percent of all females unaccompanied by

Table 2. Average numbers per square kilometer and maximum group sizes for kob in Park W, Niger and four other areas in Africa.

Location:	Park W, Niger	Arly Park, Upper Volta	Comoe Park, Ivory Coast	Uganda	Uganda
Authors:	This study (1978)	Green (1979)	Geerling & Bodkam (1974)	Leuthold (1967)	Buechner (1961)
Density	2.77	10.9	13.8	40.0	45.0
Maximum group size	13	50	58	1000	400-500

Table 3. Frequencies of kob group sizes for several herd types in percentages. These figures represent averages during the study period.

Composition	Herd Sizes									
	1	2	3	4	5	6	7	8	12	13
Males (1)	85.1	7.5	2.1	1.1	4.2	-	-	-	-	-
Females (2)	16.8	37.5	21.6	12.8	4.0	2.4	0.8	4.0	-	-
Harems (3)	-	17.2	15.6	15.5	12.5	3.1	15.6	1.6	3.1	-
Total groups	35.7	23.0	13.8	9.5	6.7	3.9	1.1	5.3	0.4	0.7

(1). Represents groups consisting of adult and subadult males.

(2). Represents groups consisting of adult and subadult females and young.

(3). Harems consist of one adult male and combinations of females, subadults and young.

Total groups represents of relative frequency of sightins for all kob groups.

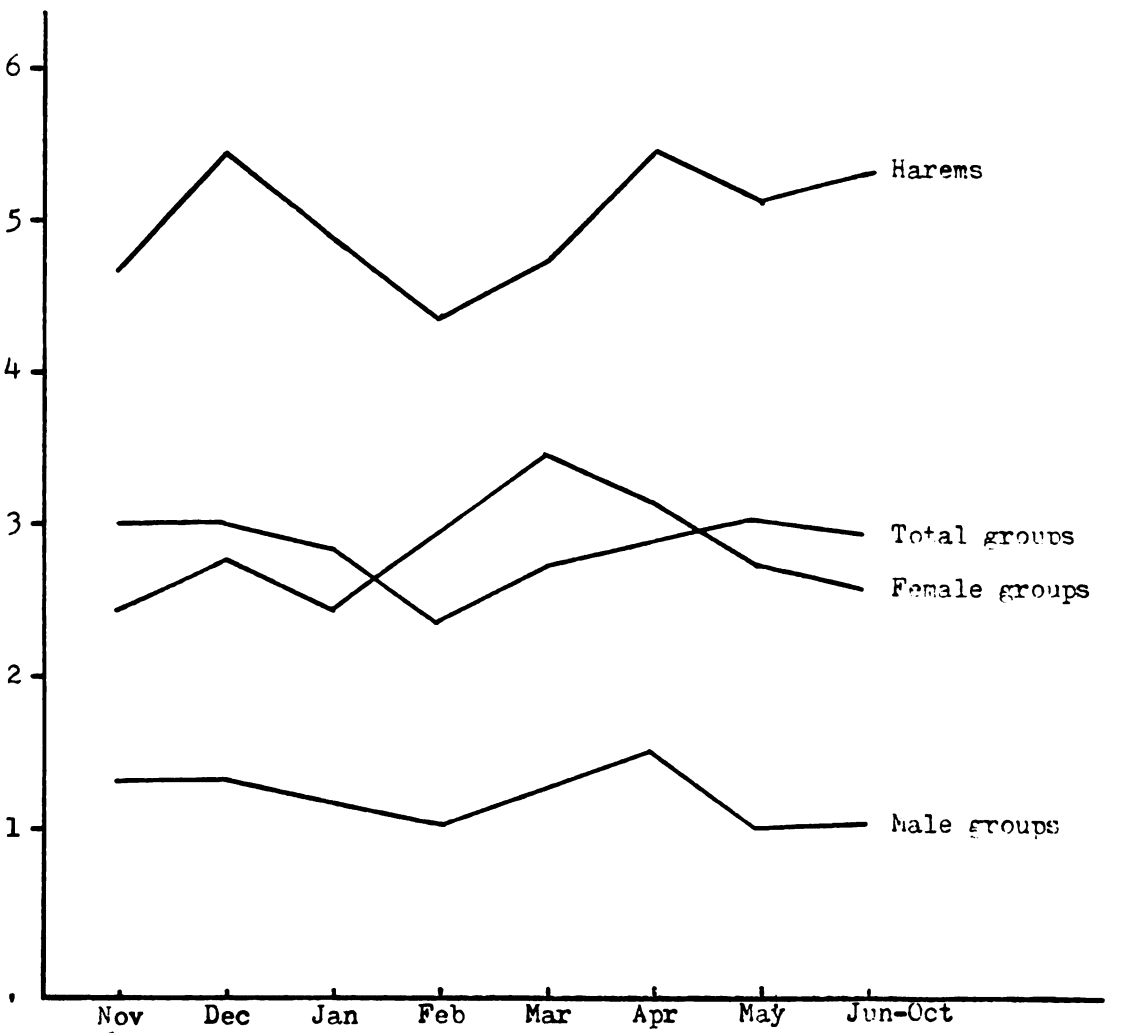


Figure 6.. Seasonal changes of mean group sizes for kob in Park W, Niger from 1975 to 1978.

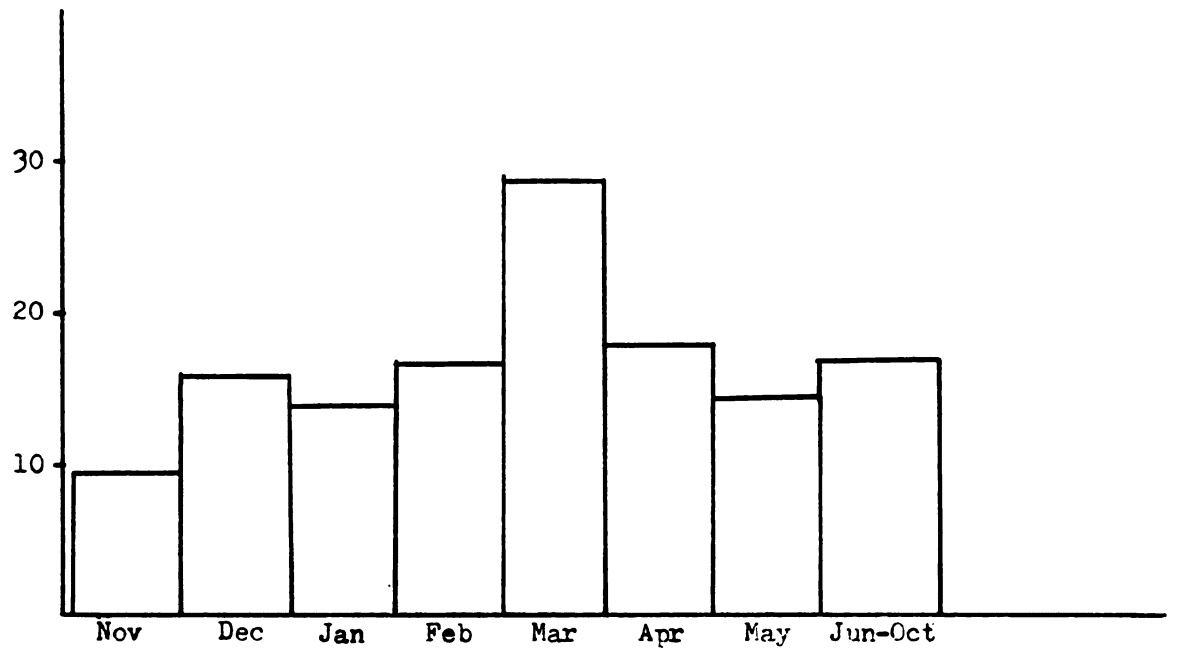


Figure 7. Average percentages of calves per adult female kob in Park W, Niger.

males were solitary or in groups of 2 to 4 individuals. Forty-five percent of these consisted of an adult and sub-adults or young. DeVos and Dowsett (1966) reported that species of the genus Kobus hide their young often up to a month after birth. Apparently, many females left larger groups to give birth, and later formed small groups with other females with young. Many of the solitary females may have been those with young hidden from view.

Mixed groups, referred to here as harems, consisted of an adult male, at least one adult female, and various combinations of sub-adults and young. The average harem size was 5.03, but varied slightly by month (Figure 6). Two harems of equal size were observed frequently for more than a year. Both averaged 8 individuals (range 6-9) including the males. Each harem remained in a 1 km^2 area throughout the year, and most were seen in a ¼ km^2 area. An adult male was present with the group in slightly less than 50% of the sightings. Both males and females appeared to be attached more to the territory than to the harem. Adult males other than the two dominant ones were never observed near the harem.

Groups of kob in which males were present occurred in only 34% of the cases, but there was a tendency for larger groups to be accompanied by males. Groups of 6 or more females had males present in 70% of the cases.

Waterbuck

Waterbucks, Kobus defassa, appeared to be more selective

of habitat than kob, but had a nearly identical overall distribution. They were almost always in the vicinity of rivers and waterholes, and remained along seasonal streams during the dry season as long as water was available. The majority of the population was found along the Mekrou River, but waterbucks were also common along the middle section of the Tapoa River. Sightings along the lower Tapoa, Niger, and lower Mekrou Rivers were rarely made. During the dry season, most waterbuck were within a 500 m band along the rivers, but occasionally they travelled as far as 1 km. During the rains, some individuals range farther into the savanna, often several kilometers, where favorable habitat existed, utilizing seasonal waterholes.

Their habitat preference was primarily for woodland with low shrub and tree densities, but with a moderately high canopy cover (see Table 1). Hirst (1975) in South Africa and Hanks et al. (1968) in Zambia reported a similar habitat preference for open woodlands. Occasionally in Park W they were found in marshy areas, but normally avoided open habitats.

Waterbuck in Park W were mainly grazers, and like many other ungulate species grazed heavily on perennial grass which sprouted after fires. Species observed eaten include Andropogon gayanus, Rottboellia exaltata, Acroceras amplectans, Hyparrhenia cyanescens, H. involucrata, Sporobolis pyramidalis, and Jardinia congoensis. Aquatic vegetation in drying riverbeds

and waterholes was also eaten. During the late dry season, waterbucks were occasionally seen feeding on sapling leaves and shrub leaves and twigs.

The population was estimated at 450, based on the 300 km^2 occupied during the survey. The average density was 2.59 per square kilometer. This figure was lower than densities reported in most other parks and reserves, where estimates as high as 46 per square kilometer have been recorded (Spinage 1969).

The adult male:female sex ratio was 37:63 and the adult: subadult (including juveniles) ratio was 79:21. The unequal sex ratio for waterbuck is even more pronounced in other areas. Bouliere and Verschuren (1960) in Zaire estimated the percentage of males at 30.5%, Verheyen (1955) also in Zaire estimated it at 20.6%, and Dekeyser (1956) in Senegal reported 26.3%. Kiley-Worthington (1965) suggested that this imbalance was caused by mortality of males from fighting and the greater vulnerability of solitary males to predation.

Throughout their range, waterbuck are territorial (Worthington 1965, Dorst 1969). They occur as solitary males, bachelor herds, harems, solitary females, female groups, couples, and juvenile groups. In Uganda, where waterbuck breed throughout the year, no seasonal differences in herd structure or size could be detected (Spinage 1969). In Park W, however, average group size increased gradually during the dry season, and peaked just prior to the rains (Figure 8).

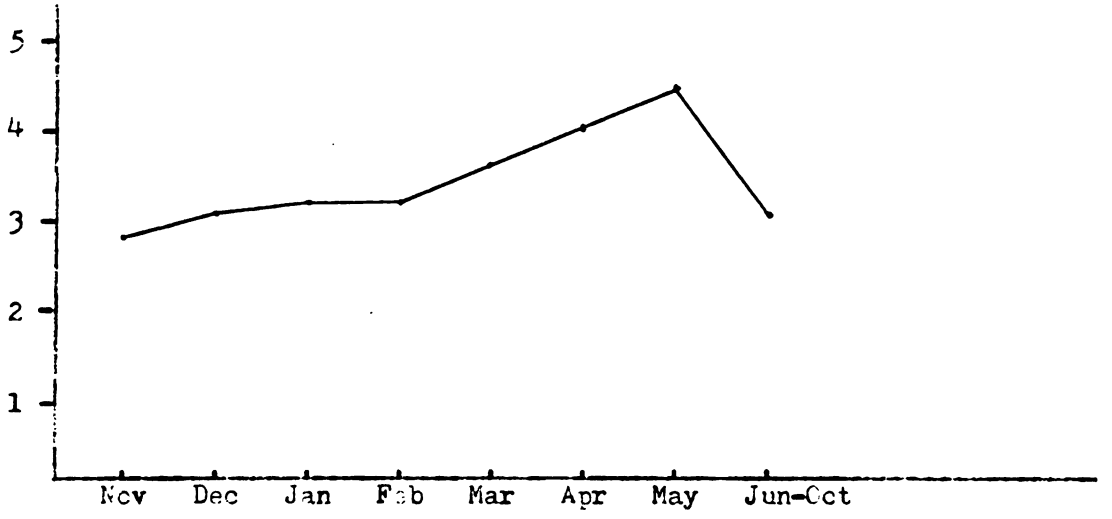


Figure 8.. Changes in average group size from 1976 to 1978 are shown by month. Observations during the rainy season (June-October) are lumped because of insufficient observations.

Concentrations around available water is believed to cause this increase.

Males were found as solitary individuals, in bachelor herds, or in mixed groups. Spinage (1969) and Hanks et al. (1968) reported that young males left their mothers when 10 to 11 months old, forming subgroups or joining adult males or bachelor herds. A similar movement was observed in this study, but male groups tended to be much smaller than those of 7 to 10 recorded in East Africa. The largest male group observed in Park W was 11 and consisted of 4 adults and 7 subadults. Only five groups of 5 of more individuals were seen during the study (Table 4). Average group size, excluding solitary males, was 3.6. Solitary males comprised 58% of all male sightings.

Male agonistic behavior was observed on several occasions. In one case, a territorial male at full gallop chased an adult male intruder more than 300 m. Other instances were of light sparring among adult males. Territory sizes were not determined, but were believed to be similar to those reported in East Africa. Spinage (1969) and Hanks et al. (1968) reported average territory sizes of 150 ha. and 133 ha. in Uganda and Zambia.

Females occurred in small groups similar to males, but appeared to have greater daily movements than males. Individual females were observed traveling more than 2 km between resting and watering areas. Spinage noted that females

Table 4. Frequencies of group size for male, female, and mixed groups of waterbuck in percentages. These figures represent averages for the 1976-1978 study period in Park W, Niger.

Group size	Males	Females	Mixed groups	Combined groups
1	54.7	26.4		30.9
2	21.9	24.5	15.2	22.2
3	6.3	18.2	12.1	12.6
4	9.4	13.6	15.2	13.5
5	1.6	7.3	12.1	6.3
6	1.6	5.5	9.1	4.8
7	1.6	0.9	12.1	2.9
8		0.9	3.0	0.9
9		0.9	6.1	1.5
10	1.6		3.0	0.9
11	1.6		3.0	0.5
12			3.0	0.5
15			3.0	0.5
17			3.0	0.5
20		0.9		0.5
23		0.9		0.5
TOT				

inhabit home ranges covering several male territories, and averaged over 200 ha. He also noted that home range shape may change seasonally as waterbuck seek burned areas or as water availability increases or decreases.

During most of the year, female groups tended to be small, usually 4 or less (Table 4) with a mean of 3.5. Late in the dry season, groups clustered as rivers and waterholes became dry. Herds of up to 23 individuals occurred in April and May at the end of the dry season. Solitary females were commonly seen during the year, and may have been those with hidden young.

Mixed groups included adult couples, and harems which consisted of an adult male and at least two females. Harems represented 15.9% of the total waterbuck sightings. In an analysis of 23 harems, 29% of the total number were adult males, 62% were adult females, and the remaining 9% were subadults and young. Females in harems tended to be accompanied by fewer subadults and young than female-only groups. Subadults and young were present in only 26.1% of the harems, but in 38% of the female groups. Subadults leaving their mother and forming separate groups may account for this difference. Couples were uncommon, representing only 15% of the total number of mixed groups.

Mixed groups occurred throughout the year, and there appeared to be a continuous breeding cycle (Table 5). This compared favorably with the findings of Spinage in Uganda

Table 5. Seasonal changes in the percentages of young seen per adult female and the percentages of mixed groups in relation to all groups sighted are given.

	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun-Oct
% young/female	15.6	8.7	14.1	11.8	17.2	16.1	4.8	8.7
% mixed groups/ total groups*	17.4	18.2	10.7	16.1	12.9	25.9	33.3	13.3

* Mixed groups are those which contain both females and an adult male and total groups refer to the total number of groups encountered during the study.

(1969), but Hanks et al. (1968) reported a sharp peak of births at the height of the rains in Zambia. There was an increase in frequency of mixed groups during the late dry season (April-May), but it is felt that this was caused by crowding around available water and not from an increase in breeding activity.

Elephant

Elephants were common in Park W, and their numbers appeared to be increasing. Visitors in the region in the 1930's reported seeing numerous elephant herds and estimated the entire Park W population there at 130 (Roure 1956). Poche (1974a) conducted the first census of Park W, Niger in 1972, and placed the late dry season population estimate at 95. His estimate was based on track counts in a relatively small area, and he believed it to be low. In 1975, Jan VanVegten (Personal communication) counted at least 150 elephants in Park W, Niger during an aerial vegetation survey, although he was not specifically searching for game. The first extensive survey was conducted by the author in late February, 1977, by helicopter, and the herd was estimated at 600 - 90. The consensus among local residents, game guards, and former park biologist Richard Poche was that elephant numbers have increased during the past 10 years. Local residents have suggested that elephant numbers may have increased because of greater hunting and grazing pressure outside Park W, Niger.

Elephant distribution in Park W was affected primarily by four factors: water, presence of livestock, hunting, and available shade. Elephants were most frequently seen drinking in late afternoon, but they commonly waited until after dark to approach waterholes. During the dry season, the lower Mekrou, Niger, and Upper Tapoa Rivers were avoided because of livestock grazing and hunting activities. The largest concentration occurred in the central, mostly inaccessable area of the park (Figure 9). Few or no signs were found in the entire western and northeastern regions.

From March through May when temperatures often reach 42°C, elephants spent the hours between 0900 and 1500 stationary mostly in shaded areas along rivers, seasonal streams, or under large trees such as Afzelia africana.

Illegal hunting has had a pronounced effect on elephant distribution. For example, following the shooting death of a 2½ year old calf near a waterhole, nearly all of the approximately 60 elephants using the area became intolerant of humans, both on foot or in vehicles. Results of encounters were invariably a series of false charges followed by either a charge of the entire herd or by their flight. Solitary animals and bull herds usually ran immediately when sighted. Observations by tourists and biologists alike were infrequent and difficult.

During the rains, elephants utilized most of the park except along the Niger River. An undetermined number

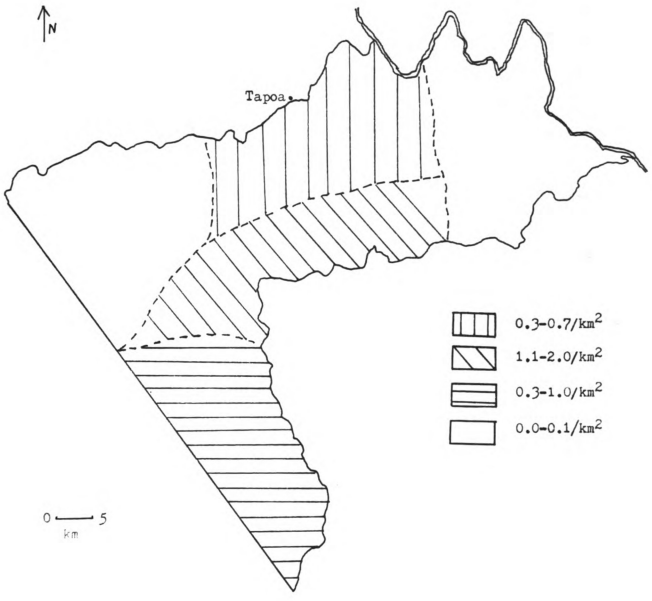


Figure 9. Approximate distribution and densities of elephants in Park W, Niger during the dry season. Estimates were based on a 1977 aerial survey.

dispersed into the region north of the park to the Dyamongou, Goroubi, and Sirba Rivers (Figure 10). Sikes (1971) noted that there is a natural tendency for seasonal migrations, and migration distances as far as 650 km have been reported in Kenya and Tanzania. Poche (1974a) stated that elephants migrate as far as Torodi, Niger, 150 km north of Park W (Figure 10), but may travel as far as the Sirba River region, about 200 km from the Mekrou River. Following the rains, elephants gradually return to the park as water sources become dry. During January and February in successive years, there has been marked increases in sightings by park personnel, corresponding to migrations from the north and other areas.

Elephants are both browsers and grazers, and sample a wide variety of herbaceous and woody plants (Wing and Buss 1970, Sikes 1971). In Park W, the diet is reported (Poche 1974a) to be 80% browse and 20% grass during November and December, a 50-50 ratio during January through March, and a 80-20 ratio during April and May. During this study, elephants were seen browsing in 82% of all dry season observations. The extensive amount of burning may influence food habits, since more than 70% of the park is burned annually.

A total of 42 woody species was found eaten by elephants in Park W (Table 6). Herbaceous species observed eaten include Andropogon gayanus, Bambusa vulgaris, Diheteropogon haguperii, Hyparrhenia involucrata, H. cyanescens, Jardinia

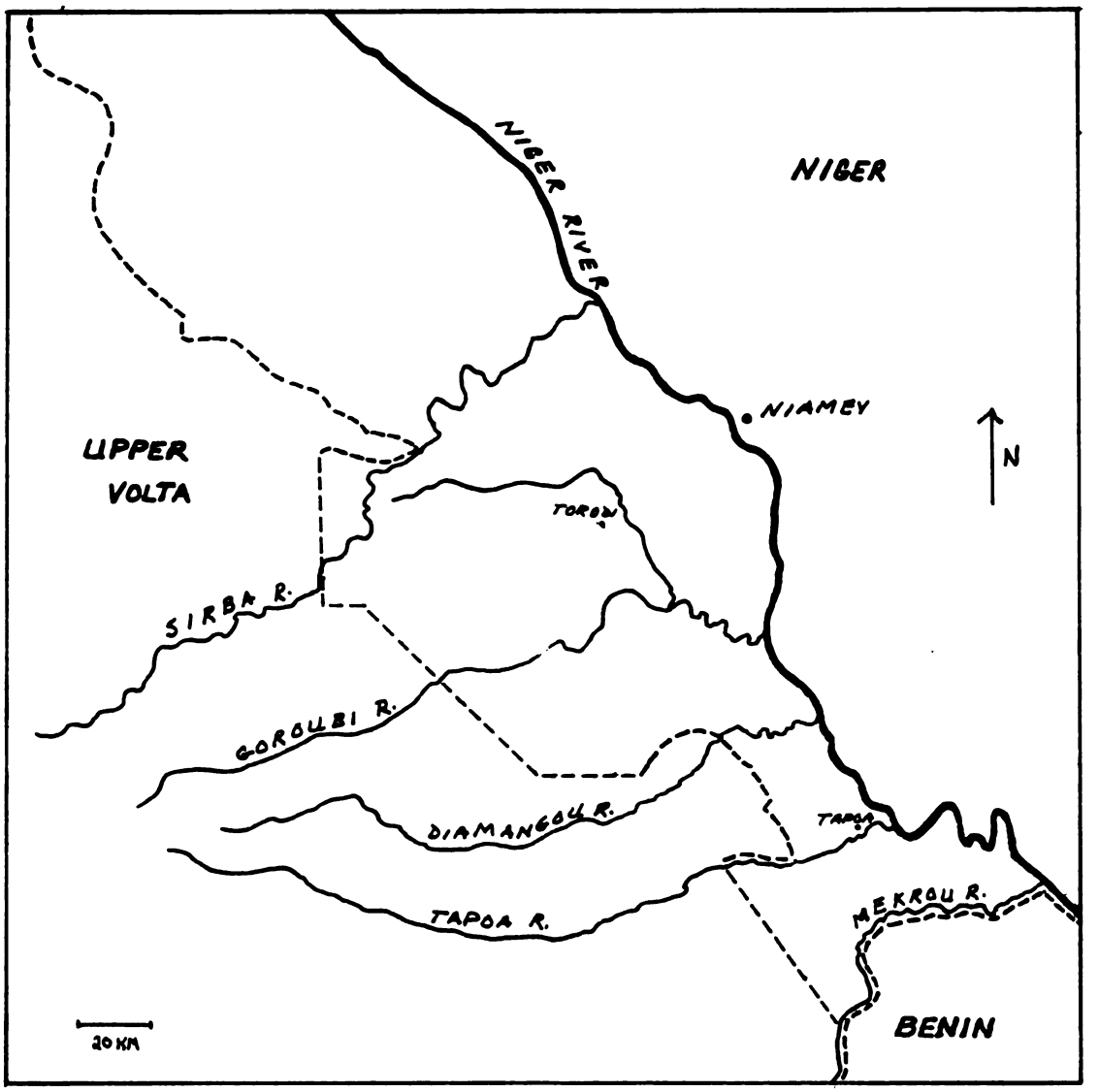


Figure 10. Park W, Niger and regions north of the park where elephants are believed to migrate during the rains. Some elephants are thought to travel as far as the Sirba River region in Niger and Upper Volta.

Table 6. Plant species observed to be eaten by elephants during the dry season in Park W, Niger, from 1976 to 1978.

Woody species	Frequently broken or uprooted	Bark damaged	Frequently eaten	Occasionally eaten
Acacia ataxacantha			x	
A. erythrocalyx			x	
A. macrostachya		x	x	
A. siberiana				x
Adansonia digitata	x	x	x	
Afzelia africana				x
Anogeissus leocarpus				x
Balanites aegyptiaca	x		x	
Bombax costatum	x	x		x
Burkea africana				x
Butryospermum paradoxum	x			x
Cassia siberiana				x
Combretum glutinosum				x
C. hypopilinum				x
C. nigricans	x			x
Crateva religiosa			x	
Crossopteryx febrifuga				x
Detarium microcarpum				x
Dichrostachya glomerata			x	
Diospyros msepiliformes				x
Ficus platyphylla				x
Gardinia sokotensis			x	
Indigofera nummulariifolia			x	
Kegelia africana				x
Lannea microcarpum				x
Lonchocarpus laxiflora				x
Mimosa pigra			x	
Mitragyna inermis				x
Nauclea latifolia				x
Parkia clappertonia				x
Piliostigma riticulatum	x	x	x	
P. thonningii				x
Prosopis africana				x
Sclerocyra birrea	x			x
Stereospermum kunthianum				x

Table 6. (continued)

Woody Species	Frequently broken or uprooted	Bark damaged	Frequently eaten	Occasionally eaten
Strychchnos spinosa				x
Tamarindus indica				x
Terminalia avicenioides	x			
T. laxiflora				x
T. macroptera				x
Ximinia americana				x

congoensis, Pennisetum pedicellatum, P. purpureum, and sporobolis pyramidalis. Use of the baobab tree Adansonia digitata was similar to that reported in East Africa (Laws and Parker 1968), and may indicate an overpopulation in some areas of the park. Three large baobab trees were found completely destroyed, and hundreds of others were damaged to varying degrees. In two separate areas, extensive numbers of Terminalia sp. trees were pushed over. Examination showed that very little of the foliage was actually consumed. Eight tree species in all were frequently found heavily damaged (Table 8). Most of the damage involved the tree being pushed over or broken, and occurred mainly in riparian and Combretum woodlands near waterholes. No measurement of past or present damage was available, but observers agreed that damage has increased considerably in recent years, and could potentially be a problem of serious magnitude.

Herd Structure

Elephants were mostly found in breeding herds or bull herds. Breeding herds consisted of adult females, subadult males and females, and young. Adult males were sometimes present in breeding herds. Bull herds were comprised almost entirely of adult and subadult males. Breeding groups were similar in size and composition to those described in other parks, but herds sizes generally tended to be smaller than in East Africa. The mean breeding herd size was 9.8, the largest being 33. Poche (1974a) reported one herd of 58

individuals in Park W. Bull herds usually consisted of 1 to 4 individuals, averaging 2.02. By comparison, Laws (1970) found breeding herds to average 11.3 and bull herds 2.4, but observed herds as large as 1000 head in Tsavo Park, Kenya.

The wary behavior of elephants and the dense vegetation made herd structure difficult to determine. Only a small proportion of herds encountered could be aged, and determination of sex was not possible except in a few cases. An analysis of 14 breeding herds showed that 62% were adults, 26% subadults, and 12% were calves less than 1 year old. The average percentage of young over a one year period was 8.2%, similar to percentages reported elsewhere. Bouliere and Verschuren (1960) reported 9.2% in Albert Park, Zaire, Buss and Brooks (1961) reported 7.5% in Uganda, and Pienar et al. (1966) found percentages ranging from 7.1% to 7.3% in Kruger Park, South Africa. Reproduction appeared to be good in Park W.

Resident breeding and bull herds are known to occupy relatively fixed home ranges in Park W. A breeding herd of six elephants was observed for more than a year along a 15 km section of the Tapoa River. A second herd of 15 to 17 individuals was repeatedly sighted along a seasonal stream near the Mekrou River for more than two years. A bull herd consisting of three adult males was seen within a 160 km^2 area near the author's residence for the duration of the study.

Discussion

Where overpopulated, elephants can cause major changes to the habitat by transforming woodlands and forests to grasslands (Laws 1970, Buechner and Dawkens 1961). Such changes have rarely been reported in West Africa, but Park W has one of the largest elephant populations among West African parks and reserves. Extensive damage there may be a threat if present trends continue. Damage thus far has been on a small scale in localized regions of the park, but could escalate rapidly if present migration patterns of the relatively large elephant population became restricted.

Laws (1970) stated that a desirable herd size was six for most habitats, and herds larger than this tended to cause destruction of trees. In Park W, herds of 8 or more were common, and in high-density areas, several herds of 20 to 30 were seen. This may serve as an indication of future problems. Suggested stocking rates for elephants range from 0.30 to 1.5 square kilometer depending on existing vegetation, available water and other species present (Pienar et al. 1966). Most of Park W was well within this range, but in the central portion were somewhat higher, ranging from 1.9 to 2.5 per square kilometer. These high densities were found only during the latter portion of the dry season (January-May), yet were of sufficient duration to allow some damage to occur.

Poaching has probably had the greatest impact on elephants and their distribution as evidenced by large concentrations

in the central portion of the park. Elephants which had previously remained along rivers north of the park, now retreat into the park and add to the problem.

The best management option at present for elephants is protection for hunting and livestock grazing. Along the Niger and Mekrou Rivers, nearly the entire 100 km section is unused by elephants, but if protected, could alleviate overcrowding in the central region. Long-term studies and management plans are needed to maintain the elephant population in Park W.

Buffalo

The overall distribution of buffalo was similar to elephants, but buffalo were distributed somewhat more evenly within their range. As with elephants, buffaloes were intolerant of livestock and hunting activities, although they utilized the Niger, lower Mekrou, and upper Tapoa regions to a greater extent. During the rains, buffalo could be found throughout nearly all of the park.

Herd structure

Most buffalo were found either in breeding herds, consisting of adults and subadults of both sexes and young, or in small bachelor herds, comprised of adult and subadult males. All females and juveniles (two years old and under) lived in herds ranging from 13 to 160 individuals. They comprised about 80% of the total population. Mean breeding herd size was 65. In comparison, Sinclair (1977) found

herd sizes in Tanzania ranging from 50 to more than 1500 in grasslands, averaging 350. Sidney (1965) reported herds up to 50 head in Kenya montane forests and to 20 head in lowland forests in the Congo. Bosch (1977) found herds up to 80 head in wooded savannas in Cameroon. Leuthold (1972) and Sinclair (1977) stated that breeding herds often formed splinter groups while feeding, but this appeared to be uncommon in Park W. Individuals were often widely scattered while feeding, but the herd moved as a single group.

Twelve breeding herds were identified in the park (Figure 11). Accurate determination of herd structure was difficult because of dense woody vegetation and grass cover, clustering and rapid flight. Three herds in which all members were categorized showed 71% adults, 14% subadults, and 15% calves. The overall sex ratio was not determined, but Sinclair (1972) has reported it to be near 50:50 among the population in East Africa.

Males frequently formed bachelor herds, or lived singly or in groups of two. The largest group recorded was 10, with a mean of 2.2. Sinclair (1977) found bachelor groups of 5 to 10 head, and occasionally as many as 50 in Serengeti National Park, Tanzania. He found that bachelor herd sizes increased significantly during the dry season. In Park W, such an increase was not detected. The total estimated bachelor population during the dry season was 200, approximately 18% of the total buffalo population in the park.

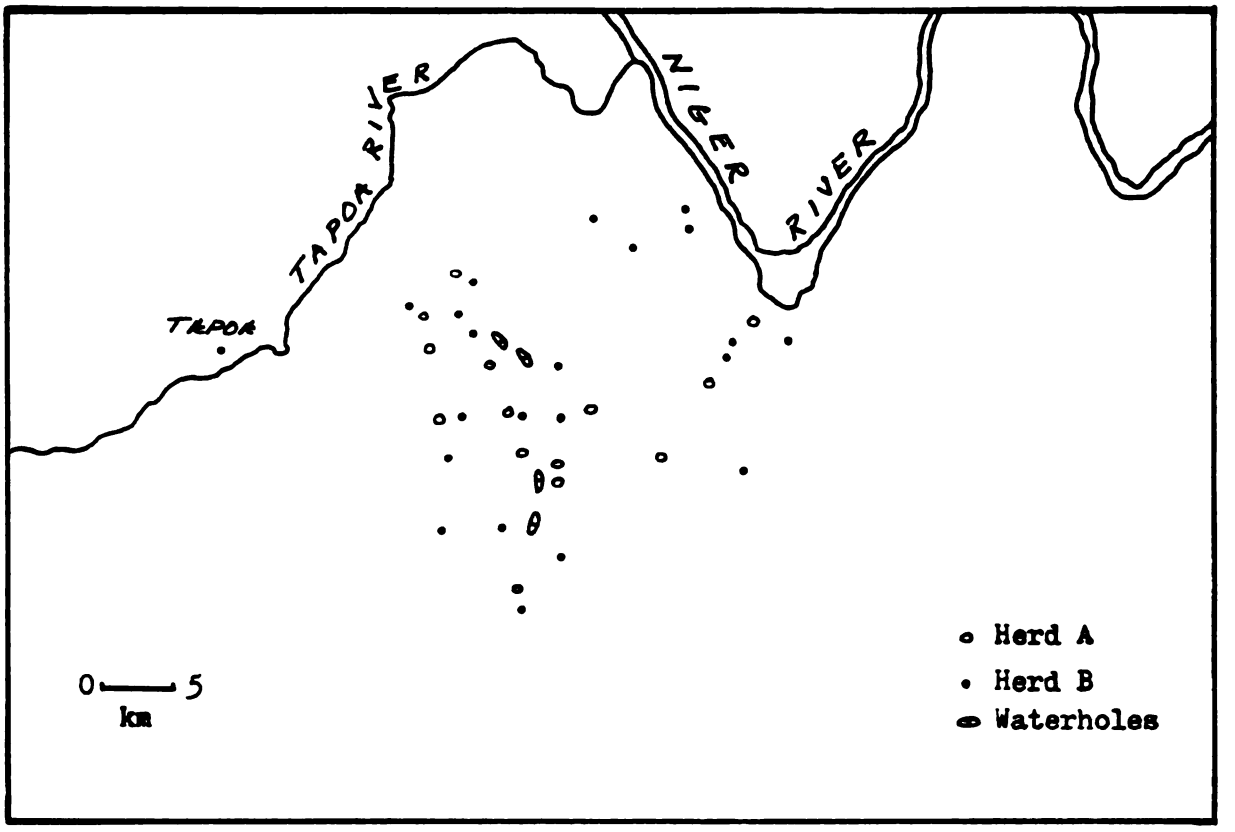


Figure 11. Locations of two buffalo breeding herds in Park W, Niger, 1975-1978.

Pienar et al. (1966) stated that bachelor males usually comprised 15% of the population.

Home ranges and movements

Bachelor males were mostly sedentary, occupying woodlands along the major rivers. Most solitary males and those in groups of two to four were usually within 1 km of rivers or waterholes, while larger groups were often several kilometers into the savanna.

Dry season observations indicated that home ranges were distributed mainly along the Mekrou and Tapoa Rivers and around permanent waterholes (Figure 14). Herds seldom ranged more than 6 to 7 kilometers from water, and usually were sighted within 3 to 4 kilometers. Moreover, they preferred Combretum and Terminalia woodlands of low to moderate density on deep soils along drainages and floodplains (see Table 1).

More detailed observations were made on two breeding herds. In the northern region of the park following the development of four waterholes along two seasonal streams, two distinct breeding herds became established (Figure 12). Game guards stated that buffalo herds were only occasionally seen there prior to the existence of these waterholes. There was considerable home range overlap of the herds throughout the year. This contrasts with the findings of Sinclair (1977) who found little or no overlap among herds in East Africa. Herd A (Figure 11) was the smaller of the two, containing 25 to 29 head. Herd B contained as few as 125 and

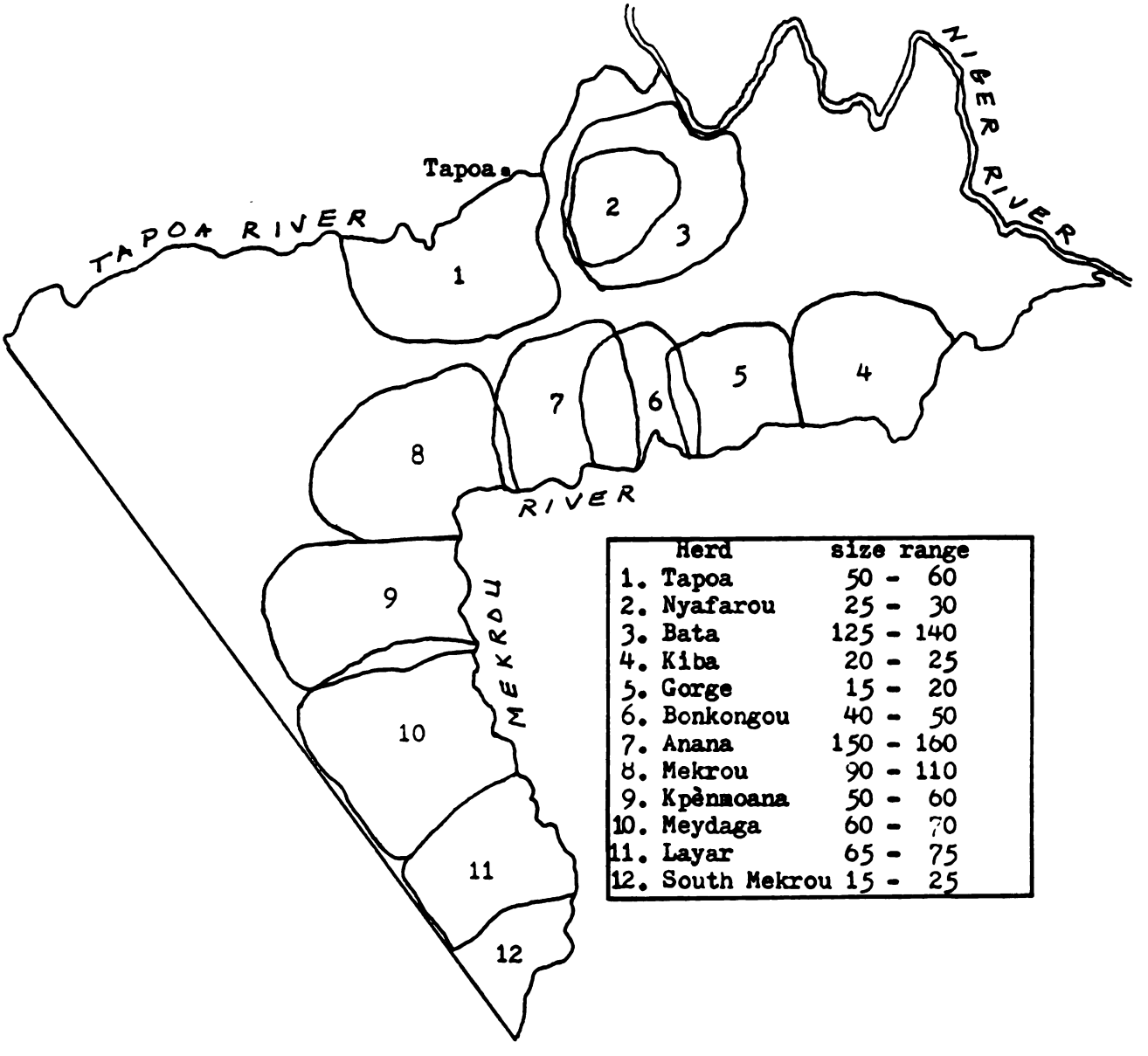


Figure 12. Approximate distributions and sizes of buffalo breeding herds in Park W, Niger. Estimates are based on ground and aerial surveys from 1975-1978. Most herds along the Mekrou River cross into Benin throughout the year, but no observations could be made in that area.

as many as 145 head. The home range of herd B appeared to be larger, but movements of both herds appeared to center around the waterholes. Herd B occasionally drank from the Niger River, but herd A was apparently restricted to the waterholes. Estimated home ranges were 450 km^2 for herd A and 600 km^2 for herd B. Observations during the rains were few, but suggested that both herds remained in approximately the same area.

The total population of buffalo in Park W, Niger was estimated to be 800. This estimate however, was only an approximation because herds frequently moved outside the study area, and herd sizes fluctuated from movements in and out of herds by males. The Mekrou and Tapoa Rivers did not act as barriers to movement even during periods of maximum flow, but the Niger River was apparently seldom, if ever, traversed.

Food habits

Buffalo appeared to be primarily grazers, but were capable of consuming woody vegetation as well. Grass species seen eaten were Andropogon gayanus, Jardinia congoensis, Pennisetum pedicellatum, Diheteropogon haguperii, Sporobolis pyramidalis, and Hyperrhenia involucrata. Buffalo were frequently seen grazing on perennial-grass flushes following early dry season fires and on dry standing grasses adjacent to rivers. Leuthold (1972) and Sinclair (1977) both found 94% of the diet to be grasses in East Africa, but Jarmann (1971) determined that 22% of the food eaten by buffalo in

Combretum woodlands in Zambia was twigs of trees and shrubs. In Park W, buffalo were occasionally seen browsing on newly sprouted leaves, but grasses comprised most of the diet. Observations on individual buffalo showed that they selected leaves of bulkier grasses and the smaller annual grasses.

Warthog

This species was ubiquitous in the park during both the rainy and dry seasons, and was one of the few species that commonly occurred along the Niger River. Although warthog were most abundant in the vicinity of water, they apparently were not wholly dependent on water for daily needs. Child (1968) suggested that they can live for several months without water and found that in Botswana, they occurred more than 60 km from surface water. In Park W, warthogs were found as far as 15 km from surface water, but few sightings were made in these drier areas. Lamprey (1964) found that warthog populations shifted in response to water availability in Tanzania, and in Nigeria, Bigourdan (1948) noticed movements toward the Niger River during the dry season. Similar shifts were apparent in Park W, as warthog were most frequently encountered along the rivers and near waterholes, although a portion of the population remained in the dry savanna.

The warthog population was estimated to be 775, and the average density was 0.35 per square kilometer. In comparison, densities reported in most other studies were seldom

below 1.0 per square kilometer (Green 1979, Lamprey 1964, Bosch 1977) during the dry season. Cumming (1975) however found densities similar to those in Park W in Combretum woodlands in Rhodesia, but considered favorable habitat to support at least 3.0 per square kilometer.

Warthogs utilized a wide variety of habitat types, and could be found in both dense and open vegetation. Even upland grasslands on ironpan soils and open rocky areas which were avoided by most ungulate species were frequented. They were most active between the hours of 0800 and 1100, and between 1500 and 1800.

As reported in other areas (Cumming 1971, 1975), warthogs regularly used holes at night, for refuge from predators and inclement weather, and to give birth. Most holes were believed to have been excavated by aardvarks, Orycteropus afer. Holes were numerous and nearly everywhere in Park W except on flat ironpan soils. Warthogs in Park W also apparently used holes to escape heat and for refuge during the day. In several cases, the user was a solitary adult resting near the entrance between the hours of 1100 and 1400. This behavior has not been reported in other areas. All family groups and most solitary warthogs found resting during the day, however, occurred in shady thickets.

The basic social group or sounder consisted of an adult male, 1 to 3 adult females, and 1 to 6 subadults and juveniles. Cumming (1975) suggested that sounders may not necessarily be

accompanied by males, which was the case in 48% of those encountered during this study. Bachelor males were commonly seen, and were nearly always seen solitarily. In contrast, Bigourdan (1948) reported bachelor groups of between 2 and 6 in Nigeria.

Group sizes tended to be small (Figure 13). The mean group size was 2.7. Average monthly variation in total group size and for sounders was small (Figure 14). No pronounced breeding season could be detected, although there was a slightly higher percentage of juveniles during the first four months following the rainy season (Table 7). The adult sex ratio was 35:65, or about 2½ to 1 in favor of females. Cumming (1975) believed that this imbalance was common throughout the warthog's range in Africa.

Food habits

Warthogs were most frequently seen eating grasses, but also were observed feeding on roots, tubers and aquatic vegetation. During the dry season, they frequently selected sandy soils for rooting, and utilized perennial grass roots and herbs such as Cochlosperm sp. and Urgenia sp. As rivers and waterholes became dry, they were often seen standing nearly completely submerged in water to obtain aquatic plants.

Roan Antelope

The distribution of roan antelope was similar to that of buffalo and elephant, but roan were more frequently observed

Table 7. Sex and age ratios for warthogs in Park W, Niger in percentages.

Time Period	% Adult:Subadult: Juvenile	Adult male: Adult female
Nov-Dec	64 : 21 : 15	38 : 62
Jan-Feb	67 : 17 : 16	34 : 66
Mar-Apr	76 : 14 : 10	32 : 68
May-Oct	74 : 13 : 13	35 : 65

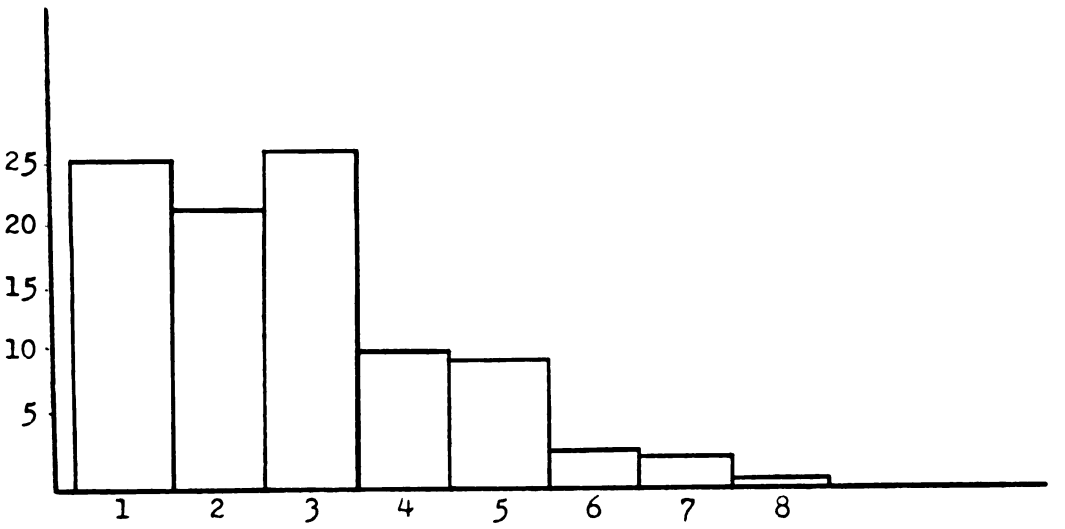


Fig. 13. Relative frequencies of group sizes of warthogs in percentages in Park W, Niger, from 1975 to 1978.

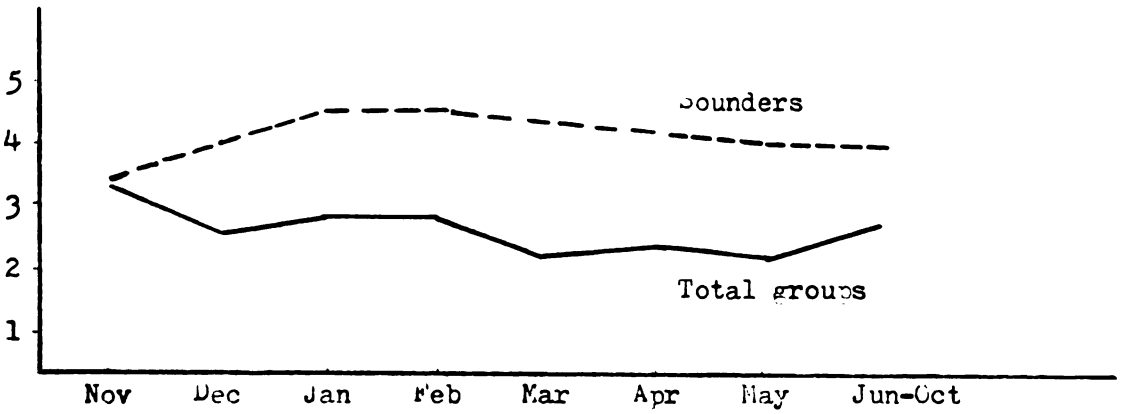


Figure 14. Seasonal changes in total mean group size and mean sounder size for warthogs in Park W, Niger from 1975 to 1978.

along the Niger and upper Tapoa Rivers in open to moderately dense woodlands. They were found at considerable distances from watering points, yet roan were seen at water at all times, though mainly in mid-to-late afternoon.

The estimated population was 450 roan, or 0.28 per square kilometer. This was considerably below the count of Poche (1974b) who had censused roan in Park W in 1972. He reported a density of 0.75 per square kilometer and a total population of 1200 roan. Both Poche's census and this survey were based over the same approximately 1600 km^2 occupied by roan during the dry season. Estimates (Koster, unpublished reports) based on aerial and road-strip counts, were similar to those reported earlier for this study. While the roan population may have declined during the past several years, the lack in refinement of census techniques may also have contributed to the difference in estimates.

Elsewhere in West Africa, reported densities of roan antelope ranged from 0.24 per square kilomeer in Yankari Reserve, Nigeria (Sikes 1964) to 2.21 per square kilometer in Deux Bale Reserve, Upper Volta Sihvonen (1977).

Little could be determined concerning roan movements and home range in Park W, but frequent sightings of recognizable herds suggested that some groups remained in a relatively fixed home range the entire year. During the rains, roan were distributed throughout the park, and a portion of the population dispersed to areas north of the park. Child and

Wilson (1964) found that roan in Rhodesia had restricted home ranges and regular cyclic movements within those ranges.

Herd structure

Herds normally consisted of a master bull and varying numbers of females, yearlings, and juveniles, and sometimes other adult males. The average group size was 4.7, but varied seasonally, with the largest herds (to 22 head) occurring during the late dry season (Figures 15 & 16). Solitary roan were frequently encountered, and males comprised 76% of those which could be positively sexed. Based on counts of 182 specimens, the adult:yearling:juvenile ratio was 72:13:15, and the adult male:adult female sex ratio was 42:58. At times, roan congregated with hartebeest and other species during the dry season. One combined group of 37 was observed. Poche (1974b) reported that in Park W young were mostly born during the early dry season (October-December), but during this study, calves were seen throughout the year. Child and Wilson (1964) reported that in Rhodesia, calves were born at any time of the year.

This species has been classified as a grazer (Dorst and Dandelot 1969) but in Park W they were observed feeding on shrubs and forbs on several occasions. Poche (1974b) found that grasses comprised approximately 85% of the diet of roan in West Africa.

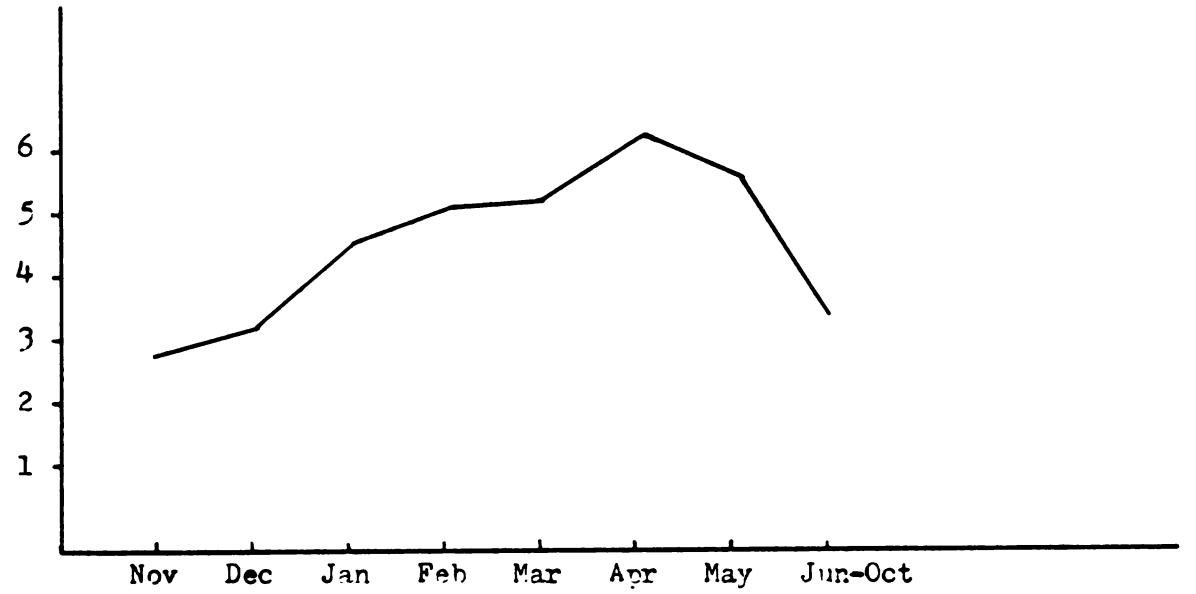


Figure 15. Average monthly group sizes for roan antelope in Park W, Niger from 1975-1978.

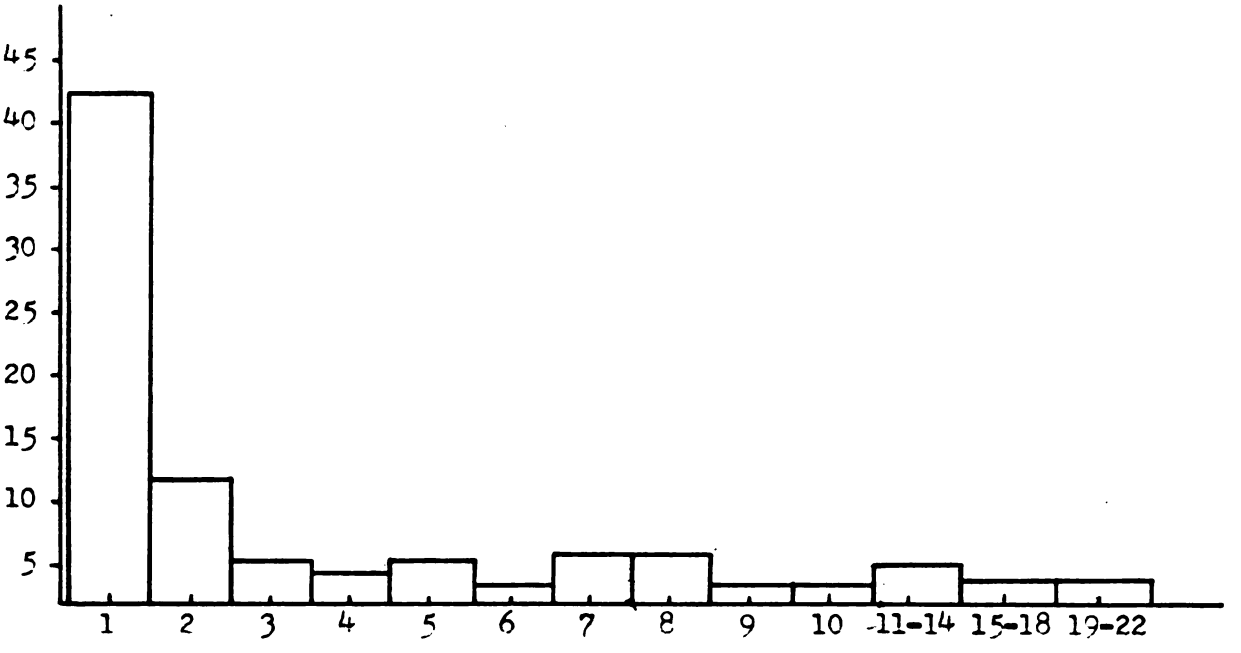


Figure 16. Frequencies of group sizes are given for roan antelope in percentages. These figures represent the cumulative totales during the study period.

Hartebeest

Hartebeest distribution and habitat selection was similar to that of roan, although hartebeests were generally found in slightly more open habitats. They normally visited riparian habitats only to drink. Water appeared to be a daily requirement, and were frequently seen at waterholes during early to mid-afternoon.

Observations showed that hartebeest tended to remain in a relatively fixed area during the dry season, provided that water was available. They utilized the entire park during the rains, but unlike roan antelope, did not appear to migrate north of the park.

As estimated 410 hartebeest lived in the park, and the average density was 0.29 per square kilometer in the approximately 1200 km^2 they occupied during the dry season. Densities appeared to have been somewhat greater along the Mekrou River in the southern one-third of the park. Other reported densities in West Africa range from 0.27 per square kilometer in Yankari Park, Nigeria (Sikes 1963), to 3.3 per square kilometer in Bouba Njida Park, Cameroon (Bosch 1977).

The average group size in Park W was 5.1, and groups as large as 23 were recorded. Some clumping of groups occurred as the dry season progressed, but sample size was too small to show a trend (Figure 18). In East Africa, herds up to several hundred have been reported in the open savannas (Dorst and Dandelot 1969).

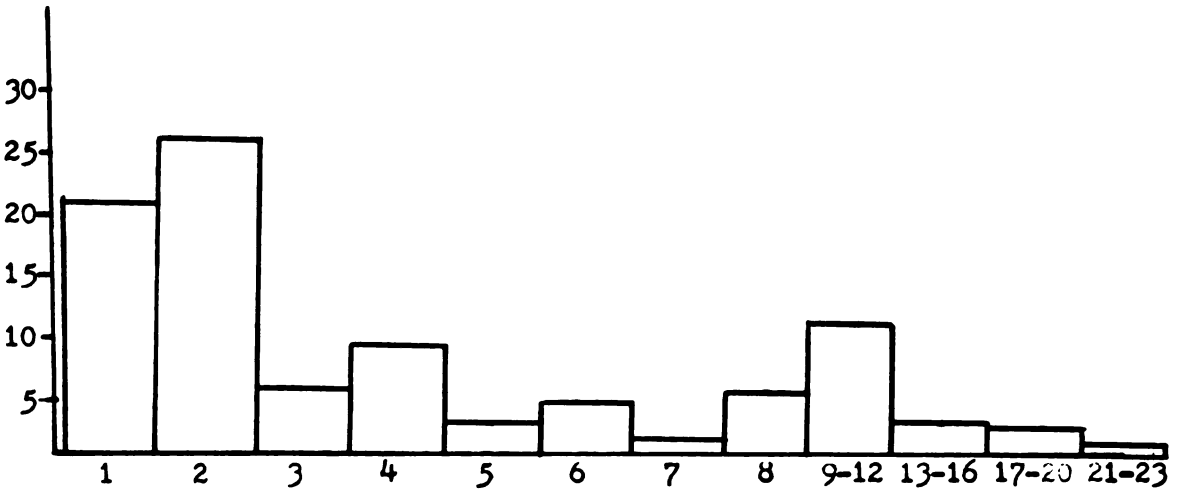


Figure 17. Frequencies of group size are given for hartebeest in percentages Figures represent averages during the study period (1975-1978) in Park W, Niger

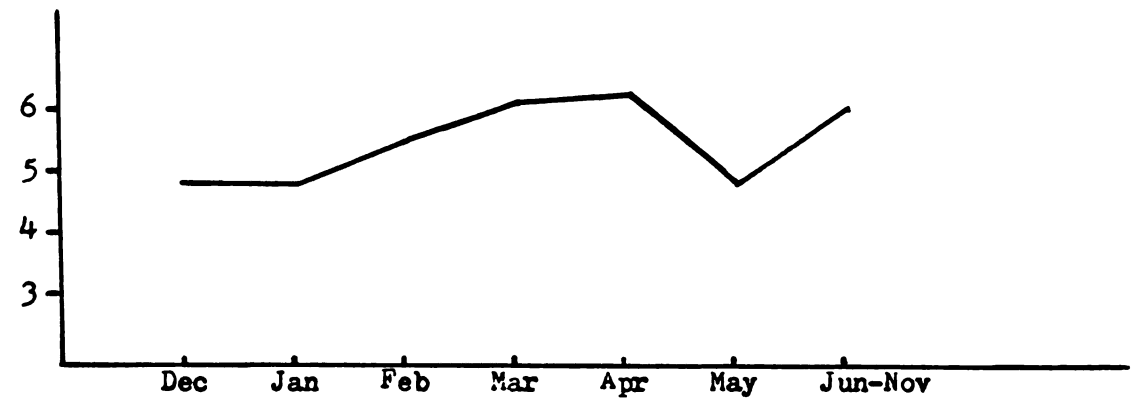


Figure 18. Average monthly group sizes for hartebeest show a slight increase during the dry season.in Park W, Niger.

Hartebeest formed harems, like those of roan antelope. Harems normally included between 6 and 12 adults, subadults, and young. Bachelor males were seen singly or in groups of 2 to 5 head. Solitary animals and groups of 2 were most frequently encountered (Figure 17). The average monthly mean group size did not change appreciably during the year. Sex determination in the field was difficult. The adult: yearling:calf ratio was 70:11:19. Calves were observed every month of the year.

Oribi

Oribi were widespread in the park, but avoided the central portion where water was unavailable. Although present along the Niger River, they appeared to be less abundant there than along the Mekrou and Tapoa Rivers. Their distribution was apparently affected by a dependence on drinking water, but they sometimes ranged several kilometers into the savanna. Sikes (1964) stated that oribi could live without water for long periods, but observations in this study suggested that Park W oribi required water frequently.

Oribi were observed singly, in pairs, or in groups of three. Males were seen alone or with 1 or 2 females. Females were also seen alone, but usually were with males or other females. Groups as large as 7 have been reported in other areas (Bosch 1977). Only 35 adults were positively sexed in Park W, and 40% were males and 60% were females. Adults represented 92% of the total number of oribi seen, many young may have been hidden by the females.

The estimated population was 630, or 0.45 per square kilometer as based on 1400 km^2 occupied by oribi at the time of survey.

In other reserves in West Africa, reported densities ranged from 1.0 per square kilometer in Arly Park, Upper Volta (Green 1979) to 5.5 per square kilometer in Bouba Njida Park, Cameroon (Bosch 1977).

Dorst and Dandelot (1969) considered oribi to be mixed feeders. My observations showed that they both browsed and grazed, but appeared to be primarily grazers.

Reedbuck

Most reedbuck occurred along the major rivers, but were also present along seasonal streams. They were usually found close to water, but occasionally occurred more than one kilometer from surface water. Reedbuck have been sighted along all but the lower 15 km of the Tapoa River, and were commonly seen along most of the Mekrou River except the lower third. None were seen along the Niger, but probably a small number occurred there. At the onset of the rains, a portion of the population dispersed along the seasonal streams, sometimes as far as 15 km from the major rivers. It was believed that reedbuck could not tolerate drought, and migrated to permanent water sources during the dry season. Schoen (1971) found that reedbuck responded poorly to heat stress and water deprivation, in comparison with other species of antelope.

Feeding activities were normally limited to evening and early morning. Night observations by spotlight showed that they sometimes congretated in small groups to graze in open woodlands and grasslands. During the day, they rested in tall grassy patches or thickets, usually within 100 m of water.

Reedbuck were seen singly, in pairs, or in small groups, with an average group size of 1.4 (range 1-4). In East Africa, group sizes were generally somewhat larger (Kutilek 1975, Holsworth 1972, Dorst and Dandelot 1969). Holsworth (1972) found that reedbuck in Dinder National Park, Sudan, formed herds as large as 400 during the late dry season.

The adult male:female sex ratio was 43:57, and the adult:juvenile ratio was 87:13, but the young may have been hidden by adult females as in many other species so that the young may have been underestimated. Sample size was insufficient to determine if breeding was seasonal or continuous. The estimated population was 450, over approximately 125 km^2 occupied by reedbuck during the dry season. Patchy distribution caused difficulties in estimating the area occupied so that population densities may not be accurate.

Although reedbucks preferred dense cover during the day, they were frequently seen grazing in short-grass meadows, and utilized green flushes following fires.

Bushbuck

This species was found mainly along the large rivers and seasonal streams. They occurred along seasonal streams more

than 3 km from surface water. Dorst and Dandelot (1969) stated that bushbuck can live without water when necessary, and apparently can survive for long periods. Bushbuck were common along the Niger River, and apparently were able to tolerate livestock and human presence unlike many other ungulate species.

Bushbuck occurred singly or in pairs, and occasionally in groups of 3. Average group size was 1.33. Their home range was believed to have been small, based on the frequent sightings of individuals near the author's residence. The adult male:female ratio was 38:62, and calves comprised 22% of the total number of bushbuck observed. Sightings of young were made during January, February, June and October, and may breed throughout the year. Wilson and Child (1964) reported continuous breeding in Rhodesia, but Sikes (1963) in Nigeria and Alsopp (1971) in Rhodesia reported seasonal breeding.

During the day, bushbuck were usually at rest in thickets or adjacent to gallery forests. They travelled into adjacent woodlands between evening and morning to feed. Although primarily browsers, they sometimes grazed. On several occasions they were observed feeding in riverbeds and in open woodlands on perennial grass flushes following fires. Bushbuck were frequently seen drinking water, but their distribution appeared to be dependent on vegetation rather than water availability.

The population was difficult to estimate because of their secretive behavior and preference for dense riparian

vegetation. Bushbuck may be present along all or some of the seasonal streams with dense vegetation, but this was impossible to determine. More than 50 seasonal streams, ravines and gullies were identified as potential bushbuck habitat as based on sightings of bushbuck during the survey. The estimated population of 800 may be unrealistic, but serves as a first approximation until bushbuck distribution is better understood.

Grimm's Duiker

Grimm's duiker were widely distributed in the park and found in nearly every habitat type, including the dry shrublands avoided by most other ungulate species. They were apparently not dependent on water but were seen drinking when water was available. During the day, these animals were usually found resting in thickets.

Both males and females were seen singly or in twos, and rarely in groups of between 3 and 5, with the average group size 1.25. The larger groups appeared to have been all males. Harems were never seen. Young duiker were rarely seen, and probably remained hidden in thickets by adult females. Adults quickly disappeared when encountered; sex and age ratios were not estimated.

The density was estimated to be 0.75 per square kilometer for a total population estimate of 1650 duiker. Other estimates ranged between 0.04 per square kilometer in Yankari (Sikes 1963) and 2.14 per square kilometer in Arly Park, Upper Volta (Green 1979).

The diet has been reported to be leaves, pods, fruit of shrubs and trees, roots, and occasionally forbs and grasses (Wilson 1966). No observations of feeding habits were made during this study.

Red-flanked Duiker

This species was nearly always found in a riparian habitat. They were usually associated with moderately dense to dense evergreen forests. The riparian forests adjacent to the Niger, Mekrou, and Tapoa Rivers, were known to harbor this species of duiker but their presence along the many seasonal streams in the park was not established. They seemed to be dependent on water or the more extensive forests along the larger rivers. Sightings usually consisted of only a glimpse, and little can be said about the sex and age structure. The population was roughly approximated to be 200, and was based on the frequency of duiker sightings per kilometer walked along the rivers, and extrapolated to the total amount of riparian habitat along the three major rivers.

Red-fronted Gazelle

Gazelles were rarely seen in the park, and probably did not exceed 50 in number. They were most common in dry grasslands and open Combretum shrublands. Bigourdan (1945) noted that red-fronted gazelles mainly occupy the northern Sudan Savanna zone, so that Park W probably represents the southern extent of their range. They were present in the park during both the rainy and dry seasons, and apparently did not migrate.

This species was seen singly or in groups of 2 or 3, and the average group size was 1.9. In other portions of their range, small herds of 5 to 10 head were reported (Dorst and Dandelot 1969). They were believed to be sedentary in the park. Several groups were seen repeatedly in nearly the same locations during the study. Gazelle both browsed and grazed. Water was consumed when available, but the presence of gazelles in waterless areas indicated that they could dispense with it if necessary.

Topi

Topis have been reported to be one of the more abundant ungulate species in Africa (Dorst and Dandelot 1969), but their distribution is patchy. In Arly Park, Upper Volta (Green 1979) and in the Yankari Game Reserve in Nigeria (Sikes 1963), topi were common. They reportedly (Jarman 1976) are able to withstand dry warm environments, such as that found in Park W, but their numbers there were unexpectedly low. During the study only 6 groups were sighted, and the total population was estimated to be 25 animals.

Hippopotamus

Hippopotami were found in the Niger and Mekrou Rivers, but the population appeared to have been small. Only 8 or 10 were believed to exist within the approximately 160 km section of the Mekrou River in Park W, with similar numbers in the Niger River. They were vulnerable to hunters, and

their presence was strongly discouraged by fishermen. No evidence of hippopotami was found in the Tapoa River.

Predation on ungulates

Predators on ungulates in Park W included the spotted hyena Crocuta crocuta, striped hyena Hyena hyena, leopard Panthera pardus, lion P. leo, cheetah Acinonyx jubatus, and side-striped jackal Canis adjustus. Other carnivores which might sometimes prey on ungulates were the crocodile Crocodilus niloticus, python Python sebae and P. reguis, baboon Papio anubis, large raptors, and smaller species of cats.

Jackals were commonly seen in Park W, and were known to have preyed on the smaller ungulate. On two occasions, jackals were observed stalking Grimm's duikers which were resting in thickets. Game guards reported seeing jackals successfully catch young duikers and oribis. Antelopes which were gazelle-size and smaller as well as calves of larger antelope species were believed to be within the prey range of jackals. Though reported to be nocturnal (Rosevear 1974), jackals were frequently seen during the day, especially early to mid-morning.

Both spotted and striped hyenas were rare in the park. Only one sighting of each species was made between 1974 and 1979, and the scarcity of hyena tracks also suggested their numbers were few. Tracks of solitary hyenas (species unknown) were seen on a regular basis in two separate areas of the park, and on a few occasions, tracks of more than one hyena were

seen together. According to Kruuk (1972), hyenas in East Africa commonly hunt alone in in groups numbering from a few to 20 or more, and may take prey many times their own weight including buffalo. Kruuk found that even lone hyenas were fully capable of killing large prey, and hyenas in Park W may have contributed a significant percentage of ungulate mortality.

Cheetahs were also rarely seen in the park, and were believed to have accounted only for a small proportion of ungulate mortality. The total sightings included two of solitary cheetah and three of pairs. Although populations of the smaller antelope prey species appeared to be fairly large, the wooded savanna was perhaps poorly suited to cheetah hunting behavior, which relies on a distant view of prey culminating in a high-speed chase. It is doubtful that cheetahs remained in the park during the rainy season, and probably returned only after the vegetation had been burned.

The leopard is a solitary, mainly nocturnal carnivore which preys on a wide variety of species (Rosevear 1974). Myers (1974) stated that densities of this species are generally higher than any other field in the Sudan/Guinea zone. Only three leopard sightings have been made in Park W since 1974, and they are probably rare because of the small amount of forested habitat. They are reported to prey on animals of kob size and smaller (Myers 1974).

Several large crocodiles were sighted in the Mekrou River and this species may prey on ungulates along the river.

Pythons were commonly seen along the rivers too. Larger specimens have been reported to capture young antelopes and warthogs or even full-grown oribis and duikers (Wilson 1966). One python measuring 3.5 m was captured along the Tapoa River and several specimens of similar size also were sighted in the vicinity. A 2.3 m python was observed to attack and hold an adult jackal for several minutes before the jackal escaped. Several other attacks on small antelopes also were seen.

Baboons also were seen eating animal materials. One adult male had a freshly killed bushbuck calf, and another was in possession of a partly-eaten young vervet.

Hunting dogs Lycaon pictus were previously common in the area, but have not been seen for several years (Albachir Mohammed, personal communication). In recent years, these wild dogs have been sighted within 200 km of Park W (Child 1974, Rosevear 1974) in Upper Volta and northern Nigeria. They may have occasionally entered Park W without being noticed.

Lions appeared to have been the most important large predator in Park W. Most evidence of lion activity was along the Mekrou River, but they were widely distributed in the park. Lions were more secretive in Park W than reported by Schaller (1972), and few observations on this species were made. Lions often crouched under a bush or retreated to thickets as vehicles approached. An estimated 40 to 50 lions inhabited the park during the survey.

A portion of the population probably disperses to the region north of Park W during the rains, as evidenced by sightings in that area by herders and villagers. Lions sometimes resorted to killing livestock north of the park, perhaps in response to low populations of wildlife. At least three adult lions which had attacked livestock, including one male and two females, were shot by government personnel, and one sub-adult female was snared by villagers. One of the two adult females was accompanied by three cubs. The other had one canine tooth broken and abscessed.

There was less tendency for lions to form prides in Park W than is reported for East Africa (Schaller 1972). Of 49 sightings, almost half (24) were of solitary lions, and 12 were groups of 2 or 3 individuals (Figure 19). The largest pride recorded was nine, and the average group size was 2.7. All prides of 6 or more were seen on buffalo kills.

On several occasions, lions were seen hunting during mid-morning and early afternoon. Buffalo and warthogs were the object of the hunts, and all those watched were unsuccessful. One pride of two adult and three sub-adult lions remained for a two week period near a waterhole. Other prides and lion groups apparently remained near well-used watering points along the Mekrou River.

The adult male:female sex ratio was 40:60, and the adult: sub-adult:cub ratio was 49:12:39. The average size of 12 litters was 2.0 (range 1-4). This figure may be low, however,

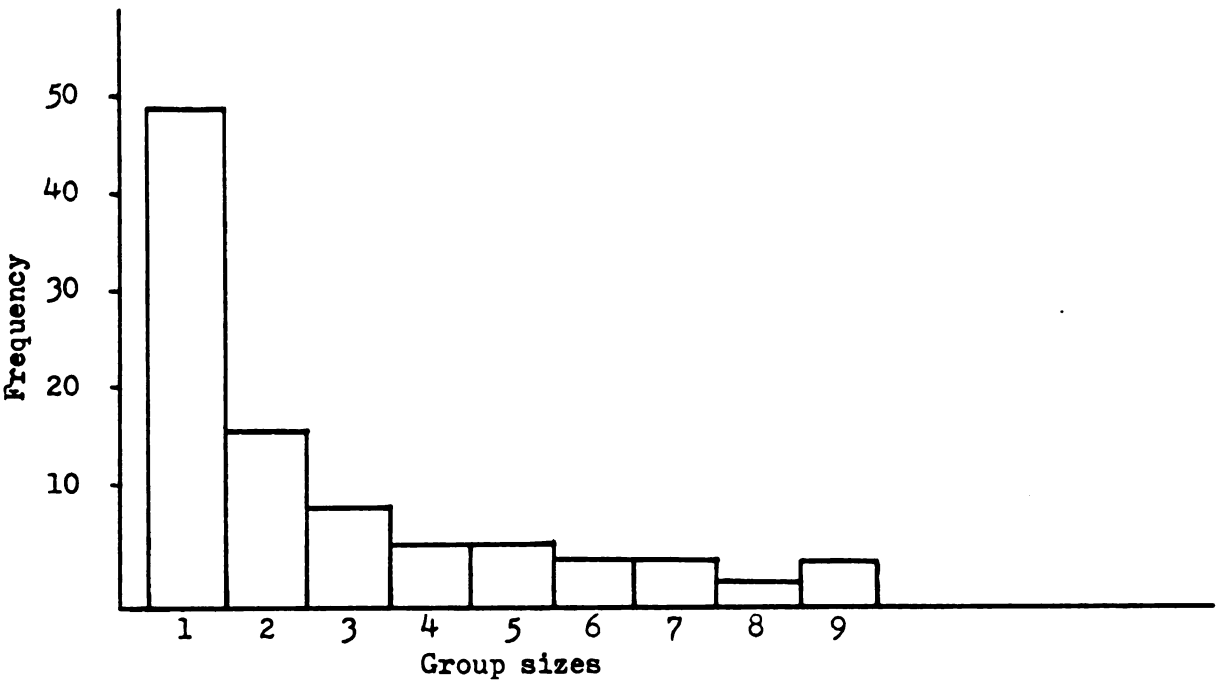


Figure 19. Frequencies of group sizes for lions in Park W, Niger, from 1975-1978.

because very young cubs are less likely to be seen than those somewhat older, and also some cubs die within the first few months of birth. Schaller (1972) found litter sizes ranging from 1.7 to 2.3 in a variety of habitats in East Africa. In Park W, young were born throughout the dry season. In East Africa (Schaller 1972), births have been recorded throughout the year.

Mortality

The remains of 80 ungulates were found and examined (Table 8). When possible, sex was determined and relative ages classified from dentition and body size. Unfortunately, many of the heads were missing or the bodies were badly eaten or decomposed. Only 15 carcasses displayed marks that could positively classify them as lion kills, but doubtless, this is a minimum figure. Few remains of the smaller antelope species were found, probably they were often consumed or destroyed. Animals classified as kills by humans were those found with snares or snare marks on the legs or with wounds from bullets or arrows.

Mortality appeared to have been fairly evenly distributed among the larger ungulate species. Although the sample size was small, there was good correlation ($r = .85$) between numbers of kills and population sizes for species kob size and larger, elephants excepted.

Elephant carcasses were rarely found in the park. Seven known deaths occurred between 1975 and 1978, but doubtless,

Table 8. The number, sex, age, and cause of death of large mammals in Park W, Niger, 1974 to 1978.

Species	Adults			Young		Cause of Death			Totals
	Males	Females	Unknown	Juveniles	Calves	Lion	Human	Unknown	
Kob	4	2	1	2	2	3	1	7	11
Waterbuck	5	3	0	2	0	4	1	5	10
Roan	3	2	3	0	0	3	1	4	8
Hartebeest	2	1	2	0	0	2	0	3	5
Buffalo	6	2	7	2	2	5	5	9	19
Elephant	1	1	6	7	0	0	7	8	15
Warthog	0	0	2	1	0	0	0	3	3
Bushbuck	1		1	0	2	0	0	4	4
Reedbuck	2	1	0	0	0	0	0	3	3
Totals	24	12	22	14	6	17	15	46	78

others were undetected. Four were caused by poisoning, two from gunshot wounds, and one by unknown causes. Two elephants were seen dragging snares which probably had been intended for buffalo. These elephants were never later found.

Five dead buffaloes were found with cable snares attached to their legs. Apparently, they had weakened and were killed by lions. Five other buffalo kills were found, and all were believed to have been killed by lions.

There were twice the number of males found dead than females, and may explain in part the unbalanced sex ratios found for most ungulate species during the survey.

Biomass Standing Crop

A commonly used basis for comparing the standing crops of animals in the different game reserves and parks is the biomass or total weight per unit area (Lamprey 1964). Biomass measurements also may be useful indexes to range carrying capacity where animal populations are controlled by forage availability (Petrides and Swank 1965).

Comparisons between parks are sometimes difficult because viewing conditions vary between parks and the methods of population estimates are not standardized. Biomass estimates for West African parks mostly are based on dry season densities over one season, whereas these estimates perhaps should reflect both rainy and dry season averages for several seasons. Also in most areas mean weights for the various

species are not measured accurately. Sex and age ratios also can vary regionally. Several authors have omitted elephants and livestock from their estimates too, and this can significantly effect comparisons. Wild ungulate distributions often may be affected by both livestock grazing and hunting. Estimates of average biomass may be somewhat distorted, too, where game avoids extensive areas, as in Park W. Furthermore, estimates may be misleading where animals move into and outside the park boundaries and estimates usually do not reflect average density.

There is considerable disagreement among authors as to mean weights of ungulate species. Weights selected here reflect the most commonly used figures in various African studies (Tables 9 and 10). If published estimates (Table 10) can be considered to be reasonable reflections of actual conditions, then Park W is clearly below most other game reserves and parks in its biomass standing crop. The main difference appears to be in its low densities of the larger antelope species. In general, the biomass estimates for East African parks are considerably higher than those for West Africa. Park W would compare with only the poorest wildlife ranges in East Africa, probably because the ungulate species there are not well adapted to arid conditions.

Hunting and Livestock Grazing

All hunting has been prohibited in Niger by a presidential decree. Hunting has continued, however, and frequently

Table 9. Total biomass estimates and the percentages of total biomass for ungulate species in Park W, Niger, from 1975 through 1978.

Species	Mean Weight in kg*	Total Population	Tot. Pop. Density	Biomass	Percentage of Total Biomass
Kob	70	500	0.227	35000	1.6
Waterbuck	150	450	0.204	67500	3.1
Roan	225	450	0.204	101250	4.7
Hartebeest	160	410	0.186	65600	3.0
Buffalo	455	1100	0.500	500500	23.0
Elephant	2100	600	0.273	1260000	57.9
Grimm's Duiker	15	1650	0.750	24750	1.1
Red-flanked Duiker	10	200	0.091	2000	0.1
Reedbuck	40	450	0.204	18000	0.8
Bushbuck	45	800	0.364	36000	1.7
Red-fronted gazelle	25	25	0.011	625	0.02
Warthog	60	775	0.352	46500	2.1
Hippopotamus	1365	5	0.002	6825	0.3
Oribi	12.5	630	0.286	7875	0.4
Topi	115	25	0.011	2875	0.1

* Average weights are taken from Lamprey (1964), Petrides and Swank (1965), and Pienaar et al. (1966).

Table 10. Comparisons between game densities and biomasses between Park W, Niger and other parks in West and East Africa.

Location	Biomass Kg/km^2	# Species	Area km^2	Total Density**	Vegetation Type	Reference
Park W, Niger	989	15	2200	3.59	Soudan Savanna	This study
Borgu Reserve, Nigeria	703	12	3504	-	Southern Soudan Sav.	Child (1976)
Comoe Park, Ivory Coast	482-2550	10	8750	7.03	Guinea Sav. (Upland & lowland)	Geerling & Bokdam (1973)
Deux Balé Park, U. Volta	1255	13	566	6.47	Soudan Savanna	Sihvonen (1977)
St. Floris Park, Central African Republic	1694	15	2643	9.33		Barber (1978)
Po National Park, U. Volta	1995	13			Soudan Savanna	Heisterberg (1975)
Bouba Njida Park, Cameroon	2021	17	2140	20.09	Soudan Sav. & Flood plain	Bosch (1977)
Arly Park, U. Volta	2202	11	1000	19.97	Soudan Savanna	Green (1979)

Table 10. (cont'd.)

Location	Biomass Kg/km^2	# Species	Area km^2	Total Density**	Vegetation Type	Reference
Nairobi Park, Kenya	2202-8341*	18	96	13-52	Themeda-Acacia Grassland	Petrides (1956)
Tarangire Game Reserve, Tanzania	2800-36200*	18	1589	23-96	Acacia Savanna	Lamprey (1964)
Queen Elizabeth Park, Uganda	17664	27	1841	38.60	Open Savanna & thickets	Petrides & Swank (1965)

*Represents biomass on undergrazed and overgrazed areas.

**Total density per square kilometer of all ungulate species present in park or reserve.

occurred in Park W during the dry season. Hunters used fires, wheel traps with cable snares, rifles, and poisoned arrows to assist in capturing game. Evidence of hunting was most prevalent along the Mekrou River, but has been discovered along the Tapoa and Niger Rivers, and in the park's interior. A total of 15 ungulate carcasses were determined to have been hunter kills. Seven of those were elephants, 5 were buffalo, and one each of roan, kob, and waterbuck. Many smaller ungulates may also have been killed by hunters. Hunter kills were mostly found in high-use visitor areas, some of which were more than 40 km from any of the park's boundaries, and corresponded with high game density areas.

Although livestock grazing was illegal, cattle and sheep could be found within the park throughout the year. The region along the Niger River was the most heavily grazed area, and cattle were the most abundant animal. Herds up to several hundred head were scattered on the floodplains and adjacent woodlands, especially near the Mekrou-Niger River confluence (Figure 20). Herds were moved as far as 5 km inland, but remained mainly next to the rivers. Where livestock was heavily concentrated, very little herbaceous material remained for wildlife. During ground and aerial surveys in 1977, more than 2,000 sheep and cattle were counted in the park.

The greatest concentrations of livestock occurred between December through July, when water and forage were in shortest supply outside the park. These annual accumulations of

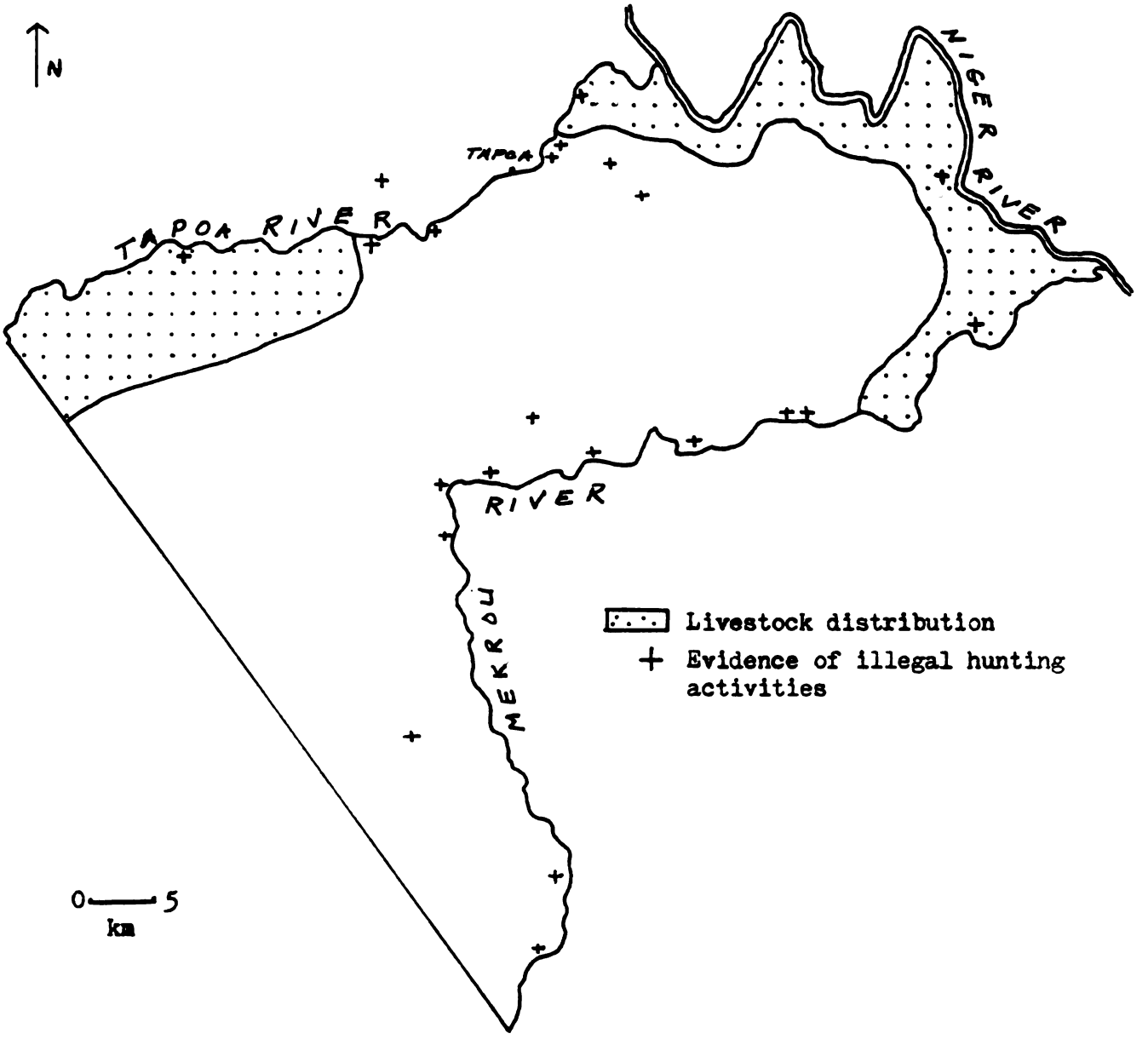


Figure 20. Approximate dry season distributions of livestock and locations of hunting incidents in Park W, Niger.

livestock have affected not only wild game communities by displacing them, but have caused changes in the plant community as well. Many grass species of low forage value have invaded those soils heavily trampled by livestock, and perennial grass cover was generally poor except on inundated soils. Trees and shrubs have been cut by herders for forage, and some erosion has occurred in these high-use areas.

Waterhole Development

Several hundred waterholes and rainpools are widely scattered throughout the park during the rains, but nearly all became dry within one to two months following the last precipitation. Small waterholes are of considerable importance because they are usually the first to contain water after early rainy-season showers, and may be the only source of water in some upland areas. Large natural waterholes are usually located in drainages, notably those with high water-tables. They may last from 2 to 6 months and sometimes throughout the 7 month dry season. Only two waterholes, other than in the main rivers, however, consistently held water for duration of the dry season (Figure 21). The Tapoa and Mekrou Rivers contained permanent pools, although most of the Tapoa River was dry by March.

Water is an important factor affecting ungulate distribution in Park W. Following the first rains which are substantial enough to form pools, game quickly disperses from

crowded waterholes and rivers. Even the normally riparian waterbuck and reedbuck move into the savanna, taking advantage of seasonal waterholes near woodlands and in seasonal streams.

The absence of water in many areas of the park caused park authorities to undertake a waterhole development plan. Its purpose was to improve game distribution and increase the carrying capacity of the park. Twelve waterholes were constructed or existing holes deepened (Figure 22). One well also was dug and cemented for replenishment of a nearby waterhole when necessary. All are used extensively by wildlife, especially by buffalo and elephant.

Waterholes can be harmful as well as beneficial. One of the main problems associated with waterholes is adjacent habitat degradation. This has been documented by Child (1971) in Botswana and Pratt and Gwynne (1977) in East Africa. Concentrations of ungulates can cause deterioration of herbaceous and woody cover, as well as erosion and permanent habitat damage. Although range overuse was apparent around several waterholes in Park W, damage thus far is on a small scale. Tree damage by elephants was the most obvious problem. Damage could escalate, however, and changes in cover should be monitored by regulated vegetation surveys and by exclosures (Petrides, in press).

A second problem with waterholes occurs when the carrying capacity of an area is exceeded. Better distributions of game, even for a portion of the dry season can result in

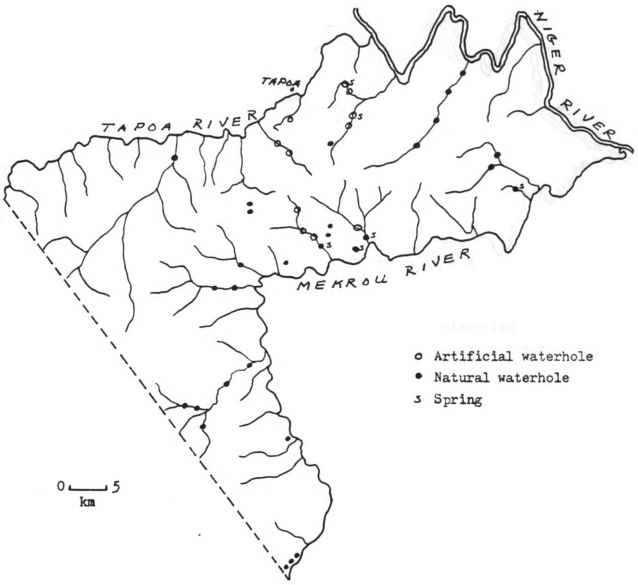


Figure 21. Distribution of water during mid-dry season (December) in Park W, Niger. Water is abundant in the Mekrou and Niger Rivers, and many waterholes remain in the Tapoa River. Monthly records of water distribution were kept from 1975 through 1978.

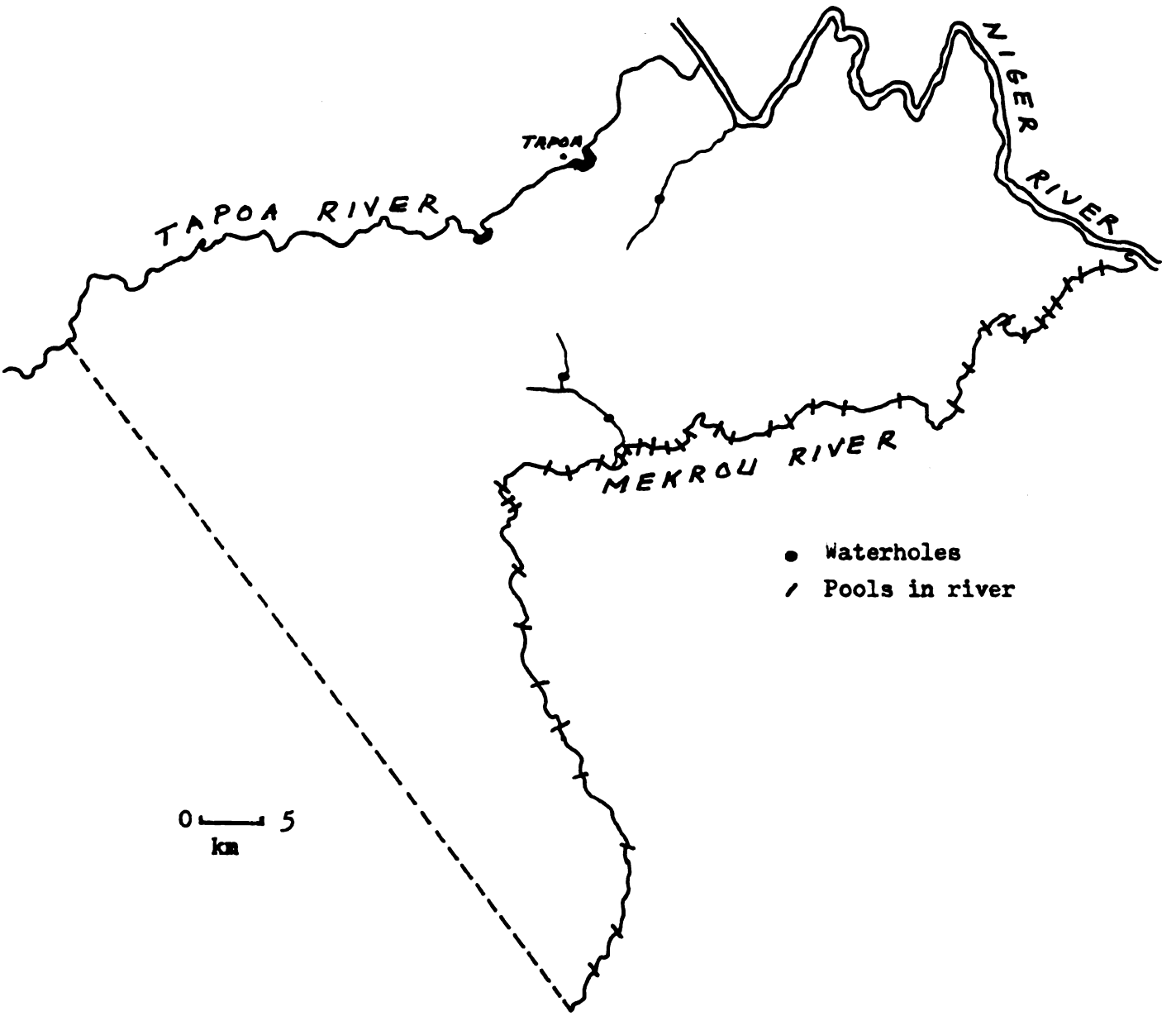


Figure 22. Distribution of water during the late dry season (April) in Park W, Niger. The Tapoa River is mostly dry, but numerous pools remain in the Mekrou.River, and the Niger River has a large volume of flow. Water distribution is based on records from 1975-1978.

widespread population increases. Inevitably in semi-arid regions, excessively dry years occur, 1972 being the last here. Even the largest and normally permanent waterholes dry up then, and game moves to the already-crowded riparian areas. Habitat damage there is potentially greater than that which would normally occur. Although care should be taken to ensure permanance of a waterhole, little can be done in the event of an extended drought.

RECOMMENDATIONS

Present game management practices in Park W include protection from illegal hunting and grazing, controlled burning to facilitate game viewing, and waterhole development. These efforts are intended to protect and preserve Niger's natural resources and to attract tourists. The success of management activities is difficult to evaluate in the relatively short span of this study, especially where vegetation and animal population trends are largely unknown. But, several park improvements could be made with present financial resources to ensure the continued existence of indigenous plant and animal communities.

Enforcement of regulations

Protection from hunting and livestock grazing is essential to the park's ecosystem. Not only is direct removal of game disruptive to park environment, but the presence of hunters and livestock can result in unnatural and undesirable distributions of wildlife. Livestock grazing reduces food supplies at the most critical times and places for ungulates. Control of illegal hunting is very difficult in Park W because of the irregular and extensive boundary, easy access from the Niger River, and the occurrence of villages adjacent to the park. Although the complete elimination of illegal

activities may be impossible at present, they could be significantly reduced if given a higher administrative priority. If each area of the park were visited monthly or even bi-monthly, illegal activities could be curtailed. It is believed that increased enforcement would have the greatest positive impact on the plant and animal communities of anything that could be done in the park.

Phosphate development

Phosphate mining is one of the most critical dangers currently facing managers in Park W. Extensive deposits have been located in the central region between the Tapoa and Mekrou Rivers. Unfortunately, this area is also one of the most important for wildlife and tourism. Effects of mining on plant and animal communities cannot reliably be predicted until more is known concerning the mining operations. Information on specific mining locations, water requirements, roads, rates of mineral removal, methods of excavation, and extent of reclamation must be obtained as soon as possible. Prior to any development, the following steps should be taken:

1. Identify the specific locations of proposed mining activity and obtain the projected time-table for their exploitation.
2. Determine water needs and sources for the operation and develop a plan to minimize competition with wildlife.

3. Determine the likely types and extent of habitat disturbances from mining, roads, men and machinery.
4. Plan work roads away from tourist tracks and riparian habitats where ever possible.
5. Encourage game use in areas away from development sites through increased protection in areas now avoided by game because of hunting and livestock grazing.
6. Provide a feasible plan for eventual land reclamation including restored topography and revegetation with native plant species.

Controlled burning

The annual burning of grass can have long-term detrimental effects on vegetation, and careful management is required. It is suggested that one official be placed in charge of all burning operations, and that he plan operations prior to the dry season. Based on existing information, fires should be set during the late as well as the early dry season to control woody vegetation (Innes 1972).

It is believed that present practices of burning 70-75% of the park annually prior to the tourist season, setting numerous fires near waterholes, and burning along rivers are incompatable with park goals. By skillful manipulation of burning patterns, the wildlife carrying capacity can be improved and the requirements of species be better fulfilled. Austen (1972) stated in his management plan for Wankie National

Park in Rhodesia that the objective was to perpetuate adequate grasslands for grazers, woodlands and thickets of various types for browsers, and samples of forest for a variety of birds and animals, and for their own sake. A similar one is needed for Park W.

Research on the effects of fire in a variety of vegetation types is needed to determine the best burning policy. The few investigations carried out thus far in West Africa have been in habitats and climates somewhat different from those of Park W. Studies designed to evaluate the long-term effects of early-, mid-, and late-season burning on plant and animal communities are needed. A vegetation-management policy should be developed which will provide the best habitats for wildlife and provide for the preservation of communities.

Considerations for a burning policy:

1. Fire should be used only when necessary to perform a definite task.
2. Frequent and excessive burning is not in the best interest of wildlife or the plant communities.
3. Early dry season burning is necessary to facilitate game viewing. This should be done in rotation along roads as soon as conditions permit. At the same time, this will provide green grass and seedling browse.
4. Avoid burning around mineral licks, waterholes, along rivers, or areas subject to erosion unless absolutely necessary.

5. Devise a firebreak system by using natural breaks such as roads and rivers, and by burning in strips using prevailing winds.
6. Direct efforts at areas of the park which are most important for wildlife since it is impossible to manage fire over the entire park.
7. Late dry-season burning should be carried out in areas where brush encroachment has significantly impaired game viewing, and in more open areas to maintain the open habitat.

These considerations are essential for a successful fire management program in Park W. Controlled burning programs are difficult to implement, however, and require a skilled and experienced park staff. The following guidelines are offered to assist implementation and are based on experience gained by the author and on suggestions made by Ross and Harrington (1968, 1969).

1. The time of implementing burning schemes is limited because vegetation usually dries quickly, and fires set too late are difficult to control.
2. Areas burned early in the dry season do not necessarily provide a fire-proof break in wooded areas. Leaf fall accumulations and unburned grasses can support late dry-season fires.
3. Illegal activity within a park is impossible to eliminate, and uncontrolled fires are inevitable. They

can be utilized in a burning scheme, however, once local burning habits are understood.

4. Experience gained from one year does not necessarily apply in another year. The times and conditions for burning are variable, and adaptability is required.
5. Areas burned during one dry season are less likely to burn the following year. Similarly, it is difficult to control fires in areas protected from fire the previous year.
6. The various grass species dry at different rates, and the vegetation of an area does not necessarily dry at an uniform rate.
7. The amount of area burned can be controlled by setting fires in early morning or mid- to late afternoon when winds are calm and the humidity is high.

Wildlife censusing

It is important to continue the monitoring of game populations. This can be done both with road strip and food transect counts. The details concerning techniques are being evaluated, and guidelines for wildlife censusing will be presented later.

Waterhole development

Habitat degradation is commmon near waterholes in high game density areas and where game is forced to concentrate

during the dry season. Damage is sometimes extensive, and can have lasting negative effects. To avert this, permanent habitat trend transects can be established by each waterhole to measure changes caused by wildlife. Severe habitat deterioration can be dealt with by creating additional waterholes nearby, by game cropping, or by using salt blocks to atrract game away from the waterholes.

A waterhole location should drain a sufficiently large area to ensure filling, yet be sufficiently limited to avoid damage from excessive flooding.

Waterholes should be at least 50 and preferably 100 meters from roads to minimize disturbances of game by tourists. Many wildlife species drink frequently during the day, and can provide enjoyable viewing if undisturbed.

A depth of 300 cm is desirable to ensure permanence of waterholes. Average water loss from evaporation, seepage, and use by animals is about 1 cm per day, or at least 210 cm over the 7 month dry season. This varies with base soil types, amount of shade, surface area (greater surface area means more rapid water loss per unit volume), and amount of use by wildlife, especially by buffalo and elephant.

Areas with high watertables and springs are more likely to retain water throughout the dry season. These areas can sometimes be identified by their plant communities, especially by the grass species present. For example, Jardinia congoensis is a good indicator of impeded drainage.

High clay content is essential for dam construction to minimize water percolation into substrate material. When adequately packed by bulldozer, dams can withstand annual flooding, if sufficient clay is present. Normally, clay can be obtained by skimming the top 25-30 cm of soil from the drainage bottom. Care must be taken to avoid exposing porous soils underlying the clay.

Wildlife research

Research should provide the basis for resource management. Wildlife research programs are deficient in Park W, and West Africa in general. Although more information is needed on every species and every facet of the Park's ecology, investigations should be approached with caution. Many African parks including Park W are simply not ready for all types of research. Even a well-designed and meaningful study has little immediate value if the park staff lacks the means to utilize the findings. Development projects such as visitor centers, roads, publicity, and waterholes are often of more immediate use to developing countries. Such developments are essential. They provide economic incentives for preservation.

The specie needing special research attention at present is the elephant. Elephant damage is becoming excessive in several areas of the park. Research on elephant distribution and movements is needed in the near future for the proper management and protection of both elephants and park values. No comprehensive elephant studies have been conducted in West Africa thus far.

APPENDICES

Appendix A

Large mammals of Park W.

The following list includes only the larger mammals of Park W. Nomenclature follows that of Dorst and Dandelot (1969).

Bovidae	
African buffalo	Synceras caffer Sparrman
Bushbuck	Tragelaphus scriptus Pallas
Bohor reedbuck	Redunca redunca Pallas
Bubal hartebeest	Acelaphus bucelaphus major Pallas
Grimm's duiker	Sylvicapra grimmia L.
Kob	Kobus kob kob Erxleben
Oribi	Ourebia oribi Zimmerman
Red-flanked duiker	Cephanlophus rifilatus Gray
Red-fronted gazelle	Gazella rufifrons Gray
Roan antelope	Hippotragus equinus koba Desmarest
Topi	Damaliscus korrigum korrigum Ogilby
Waterbuck	Kobus defassa Küppell
Canidae	
Side-striped jackal	Canis adjustus Sundevall
Cercopithecidae	
Anubus baboon	Papio anubus J. P. Fischer
Patas	Erythrocebus patas Schreber
Vervet	Cercopithecus aethiops tantalus L.

Elephantidae	
African elephant	Laxodonta africana africana Blumenbach
Felidae	
African wild cat	Felis libyca Forster
Caracal	F. caracal Schreber
Cheetah	Acinonyx jubatus Schreber
Leopard	Panthera pardus L.
Lion	P. leo L.
Serval	Felis serval Schreber
Hippopotamidae	
Hippopotamus	Hippopotamus amphibius L.
Hyaenidae	
Spotted hyena	Crocuta crocuta Erxleben
Striped hyena	Hyena hyena L.
Orycteropodidae	
Aardvark	Orycteropus afer Pallas
Suidae	
Warthog	Phacochoerus aethiopicus Pallas

APPENDIX B

Vascular plants of Park W, Niger

The nomenclature follows the Flora of West Tropical Africa (Hutchinson 1954). The plant list is based on the collection in the Park W herbarium and on collections by Boudouresque et. al. (1978) in Park W. Columns refer to the general habitat types described in the text, and the symbols used are according to the following description:

1. Combretum shrubland
2. Upland grassland
3. Combretum woodland
4. Terminalia woodland
5. Riparian woodland
    - A. Floodplain grassland
    - B. Upland grassland
    - C. Seasonal streams
    - D. Riparian woodland
    - E. Evergreen forest
    - F. Aquatic vegetation
    - G. Disturbed soils

	1	2	3	4	5
Acanthaceae					
Blepharis linarifolia Pers.			x	x	
Hygrophilia laevis (Nees.) Lidau.					F
Hypoestes verticillaris (L.f.) Soland ex. Roem & Schult.					x
Monechma ciliatum (Jacq.) Milne-Redh.			x		
Nelsonia canescens (Lam.) Spreng.					F
Amaranthaceae					
Achyranthes sicula (L.) All.					D
Pandiaka angustifolia (Vahl.) Hepper.					D
Ampelidaceae					
Ampelocissus grantii (Bak.) Planch.			x		x
Cissus touraensis A. Chev.			x		x
C. *quadrangularis* L.			x		x
Anacardiaceae					
Heeria insignis (Del.)). Ktze.			x		
Lannea acida A. Rich.			x		
L. *microcarpa* Engl. et K. Krause			x		
Sclerocarya birrea (A. Rich.) Hochsta			x		
Annonaceae					
Annona senegalensis Pers.			x		
Apocynaceae					
Baissea multiflora A. DC. in DC.			x		x
Strophanthus sarmentosus DC.					D

	1	2	3	4	5
Asclepiadaceae					
Caralluma dalzielii N. E. Br.	x		x		
Glossonema boveanum (Pers.) Decne.			x		x
Leptadinia lancifolia Decne.			x		x
Azioaceae (Mulluginaceae)					
Glinus lotoides L.					x
Mullugo nudicaulis Lam.			x		x
Bignoniaceae					
Kigelia africana (Lam.) Benth.					D
Stereospermum kunthianum Cham.			x		D
Bombaceae					
Adansonia digitata Linn.	x		x	x	x
Bombax costatum Pellegr. & Vuillet.			x		D
Boraginaceae					
Coldenia procumbens Linn.					x
Heliotropium indicum Linn.			x		x
H. *strigosum* Wildl.					x
Burseraceae					
Commiphora africana (A. Rich.) Engl.			x		D
Caesalpiniaceae					
Afzelia africana (Lam.) Benth			x		D
Burkea africana Hook.	x		x	x	D
Cassia mimosoides Linn.			x		D
C. *sieberiana* DC.					
Daniellia oliveri (Rolfe.) Hutch. & Dalz.			x	x	x

	1	2	3	4	5
Detarium microcarpum Guill. & Perr.	x		x		
Isoberlinia doka Craib. & Stapf.					D
Piliostigma reticulatum (DC.) Hochst.			x	x	x
P. *thonningii* (Schum.) Milne-Redhead			x	x	x
Tamarindus indica Linn.					x
Capparidaceae					
Boscia agustifolia A. Rich.	x		x		x
B. *senegalensis* (Pers.) Lam. ex Poir.			x		
Cadaba farinosa Forsk.			x		D,E
Capparis tomentosa Lam.					D
Cleome viscosa Linn.					x
Crateva religiosa Forsk.					D
Maerua angolensis DC.			x		D
M. *oblongifolia* (Forsk.)					
Caryophyllaceae					
Polycarpaea corymbosa (L.) Lam. var. *corymbosa*	x		x		
P. *eriantha* Hochst. ex Rich.			x		
P. *linearifolia* (DC.) DC.			x		
Celastraceae					
Maytenus senegalensis (Lam.) Exell.			x		
Cochlospermaceae					
Cochlospermum planchonii Hook.	x		x		
C. *tinctorium* A. Rich.	x		x		
Combretaceae					
Anogeissus leiocarpus (DC.) Guill. & Perr.			x		C,D,E

	1	2	3	4	5
Combretum aculeatum Vent.	x		x		x
C. hypopilinum (Diels.) Okafer.	x		x	x	x
C. glutinosum Perr. ex DC.	x		x	x	x
C. micranthum G. Don.	x		x	x	C,D,E
C. nigricans Lepr. ex Guill. et Perr.	x		x	x	C,D,E
C. paniculatum Vent.					x
Guiera senegalensis J. F. Gmel.	x		x		
Pteleopsis suberosa Engl. & Diels.			x	x	
Terminalia avicennioides Guill. & Perr.			x	x	x
T. laxiflora Engl.			x	x	x
T. macroptera Guill. & Perr.			x	x	
Compositae (Asteraceae)					
Aspilia paludosa Berh.			x		D
Melanthera rhombifolia O. Hoffm.			x		C,D
Convolvulaceae					
Evolvulus alsinoides (L.) L.					x
Ipomoea aquatica Forsk.					x
I. rubens Choisy.					x
Jacquemontia tamnifolia (L.) Griseb.					x
Merremia aegyptiaca (Linn.) Urban.					x
M. hederacia (Burmif.) Hallier f.					x
Crassulaceae					
Kalanchoe lanceolata (Forsk.) Pers.			x		x

	1	2	3	4	5
Dioscoraceae					
Dioscorea bulbifera L.			x		x
D. dumetorum (Kunth) Pax.			x		
Ebenaceae					
Diospyros elliotii (Hiern.) F. White					D,E
D. mespiliformis Hochst. ex. A. DC.					D,E
Euphorbiaceae					
Caperonia fistulosa					x
Euphorbia unispina N. E. Br.			x		
Phyllanthus reticularus Poir.			x		
Securinega virosa (Roxb. ex Willd.) Baill.			x	x	x
Ficoidaceae					
Trianthema portulacastrum L.	x		x		
Hippocrateaceae					
Loeseneriella africana (Willd.) R. Wilczek ex Halle.					E
Labiatae					
Tinnea barteri Gurke.			x		
Lentibulariaceae					
Utricularia gibba L.					F
U. inflexa Forsk. var. stellris (Linn. f.) P. Tayl.					F
U. thonningii Schum.					F
Loganiaceae					
Strychnos innocua Del.			x		

	1	2	3	4	5
Strychnos spinosa Lam.			x	x	
Loranthaceae					
Tapinathus dodoneifollius	x		x	x	
T. globiferus (DC.) Danser.					x
Lythraceae					
Ammannia gracilis G.					x
A. senegalensis Lam.		A			x
Nesaea cordata Hiern.		A			x
Malvaceae					
Hibiscus asper Hook.			x		
Sida alba Linn.					D
Urena lobata Linn.			x		x
Melastomataceae					
Dissotis senegambiensis					x
D. irvigiana Hook.					x
Meliaceae					
Kaya senegalensis (Desv.) A. Juss.					D
Pseudocedrela kotschyi (Schw.) Harms.					D
Menispermaceae					
Chasmanthera dependens Hochst.			x		
Mimosaceae					
Acacia ataxacantha DC.	x		x		
A. erythrocalyx Brenan.					x
A. macrostachya Reich.	x		x		
A. nilotica var. adansonii (Guill. & Perr.)			x		x

	1	2	3	4	5
Acacia seyal Del.	x		x		
A. sieberiana DC. var. sieberiana			x		x
A. sieberiana var. villosa A. Chev.					x
Albizia zygia (DC.) J. F. Macbr.					E
Dichrostachys cinerea (L.) Wight. & Arn.					x
D. glomerata (Forsk.) Chiov.			x		D
Entada africana Guill. & Perr.			x		
Parkia clappertoniana					D
Prosopis africana (Guill. & Perr.)			x		
Mimosa pigra Linn.					C,F
Molluginaceae					
Mollugo nudicaulis Lam.			x		
Moraceae					
Ficus albutilifolia (Mig.) Mig.					D,E
F. glumosa Del.			x		
F. platyphylla Del.					D,E
Moringaceae					
Moringa oleifera Lam.			x		D
Myrtaceae					
Syzygium guineense (Willd.) DC.					D,E
Nyctaginaceae					
Boerhavia coccinea var.			x		
Nymphaeaceae					
Nymphea lotus Linn.					F
N. micrantha Guill. & Perr.					F

	1	2	3	4	5
Olaceae					
Ximinia americana Linn.	x		x	x	x
Onagraceae					
Jussiaea abyssinica (A. Rich.) Dandy & Brenan.					x
Papilionaceae (Fabaceae)					
Crotolaria macrocalyx Benth.				x	
Indigofera nummulariifolia (Linn.) Livera. ex Alston.			x		
I. *secundiflora* Poir.			x		
Lonchocarpus laxiflorus Guill. & Perr.	x		x		
L. *sericeus* (Poir). H. B. & K.					D,E
Ormocarpum sennoides (Wild.) DC.					x
Pterocarpus erinaceus (Poir.) H.B. & K.					D,E
P. *santalinoides* L'Her. ex DC.					E
Tephrosia bracteolata Guill. & Perr.			x		
T. *linearis* (Willd.) Pers.			x		
Vigna racemosa (G. Don.) Hutch &					x
Xeroderris stuhlmannii (Taub.) Menderrya & Forst.			x	x	
Zornia glochidiata Reichb. ex DC.			x		
Pedaliaceae					
Ceratotheca sesamoides Endl.			x		
Polygalaceae					
Polygata arenaria Willd.			x		x

	1	2	3	4	5
Pontederiaceae					
Eichhornia natans					F
Polygonaceae					
Polygonum senegalensis Meisn.					x
Portulaceae					
Portulaca quadrifida L.	x		x		x
P. *foliosa* Ker-Gawl.					x
Rhamnaceae					
Ziziphus abyssinica Hochst.			x		
Z. *mauritiana* Lam.	x		x		
Z. *mucronata* Wild.	x		x		D
Rubiaceae					
Canthium cornelia Cham & Schlecht.					E
Crossopteryx febrifuga (Afzel. ex G. Don.) Benth.			x	x	x
Feretia apodanthera Del.			x		D
Gardenia sokotensis Hutch.			x	x	x
G. *ternifolia* Schum. & Thonn.			x	x	D
Mitracarpus scaber Zucc. in Schultes			x	x	x
Mitragyna inermis (Wild.) O. Ktze.					D,E
Morelia senegalensis A. Rich. ex Del.					E
Nauclea latifolia Sm.					D,E
Sapindaceae					
Cardiosperm halicacabum Linn.			x		x
Paullinia pinnata Linn.					D

	1	2	3	4	5
Sapotaceae					
Butyrospermum paradoxum ssp. *parkii* (G. Don.) Hepper.			x	x	D
Manilkara multinervis (Bak.) Dub.					D
Scrophulariaceae					
Bacopa hamiltoniana (Benth.) Wettst. var *hamiltoniana*			x		
Limnophila fluriatilis A. Chev.					F
Scoparia ducis L.			x		x
Sterculiaceae					
Cola laurifolia Mast.					E
Sterculia setigera Del.			x	x	
Waltheria indica L.			x		
Tiliaceae					
Corchorus sp.					
Grewia bicolor Juss.	x		x		
Grewia barteri Burret.			x		x
Grewia mollis Juss.			x		D
Thymeleaceae					
Gnidia kraussianum (Meisn.) Burtt-Davy.					D
Lasiosiphon kraussianus (Meisn.)			x		D
Ulmaceae					
Celtis intergrifolia Lam.					D,E
Verbenaceae					
Stachytarpheta angustifolia Vahl.	x		x		
Vitex doniana Sweet.					D,E

	1	2	3	4	5
Vitex chrysocarpa Planch. ex Benth.					C,E
V. *simplicifolia* Oliv.			x		D
Zingberiaceae					
Kampferia aethiopica (Schweinf.) Solms-Laub.			x		D
Zygophyllaceae					
Balanites aegyptiaca (Linn.) Del.			x		D
MONOCOTYLEDONES					
Agavaceae					
Sanservieria liberica Ger. & Labr.					D,E
Alismataceae					
Lymnophyton obtusifolium Linn.					F
Amaryllidaceae					
Crinum distichum Herb.					D
C. *ornatum* (Ait.) Bury					D
Pancratium hirtum A. Chev.			x		D
Scadoxus multiflorus Bak. (*Haemanthus multiflorus*)					D
Araceae					
Amorphophallus dracontoides (Engl.) N.E. BR.					D
A. *flavovirens* N.E. BR.					D
Pistia stratioites L.					F
Commelinaceae					
Commelina forskalaei Vahl.		B	x		

	1	2	3	4	5
Cyanotis lanata Benth.			x		D
Murdannia simplex (Vahl.) Brenan			x		D,E
M. *tenuissima* (A. Chev.) Brenan		A			A
Cyperaceae					
Bulbostylis barbata (Rottb.) C.B. CL.					A,D
B. *coleotricha* (Hocst. ex A. Rich) C.B. CL.					x
B. *filamentosa* (Vahl.)					A
B. *scabricaulis* Cherm.					A
Cyperus digitatus Roxb. ssp. *auricomus*					A
C. *dilatatus* Schum. & Thonn.					A
C. *esculentus* L.					D
C. *iria* Linn.					A,D
C. *tenuispica* Steud.					A
Eleocharis atropurpurea (Retz.) Presl.					x
E. *setifolia* (A. Rich.) J. Reynal.					A
Fibristylis dichotoma (Linn.) Vahl.					x
Fuirena umbellata Rohb.					x
Isolepis microcephala (Steud.) Lye.					
Kyllinga debillis C.B. CL.			x		D
Lipocarpha gracilis (L.C. Rich.) Mees.			A		
Mariscus alternifolius Vahl.					x
M. *cylindristacryus* Steud.					D
M. *squarrosus* (L.) C.B. CL.			x		D
M. *sumatrensis* (Retz.) J. Reynal.					D

	1	2	3	4	5
Oxycaryum cubense (Poepp. & Kunth.) Lye.					
Schoenoplectus oxyjulos (Hooper) J. Raynal.			A		
Scleria sphaerocarpa (E.A. Robinson) Happer.					D,E
Fougerae					
Ceratopteris cornuta (P. Beauv.) Leprs.					x
Gramineae					
Acroceras amplectans Stapf.					F
Andropogon fastigiatus Sw.			x		
A. *gayanus* var. *gayanus* Kunth.	x	A,B	x	x	x
A. *gayanus* var. *squamulatus* (Hochst.) Stapf.	x	A,B	x	x	x
A. *pseudapricus* Stapf.	x	B	x	x	
A. *tectorum* Schumach.				x	D
Aristida kerstingii Pilger.			x		
Bambusa vulgaris					D
Brachiaria distichophylla (Trin.) Stapf.			x		D
B. *kostschyana* (Hochst. ex. Steud.) Stapf.			x		D
B. *lata* (Schumach.) C.F. Hubbard.			x		x
B. *mutica* (Forsk.) Stapf			x		x
Cenchrus biflorus Roxb.	x		x		
Chasmopodium caudatum (Hack.) Stapf.			x		D
Chloris pilosa Schumach.					x

	1	2	3	4	5
Ctenium elegans Kunth.	x	B	x		
C. newtonii Hack.	x		x		
Cynodon dactylon					
Dactyloctenium aegypticum (L.) P. Bearu			x		
Digitaria adscendens Henr.					B
D. gayana (Kunth.) Stapf. ex. A. Chev.			x		D
D. lecardii (Pilger.) Stapf.			x		
Diheteropogon hagerupii Hitchc.	x		x		D
Echinochloa pyrimidalis (Lam.) Hitchc & Chase				x	A,D
Eleusine indica (Linn.) Gaertn.			x		
Elytrophorus spictus A. Cam.					A
Eragrostis atrovirens (Desf.) Trin. ex. Steud.			x		D
E. ciliaris (L.) R. Br.	B	x			
E. gangetica (Roxb.) Steud.			x		B
E. tenella (Linn.) Beauv. ex. Toem. & Schult		x			
E. tremula (Lam.) Steud.	B	x			
E. tenuifolia		x			
E. turgida Schum.	B				
Euclasta condylotricha Stapf.				x	C,D
Hachelochloa granularis (L.) O. Ktze.	x	B			D
Hyparrhenia cyanescens Stapf.				x	D

	1	2	3	4	5
Hyparrhenia filipendula var. filipendula (Hochst.) Stapf.			x		D
H. involoucrata Stapf.	x	x	x	x	x
H. subplumosa Stapf.			x		D
Hyperthelia dissoluta (Nees. es. Steud.) W.D. Claton.					D
Jardinia congoensis Franch.					A
Loudetia annua (Stapf.) C.E. Hubbard.			x		
L. togoensis (Pilger.) C.E. Hubbard.	x	x	x		
Microchloa indica (Linn.) P. Beauv.	x	x	x		
Oryza glaberrima Steud.			A		F
Panicum dregeanum Nees.					E
P. fluviicola Steud.		A			x
P. pansum Rendle					x
P. pilger Mez.					E
P. subalbidum Kunth.			x		D
Paspalum orbiculare Forst.					D,E
Pennisetum hordeoides (Lam.) Steud.			x		D
P. pedicellatum Trin.	x		x		x
P. polystachion (C.) Schult.			x	x	x
P. subangustum (Schumach.) Stapf. & C.E. Hubbard.			x	x	x
Rhytachme triaristata Stapf.					x
Rottboellia exaltata					C,D
Sacciolepsis africana C.E. Hubbard. & Snowden					A,F

	1	2	3	4	5
Schizachyrium brevifolium (SW.) Nees. ex. Buse IN. Mig.					A,D,E
Schoenefeldia gracilis Kunth.			x		x
Setaria anceps Stapf. & Nassey					A
S. pallidefusca (Schumach.) Stapf. & C.E. Hubbard.		A			A
S. sphacelata (Schumach.) Stapf. & C.E. ex. M.B. Moss					D
Sporobolus festivus Hochst. ex. A. Rich.		A			A,C
S. pyrimidalis Beauv.		A			A,C
Tripogen minimus (A.R.) H.			x		
Vetivera nigritana (Benth.) Stapf.		A			A,C
Vossia cuspidata		A			x
Hydrocharitaceae					
Ottelia ulvifolia (Planch.) Walp.					x
Hypoxidaceae					
Curculigo pilosa (Schum. & Thonn.) Engl.			x		
Liliaceae					
Anthericum limosum Bak.					
Asparagus africanus Bak.			x		D
Chlorophyrum macrophyllum (A. Rich.)			x		
Gloriosa superba L.					D
Urginea altissima (Linn. f.) Bak. ensifolia	x	x	x	x	
Menyanthaceae					
Nymphoides indica					F

	1	2	3	4	5
Orchidaceae					
Eulophia cucullata (Sw.) Steud.					D
Palmae					
Borassus aethiopum Mart.					D,E
Raphia sudanica A. Chev.					E
Taccaceae					
Tacca leontopetaloides (Linn.) O. Ktze.			x		
Vitaceae					
Cyphostemma sohondense					
Zingiberaceae					
Kaempferia aethiopica (Schurveimf.) Solms-Lamb.			x		D
PTERIDOPHYTES					
Adiantaceae					
Ceratopteris cornuta (P. Beauv.) Lepr.		A			
Azollaceae					
Azolla africana Desv.					F

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