INVENTORY OF LARGE MAMMALS IN THE DEUX BALÉ NATIONAL PARK, UPPER VOLTA

Thesis for the Degree of M. S.

MICHIGAN STATE UNIVERSITY

JOHN P. SIHVONEN

1977

ABSTRACT

INVENTORY OF LARGE MAMMALS IN THE DEUX BALÉ NATIONAL PARK, UPPER VOLTA

By

John P. Sihvonen

During 1972-1974, the densities of large mammal populations were estimated in the Deux Balé National Park, an area of 566 km^2 in the Sudan savanna zone of west-central Upper Volta, West Africa. Indices to animal abundance used were: 1) Hahn (1949) walking-strip counts, 2) animals seen per kilometer of travel, and 3) territorial mapping. Results obtained from the first and second methods were similar, but the visibility factor in the first method made it the more reliable index from year to year. The third method was applied to species with distributions not amenable to strip-count methods.

INVENTORY OF LARGE MAMMALS IN THE DEUX BALÉ NATIONAL PARK, UPPER VOLTA

By

John P. Sihvonen

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

1977

ACKNOWLEDGMENTS

I would like to thank the Departement des Eaux et Forêts, Ministère de l'Agriculture, Upper Volta, and the United States Peace Corps for the opportunity to work in the Deux Balé National Park. I express my appreciation to Monsieur Jean Barry, former Directeur des Eaux et Forêts, and to members of his staff, particularly Mssrs. Casimir Ziba, Chef d'Inspection, and Matias Siéba, Chef du Cantonnement. I owe a deep debt of gratitude to Eaux et Forêts personnel assigned to the Deux Balé, Mssrs. Yaya Boly, Koffi Ganou, Ernest Yao, Ousmane Kagoné, Ernest Kaboré, Marcel Somé, Adama Barry, and Béton Dao for their help with the faunal inventories of the region. Their enthusiasm and encouragement were abundant and welcome.

I extend heartfelt thanks to Mssrs. Simon Ouattara and Ouétian Bognounou of the Section Botanique, Centre Voltaique de la Recherche Scientifique in Ouagadougou, for their immense assistance with plant identification.

I express my gratitude to Dr. W. Derek Clayton of the Royal Botanic Gardens, Kew, England, for kindly identifying the Gramineae.

I pay special homage to my interpreter and companion, Kokoro Matias Tindano, who with constant good humor, willingness, competency, and a precocious perception of the foibles of man, made possible so much that seemed otherwise.

My concluding words of thanks go to Michigan State University, especially my major advisor, Dr. George Petrides. I would like to thank the members of my committee, Drs. Donald Dickmann and Leslie Gysel, for their critical review of this thesis.

TABLE OF CONTENTS

LIST OF TABLES

Table		Page

LIST OF FIGURES

LIST OF APPENDICES

INTRODUCTION

The author had the privilege, under the auspices of the United States Peace Corps and Upper Volta's Departement des Eaux et Forêts, of working from December, 1971 through June, 1974 in the Deux Balé National Park. The park was an unknown entity in 1971, having never been the subject of the faunal studies logically prerequisite to its intended development for nature preservation and wildlife-oriented tourism.

The author undertook the inventory of the Deux Balé's wildlife resources to provide the Departement des Eaux et Forêts with data on which to base management and developmental decisions. The inventory techniques used in these studies were limited to those possible under a very meager operating budget, but with the cooperation of an excellent complement of Eaux et Forets rangers.

Objectives of the study were: 1) to determine the composition and relative abundance of the large-mammal fauna, and 2) to assess the implications of those findings for park management.

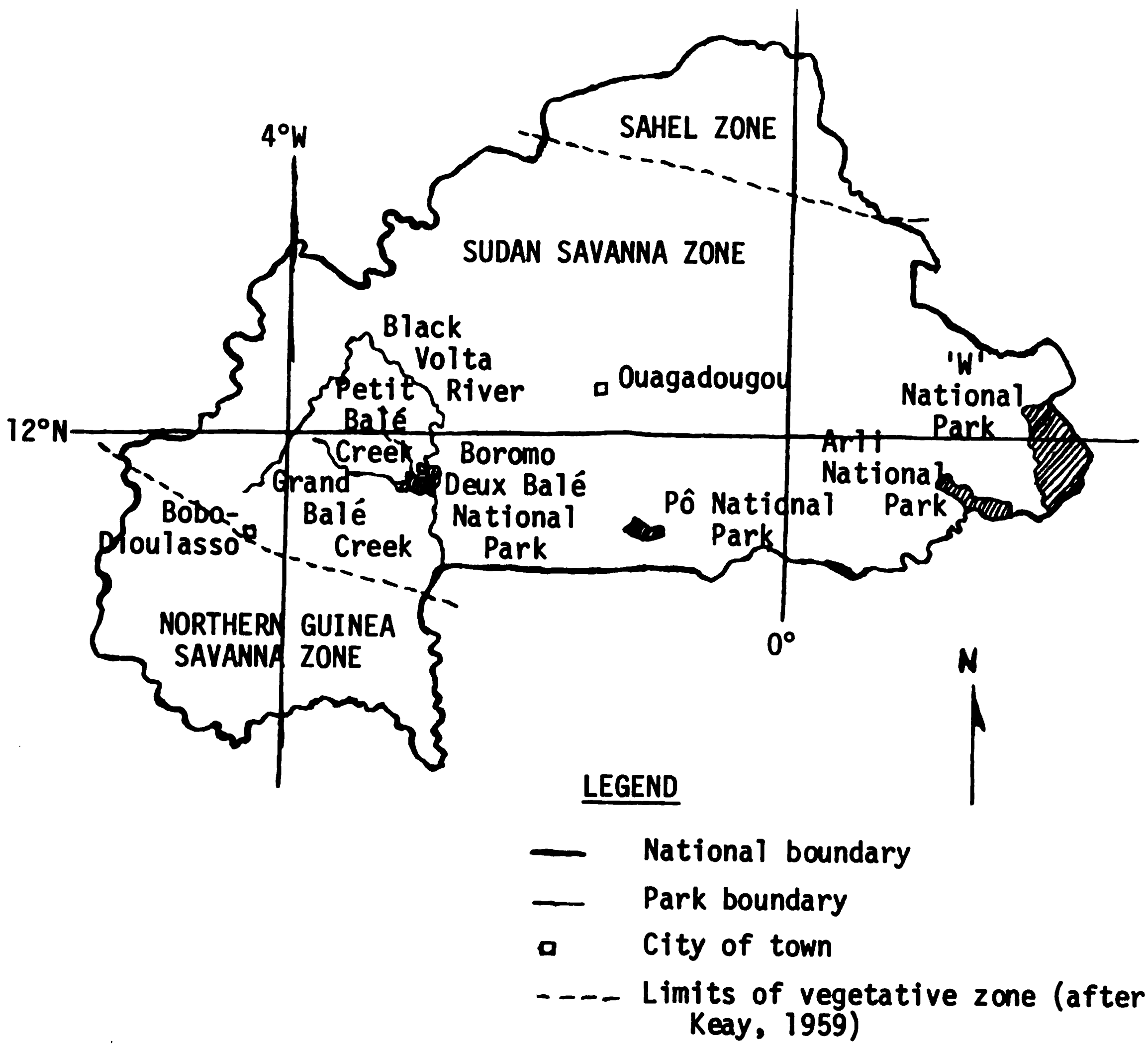
THE STUDY AREA

The Deux Balé National Park has an area of 566 km^2 and is located between latitudes N11°30' and N11°50' and longitudes W2°40' and W3°10' in Upper Volta, West Africa (Figure 1). The park is situated in the Sudan savanna zone as delineated by Keay (1959), and within the Meridianal Subdomain of the Sudan Domain of the Soudano-Zambesian Vegetative Region in the classification scheme proposed by Troupin (1966).

In 1937, the area presently occupied by the park was included in the forest reserve system in recognition of its being one of the least altered and most heavily wooded zones in the region destined to become Upper Volta (Plaisance, 1936). The Deux Balé Forest was upgraded to national park status in 1968, but necessary legislative action remains incomplete.

The park, being in a relatively densely-populated part of Upper Volta, is subject to the pressures usually associated with wildlands in proximity to human settlements: poaching, livestock grazing, and unauthorized burning. Demand for land in the region is increasing due to recent population influxes from the drought-stricken Sahel and, in many places, bush fallow agriculture is practiced to the very boundaries of the park.

Actual management of the area comprises only the maintenance of the 102 km tourist track, an early dry-season burning



Scale 1:4,000,000 - 62% of scale

Figure 1. Upper Volta, West Africa, showing the locations of its national parks and major vegetation zones (Keay, 1959).

sch

Tou

twe

yea

Me

in

19

ar

Se

ra

pe

av

fr

to

fr

ar

30

schedule, and infrequent patrols to control illegal activities. Tourism in the park is not being actively promoted, and fewer than twenty groups of tourists--foreign and local--visit the Deux Balé yearly.

Climate

Rainfall records over the period 1921-1974 from the Boromo Meteorological Station, located near the northern limit of the park, indicate an average annual rainfall of 967 mm (Begué, 1937; Anon., 1966, 1972; unpublished station records, 1971-1974). The Deux Balé area is considered to have a five-month rainy season, May through September. The period from November through mid-March is nearly rainless.

Relative humidity over the period 1961-1970 averaged 52 percent (Anon., 1972). Seasonally, relative humidities (percentages) average in the low 80's from July through September and in the 20's from December through March. The average annual evaporation is close to 2200 mm with annual evapotranspiration on the order of 1700 mm.

During the dry season, maximum daily temperatures range from 37° to 40°C with minimums from 17° to 25°C. Daily variations are less extreme during the rainy season with maximums ranging from 30° to 32°C and minimums from 20° to 22°C (Anon., 1966, 1972).

A summary of weather data is given in Appendix 1.

Topography and Geology

The general aspect of the Deux Balé is gently-rolling terrain with occasional lateritic prominences; elevations range from 235 to 310 m. Soils are predominantly of the tropical ferruginous group, hydromorphic soils are found along the major streams (Figure 1) and on their floodplains (Leprun and Moreau, 1968). The park is underlain by three rock formations of approximately equal width which are oriented south-south-west to north-north-east. From east to west they are composed of 1) green and sericitic schists from the Birrimean period, 2) metamorphosed birrimean schists, and 3) granito-gneisses, respectively (Anon., 1968).

Mammalian fauna

The Deux Balé has twenty-three species of mammals which are jackal-sized or larger. Among them are five frequently-encountered antelope species: roan antelope (*Hippotragus equinus* Desmarest), oribi (*Ourebia ourebi* Zimmermann), Grimm's duiker (*Sylvicapra grimmia* Linn.), western hartebeest (*Alcelaphus buselaphus major* Pallas), and bushbuck (*Tragelaphus scriptus* Pallas). Less-frequently encountered are western kob (*Adenota kob* Erxleben), red-flanked duiker (*Cephalophus rufilatus* Gray), defassa waterbuck (*Kobus defassa* Ruppell), and African elephant (*Loxodonta africana* Blumenbach). There are three primates all of which are commonly seen: green monkey (*Cercopithecus aethiops* Linn.), patas monkey (*Erythrocebus patas* Schreber), and an

sp

a

19

ma

la

ve

or

pa

te

ar

w

le

li

up

bi

it

ba

sa

co

wi

sa

anubis baboon (Papio anubis Fisher). A total of thirty-six mammal species is known to be present in the park (Appendix 2).

Flora

Deux Balé vegetation is largely typical Sudan savanna with a few areas dominated by Northern Guinea savanna species (Kershaw, 1968). Numerous vegetation types are found in the area. The vast majority of the park is covered by tree savanna or open savanna woodland types; small areas of grassland are found on floodplains and on very shallow soils underlain by laterite. Woody species ubiquitous on upland areas are: Acacia dudgeoni Craib ex Holl., Butyrospermum paradoxum (G. Don) Hepper, Combretum glutinosum Perr. ex DC., Crossopterix febrifuga (Afzel. ex G. Don) Benth., Detarium microcarpum Guill. and Perr., Lannea acida A. Rich., Piliostigma thonningii (Schum.) Milne-Redhead, and Terminalia laxiflora Engl. Locally, Anogeissus leiocarpus (DC.) Guill. and Perr., Burkea africana Hook., and Isoberlinia doka Craib and Stapf may be quite common. Important grasses on upland areas are: Andropogon ascinodis C.B. Cl., A. gayanus var. bisquamulatus (Hochst.) Hack., Diheteropogon hagerupii Hitchc., Hyparrhenia subplumosa Stapf, Loudetia togoensis (Pilger) C.E. Hubbard, Monocymbium ceresiiforme (Nees) Stapf, and Schizachyrium sanguineum (Retz.) Alston. The forest galleries along major watercourses are mainly composed of Mitragyna inermis (Willd.) O. Ktze., with Acacia sieberiana DC., Cola laurifolia Mast., and Pterocarpus santilinoides L'Her. ex DC. being the most frequent component species.

Small

speci

foun

Smaller watercourses rarely support galleries comprised of riverine species; denser-than-average strips of upland species are normally found along their banks.

METHODS

Hahn (1949) described a method for censusing Texas white-tailed deer (*Odocoileus virginianus* Miller) with walking-strip counts. Transects two or more miles in length were surveyed across habitat representative of the vegetation and land-use on the count areas. The distances to which deer were visible along each transect line were estimated by having a second observer pace at right angles to the line at 100-yd intervals. The distance at which a white handkerchief--simulating a deer's tail--in the second observer's hip pocket was obscured by brush and slope from the observer on the transect line was measured. The visibility measurements for each transect were then summed and twice the mean of the measurements times the length of the corresponding transect line was taken as the acreage on which deer could be seen. This acreage divided by the number of deer seen by a single observer while following the transect gave a figure of acres per deer. Acreage per deer divided into the total area for which the transect line was representative gave an estimate of that area's deer population.

Hahn's (1949) walking-strip census was modified for use in the Deux Balé National Park and in three contiguous reserves, the Baporo, Dibon, and Laba Forests. There being no map showing the vegetation types of the region, the situation of transects in a manner representative of vegetation and land-use was not possible. Transect locations were chosen randomly in the park from a system of zones accessible along their lengths by vehicle or motorbicycle. A base line was drawn across each zone (Figure 2), the base lines were measured, and points at 100-m intervals along each base line were given three-digit numbers. Starting points for transects were then located on the base lines by drawing sets of three digits each from a table of random numbers. A minimum distance of one kilometer was kept between transects in the same zone (Figures 3 and 4). In the three forests, transect lines were spaced equally along base lines (Figure 4).

Transect routes followed were in the form of open or closed rectangles with their long axes 4-7 km in length and usually 1 km apart (Figures 3 and 4). They were followed by two-man teams using compasses and counts were started from twenty minutes before to forty minutes after sunrise. Distances were determined by pacing. Considerations of vehicular access, area to be counted, time, and manpower limited the number of transects selected to thirty in the park and to five, twelve, and eleven in the Baporo, Dibon, and Laba Forests, respectively.

Walking-strip counts were carried out in the Deux Balé during 4-9 February and 25-29 March, 1974, with respectively 350 and 352 km being traversed. The northern two-thirds of the 245 km^2 Dibon Forest was counted during 1-3 April, 1974 by walking 151 km of transects. The 81 km^2 Baporo and 188 km^2 Laba Forests were inventoried during 4-7 June, 1974, with respectively 74 and 150 km of transect routes being followed.

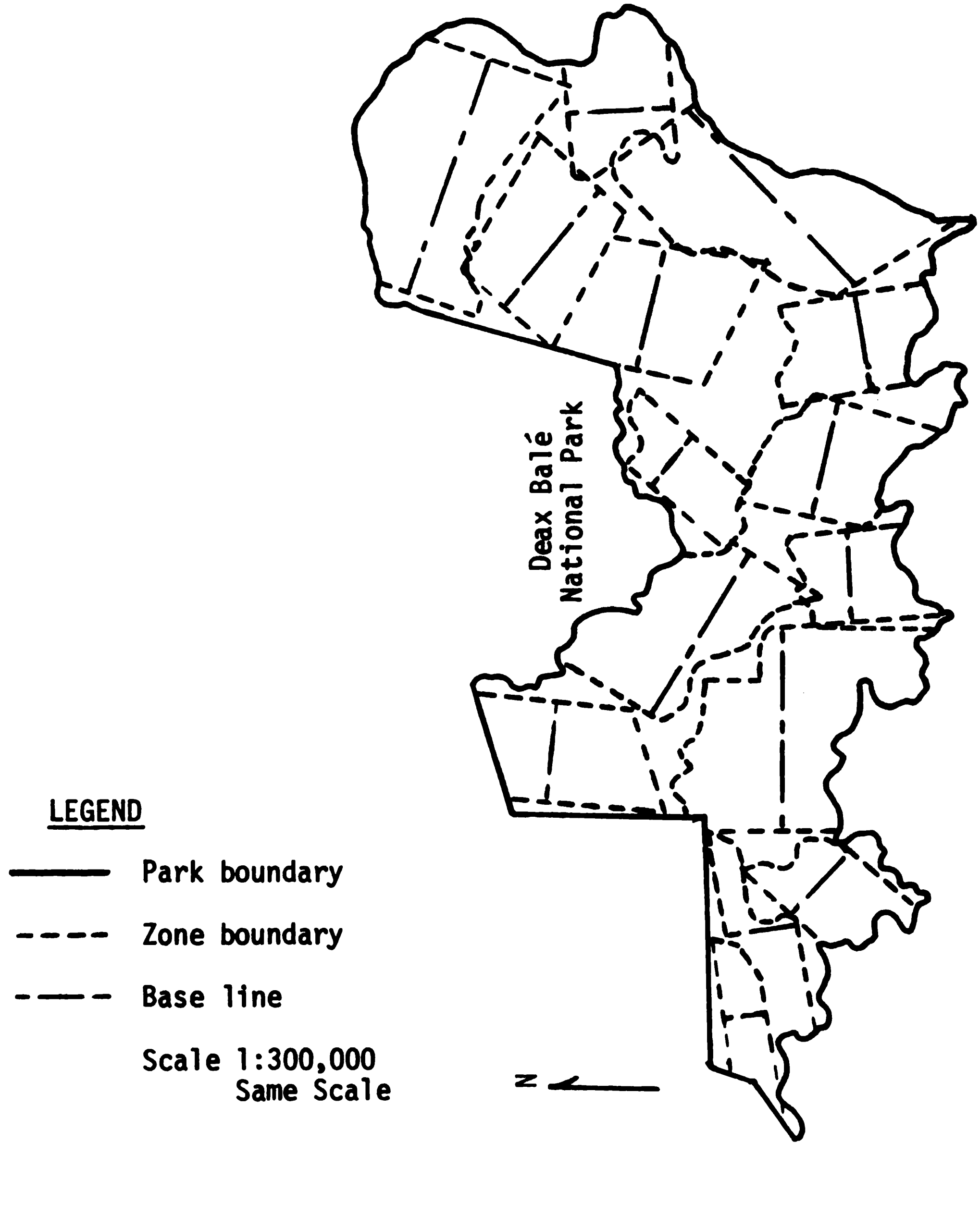
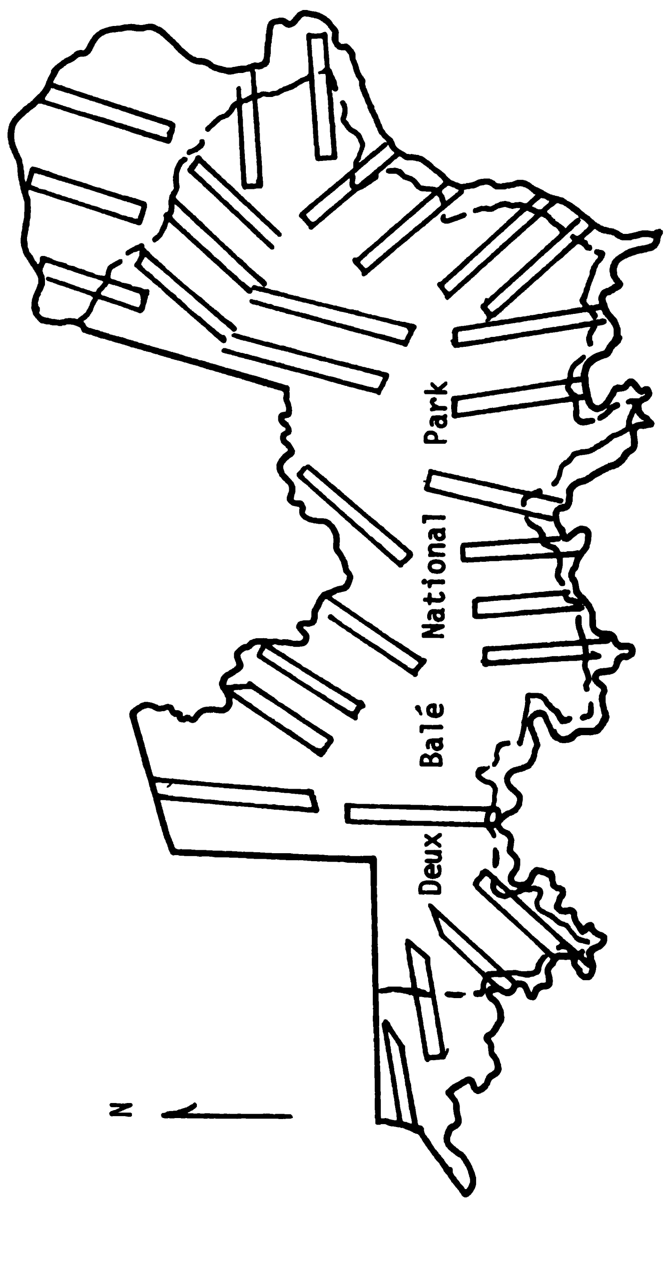


Figure 2. System of zones and base lines used in the random selection of walking-strip count transects, Deux Balé National Park, Upper Volta.



LEGEND

Park boundary

Transect outline

Tourist track

Scale 1:300,000
Same Scale

Figure 3. Transect locations for 4-9 February 1974 large-mammal census, Deux Balé National Park, Upper Volta.

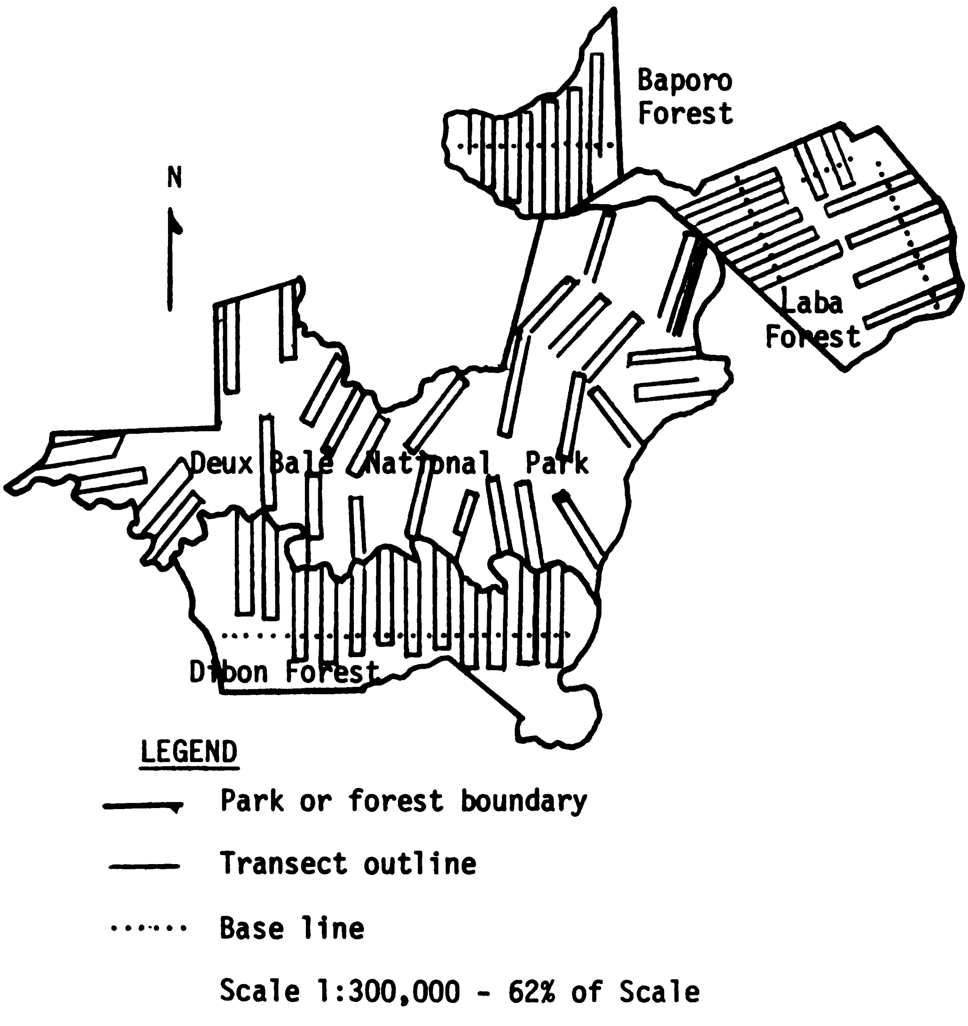


Figure 4. Distribution of census transects, Deux Balé National Park and Baporo, Dibon, and Laba Forests, Upper Volta.

regi
were
were
at
80
at
At
fr
wh
of
ur
ob
t
c
w

s
d
M

u

wh
ob

Determination of visibility along transects in the Deux Balé region varied slightly from Hahn's (1949) design. Visibility profiles were not determined for every transect. Further, visibility distances were calculated for three size-classes of antelope: 1) small, 50 cm at the shoulder corresponding to Grimm's duiker and oribi, 2) medium, 80 cm at the shoulder corresponding to bushbuck, and 3) large, 145 cm at the shoulder corresponding to roan antelope and western hartebeest. At 200-m intervals, the second observer walked at right angles away from the transect line. Average distances from the line of travel at which cloth strips pinned to the second observer's clothing at heights of 50, 80, and 145 cm became hidden by vegetation or slope were measured by pacing. In January, 1974, a total of 208 visibility distance observations for each size-class was made in the Deux Balé along eight transect courses selected by the same method as were walking-strip count transects. Average visibility distances computed in the park were also used in the vegetatively-similar Dibon Forest.

Due to visibility changes between January and the dates scheduled for counts in the Baporo and Laba Forests, 180 visibility distance observations for each size-class were made in each forest in May-June, 1974.

Population estimates (P) were calculated for each count area using the formula:

$$P = \frac{AN}{2DL}$$

where A = total area of the park or forest, N = total number of animals observed, D = average width of the visible strip, and L = total length of transects walked. The mean visibility distance was doubled so as to equal the width of the strip viewed on both sides of the line of travel.

The herd-forming tendencies exhibited by roan antelope and western hartebeest violated an assumption of the Hahn census model that individual animals are randomly distributed throughout the area. Robinette, Loveless, and Jones (1974) believed that some herding could be tolerated by walking-strip censuses if area coverage was high. The area visually covered in counting roan and hartebeest, however, though comprising approximately 20 percent of the park area, was found to be insufficient to overcome herding effects.

To diminish the effects, herd numbers were approximated by eliminating duplicate sightings from all observations of roan and hartebeest made from December, 1973 through April, 1974. Observations of each species were then divided into two classes depending on whether the number of animals in the herd was more than or less than the median number in all herds. A herd was defined as one or more animals. The average number of animals per observation for each class was defined as a herd-class average. The number (N) for one of these species was then taken as the sum of the products of the numbers of observations in the two classes made during a count times their corresponding herd-class averages. Simple averages (total animals seen divided by total observations) were not used. The difficulty of distinguishing duplicate sightings of the smallest herds (one or two animals) could conceivably cause a greater distortion of such averages--with resulting effects on population estimates--than could occur with herd-class estimators.

Only nineteen of fifty-nine bushbuck seen during dry-season counts in 1973 and 1974 were farther than 0.5 km from a streambed. Wilson and Child (1964), Jacobsen (1974), Waser (1974), and Green (1976) all found bushbucks to be strongly associated with riverine areas. In accord with these observed dry-season habitat preferences of bushbucks, walking-strip counts in the Deux Balé were stratified with the 261 km^2 within 0.5 km of watercourses considered as high-density habitat and the remainder of the park as low-density habitat.

Relative abundances of mammals in the park also were calculated per kilometer traveled on a motorbicycle and per kilometer walked during counts. Observations were made from a motorbicycle moving 25 km/h along the tourist track by single observers during the period December through March over 644 km in 1971-72 and over 366 km in 1973-74. Observations on foot were made by pairs of observers along 702 km of transects in February-March, 1974.

The distributions of anubis baboon, green monkey, patas monkey, and red-flanked duiker in the Deux Balé rendered walking-strip counts infeasible for determining their populations. Their populations were estimated using modifications of territorial mapping techniques described by Overton (1969) and elaborated by Green (1976). All observations of these species were plotted on a 1:50,000-scale map of the park. Plotting revealed that observations of baboon, green monkey, and patas monkey were sometimes clustered. Home range boundaries were subjectively drawn around adjacent clusters and these areas, presumed to be occupied by different troops of baboon and patas monkeys, were measured. The average area of the home ranges was divided into the area of the park to estimate the numbers of possible baboon and patas monkey home ranges.

Clusters of green monkey observations were always near gallery forest along streams. Dorst and Dandelot (1970) and Heisterberg (1975) also found green monkeys to be closely associated with riverine areas. To estimate the number of green monkey home ranges, the stream frontages thought to be occupied by oft-observed troops were measured and then averaged. The length of streams in the park which were bordered by gallery forest was determined. This latter length divided by the average stream frontage per troop gave the possible number of green monkey home ranges.

Red-flanked duikers also exhibited strong affinities for riverine areas. The average stream frontage occupied by a duiker was estimated from repeated observations along a 5-km strip of the Grand Balé Creek. The length of stream frontage considered suitable for red-flanked duikers was longer than for green monkeys as the former species was occasionally observed along streams without galleries.

Elephant, African buffalo (Syncerus caffer Sparrman), and lion (Panthera leo Linn.) populations were estimated on the basis of observations made from December, 1973 through June, 1974, and from track counts begun in 1972. The spotted hyena (Crocuta crocuta Erxleben) population was estimated from track counts. The population of hippopotamus (Hippopotamus amphibius Linn.) was estimated from conversation with fishermen on the Black Volta River. Populations of eight other large mammals were judged from sightings and spoor.

RESULTS

Accuracy of Walking-Strip Counts

Only roan antelope, oribi, Grimm's duiker, western hartebeest, and bushbuck were encountered frequently enough during walking-strip counts in the Deux Balé to justify Hahn-method population estimates (Table 1).

Table 1. Hahn-method population estimates and densities per km^2 for five ungulate species in February-March, 1974, Deux Balé National Park, Upper Volta.

Species	Population Estimates		Averages	
	February	March	Numbers	Densities
Roan antelope	942	1546	1244	2.20
Oribi	470	485	478	0.84
Grimm's duiker	294	286	290	0.51
Western hartebeest	269	251	260	0.46
Bushbuck	147	130	139	0.25
Totals	2122	2698	2410	4.26

The distribution of individuals of the different species directly influenced the consistency of Hahn-method estimates. Especially oribi, but also Grimm's duiker and bushbuck, were seen at or near the same places on different dates. Dupuy (1968) and Monfort and Monfort (1974) believed oribis to be sedentary and strongly attached to their particular areas. Child (1974) noted a similar behavior by Grimm's duikers, and the same phenomenon was reported for male bushbucks by Jacobsen (1974). Herd size in these three species was almost always less than four animals (Table 2). These factors, sedentary behavior and small herd size, produced the relatively uniform distributions necessary for consistent results with the Hahn method.

In contrast, roan antelope and western hartebeest presented very uneven distributions. These species formed large herds (Table 2), ranged over great distances, and roans in particular were concentrated in favorable areas. Scattered rains in the park on 13 March 1974 caused localized flushes of green grass which markedly affected roan distribution. Of 367 roans observed during the March count, 303 were seen on five transects that crossed the grass-flush areas. Only 204 roans were observed along thirty other transects during the February and March counts. Consistency in successive Hahn-method estimates of roan and hartebeest populations based on the numbers of animals seen during counts was not probable.

The variability of roan and hartebeest estimates was appreciably diminished by employing herd-class averages to compute N (Table 3). The main assumptions in the use of averages were: 1) population structures remain constant during the period of observation, and 2) the distribution of herds in the two classes is more random than the distribution of individual animals. These assumptions were in part

Table 2. Herd sizes observed in five ungulate species, December, 1973 - April, 1974, Deux Balê National Park, Upper Volta. Duplicate sightings eliminated.

	Numbers of Observations by Species (Percentages of Observations)				
Herd Size	Roan antelope	Oribi	Grimm's duiker	Western hartebeest	Bushbuck
1	46(40)	44(40)	104(92)	15(28)	39(74)
2	13(11)	43(39)	9(8)	5(10)	14(26)
3	5(4)	21(19)	-	5(10)	-
4	1(1)	1(1)	-	3(6)	-
5	3(3)	1(1)	-	3(6)	-
6	5(4)	-	-	3(6)	-
7	5(4)	-	-	2(4)	-
9	4(3)	-	-	2(4)	-
10	2(2)	-	-	1(2)	-
11	3(2)	-	-	3(6)	-
12	3(2)	-	-	2(4)	-
13	2(2)	-	-	-	-
14	1(1)	-	-	1(2)	-
15	3(2)	-	-	3(6)	-
16	1(1)	-	-	-	-
17	2(2)	-	-	-	-
18	2(2)	-	-	-	-
19	2(2)	-	-	1(2)	-
20	1(1)	-	-	-	-
21	3(2)	-	-	-	-
22	1(1)	-	-	1(2)	-
25	1(1)	-	-	-	-
27	-	-	-	1(2)	-
28	1(1)	-	-	-	-
29	1(1)	-	-	-	-
31	1(1)	-	-	-	-
37	2(2)	-	-	-	-
38	1(1)	-	-	-	-
40	1(1)	-	-	-	-
Totals	116(100)	110(100)	113(100)	51(100)	53(100)

Table 3. Park-wide population estimates of roan antelope and western hartebeest based on herd classes and individuals in the Deux Balé National Park, Upper Volta.

Roan antelope	Feb 1974	Mar 1974	Change
Number of individuals = I	140	367	
Population estimate = $\frac{566\ km^2 \times I}{(2 \times 0.163\ km)L}$	714	1855	+160%
Average estimate	1285		
Number of herds = N	25	40	
Small herds ($\bar{x}$ = 1.2) = N_1	13	20	
Herds of 3+ animals ($\bar{x}$ = 14.1) = N_2	12	20	
Number estimated $(N_1 \times 1.2) + (N_2 \times 14.1) = N_e$	185	306	
Population estimate = $\frac{566\ km^2 \times N_e}{(2 \times 0.163\ km)L}$	942	1546	+ 64%
Average estimate	1244		
Western hartebeest	**Feb 1974**	**Mar 1974**	**Change**
Number of individuals = I	60	36	
Population estimate = $\frac{566\ km^2 \times I}{(2 \times 0.163\ km)L}$	306	184	- 40%
Average estimate	245		
Number of herds = N	11	9	
Small herds ($\bar{x}$ = 1.6) = N_1	7	5	
Herds of 4+ animals ($\bar{x}$ = 10.4) = N_2	4	4	
Number estimated $(N_1 \times 1.6) + (N_2 \times 10.4) = N_e$	53	50	
Population estimate = $\frac{566\ km^2 \times N_e}{(2 \times 0.163\ km)L}$	269	251	- 7%
Average estimate	260		

supported by the approximately equal numbers of observations in both classes of the roan and hartebeest populations (Table 3).

Oribis, Grimm's duikers, and bushbucks, when well-hidden, often permitted an observer to approach within 50 m before taking flight. On occasion, too, they were seen to remain in position but to lower themselves to the ground to escape detection. The tracks of freshly-departed roans and hartebeests were observed on several transects indicating that some animals had escaped unseen and unheard. It seemed certain, therefore, that a sizable proportion of these five species was not counted and that populations and densities calculated from walking-strip data were underestimates.

The magnitudes of the errors stemming from uncounted animals were undetermined; hence, no correction of the estimates was possible. Hahn-method counts, as employed in this study thesis, were judged to be inadequate as complete censuses.

The consistency of population and density estimates calculated from counts in February and March, 1974 (Table 1) indicated, however, that the Hahn method using two-man teams of observers was satisfactory as an index to oribi, Grimm's duiker, hartebeest, and bushbuck abundances. It could probably serve also as an index to roan antelope numbers, barring gross changes in their distribution patterns such as that caused by rain-induced grass flushes during the March, 1974 count.

The accuracy of the Hahn method as an index to population trends depends on reliable year-to-year assessments of the visibility of animals. Lamprey (1964) and Hirst (1969) found Hahn-method visibilities and actual disappearance distances to be closely correlated for the species in their studies. Heisterberg's (1977) comparisons of Hahn-method visibility distances to the actual disappearance distances of roan antelope, oribi, Grimm's duiker, western hartebeest, and bushbuck indicated a rough correlation, the Hahn-method distances being from 3 percent to 51 percent shorter than the actual disappearance distances. Lavieren and Bosch (in press) reported similar variability in their comparisons of Hahn-method profile measurements to actual disappearance distances. The correlations noted between Hahn-method and actual visibility distances suggest that the Hahn method measures the visibility of animals in a consistent, though not an exact, manner.

Robinette, et al. (1974) believed that visibility measurements based on the distance of animals from the observer either where first or last seen were preferable to Hahn-method measurements. This may be true in some areas, but in the Deux Balé region the paucity of animal observations during counts (Table 4) yielded sample sizes which were unlikely to reflect year-to-year visibility differences accurately.

Based on variances calculated from the sets of 208 Hahn-method measurements, 200 measurements would be required to calculate a mean visibility distance with a 95 percent confidence interval less than 10 percent of that mean for large antelopes; 295 measurements would be needed to meet the same criterion for the small antelopes. Such high numbers of animal observations were not available for any counting period. Further, the 95 percent confidence intervals for mean visibilities computed from the distances of animals from observers

Table 4. Numbers of herds seen for five ungulate species, Deux Balé National Park and Baporo, Dibon, and Laba Forests, Upper Volta, 1974.

Area and Census date	Kilo-meters walked	Roan antelope	Oribi	Grimm's duiker	Western harte-beest	Bush-buck
Deux Balé 4-9 February	350	25	33	32	11	20
Deux Balé 25-29 March	352	40	27	33	9	13
Dibon Forest 1-3 April	151	8	14	11	6	6
Baporo Forest 4-5 June	74	11	5	4	*	4
Laba Forest 5-7 June	150	4	5	6	*	6

*Though known to be present, no western hartebeest were seen in the 4-7 June counts of the Baporo and Laba Forests.

where first seen were much wider than those for the Hahn method (Table 5). It was felt that the work involved in calculating Hahn-method visibility distances--about 50 man-hours for 200 measurements--was necessary to provide the desired accuracy.

Indices to Abundance: The Hahn Method Vs. Relative Abundance Counts

The Hahn census method, as stated above, was thought to underestimate population numbers but to be a useful index to animal abundances. The results of relative-abundance counts were computed (Tables 6 and 7) and data for the five common antelope species were compared to Hahn-method results to determine which type was better.

For the herd-forming species, the relative abundance figures calculated from walking counts yielded less consistent results (Table 8). The difference in consistency was due to the use of herd-class averages in the Hahn estimates; their employment in the relative-abundance calculations would result in similar variations. Also, stratification of the relative-abundance counts for bushbuck by the same criteria used in computing the Hahn estimates would give a variation identical to that of the Hahn counts.

The order of abundance of the five ungulate species determined by the two methods also were in disagreement, the abundances of hartebeest and Grimm's duiker being reversed in February (Table 8). The order of abundance as determined by the Hahn method was considered to be correct because it seemed certain that a smaller proportion of the smaller, less visible species would be seen per kilometer walked.

Table 5. Mean visibility distances and 95 percent confidence intervals calculated from first-sighting distances* and from Hahn-method visibility measurements, January-March, 1974, Deux Balé National Park, Upper Volta.

	First-sighting Distance by species		Distance by size-class**			
			First-sighting distance		Hahn method	
Species	Sightings	Mean(m)	Sightings	Mean(m)	Measure-ments	Mean(m)
Grimm's duiker	63	84±13	121	91±13	208	103±6
Oribi	58	98±22				
Bushbuck	33	101±20	33	101±20	208	132±7
Western hartebeest	20	171±38	89	180±15	208	163±8
Roan antelope	69	183±16				

*First-sighting distances were ocular estimates
**See text

Table 6. Relative abundance* of fourteen mammals from counts by pairs of observers on foot, February-March, 1974, Deux Balé National Park, Upper Volta.

Species	Count (Distance Walked)				Average
	February (350 km)		March (352 km)		(702 km)
	Number seen	Number per km	Number seen	Number per km	Number per km
Roan antelope	140(25)**	0.400	367(40)**	1.043	0.722
Anubis baboon	64(11)	0.183	245(24)	0.696	0.440
Oribi	59(33)	0.169	61(27)	0.173	0.171
Hartebeest	60(11)	0.171	36(9)	0.102	0.137
Grimm's duiker	37(32)	0.106	36(33)	0.102	0.104
Elephant	8(2)	0.023	54(6)	0.153	0.091
Patas monkey	23(3)	0.066	28(12)	0.080	0.073
Bushbuck	24(20)	0.068	18(13)	0.051	0.060
Buffalo	2(1)	0.005	30(1)	0.085	0.045
Side-striped jackal	4(2)	0.011	2(1)	0.006	0.008
Green monkey	6(3)	0.017	0	0.000	0.008
Waterbuck	1(1)	0.003	2(2)	0.006	0.004
Western kob	3(3)	0.009	0	0.000	0.004
Warthog	1(1)	0.003	0	0.000	0.001
Totals	432(148)	1.234	879(168)	2.497	

*See text
**(Number of observations)

Table 7. Relative abundance* of twelve mammal species from road counts by single observers on motorbicycle, Deux Balé National Park, Upper Volta.

	Road Count (Distance Traveled)			
	Jan-Mar, 1972 (642 km)		Dec, 1973-Jan, 1974 (366 km)	
Species	Number seen	Number per km	Number seen	Number per km
Roan antelope	212(23)**	0.330	169(14)**	0.462
Anubis baboon	78(6)	0.121	156(11)	0.426
Hartebeest	50(12)	0.078	40(4)	0.109
Oribi	40(21)	0.062	24(14)	0.066
Green monkey	26(4)	0.040	20(9)	0.055
Patas monkey	12(1)	0.019	11(6)	0.030
Bushbuck	11(8)	0.017	6(5)	0.016
Grimm's Duiker	11(11)	0.017	5(5)	0.014
Waterbuck	8(2)	0.012	6(1)	0.016
Red-flanked duiker	2(2)	0.003	2(2)	0.005
Warthog	0	0.000	3(1)	0.008
Western kob	0	0.000	2(1)	0.005
Totals	450(91)	0.699	444(73)	1.212

*See text
**(Number of observations)

Table 8. Hahn-method estimates compared to animals - seen indices during walking-strip counts, February-March, 1974, Deux Balé National Park, Upper Volta.

	Hahn-Method Population Index			Animals Seen Per km		
Species	February	March	Change	February	March	Change
Grimm's duiker	294	286	-3%	0.106	0.102	-4%
Oribi	470	485	+3%	0.169	0.173	+2%
Bushbuck	147	130	-12%	0.068	0.051	-25%
Hartebeest	269	251	-7%	0.171	0.102	-40%
Roan antelope	942	1546	+64%	0.400	1.043	+160%
Totals	2122	2698	+27%	0.914	1.471	+61%

The observer's speed (25 km/h) and the engine noise during the motorbicycle counts (Table 9), too, introduced likely biases against sightings of the smaller antelopes. In comparison to the Hahn estimates, the ratios of hartebeests to roans were higher in the motorbike counts while those of the three smaller antelopes to roans, particularly Grimm's duiker, were lower. The order of abundance computed from motorbicycle data was also different from that of the Hahn estimates, but was consistent between years. The proportions of the five species in the 1972 and 1974 motorbike counts were not significantly different ($X^2 = 2.37$) either.

The relative-abundance methods do not allow for visibility changes between years and such changes can apparently be considerable in the Deux Balé (Table 10). Although not accurate measurements of visibility changes, these data (Table 10) seem to indicate that changes substantial enough to negate the usefulness of indices devoid of some assessment of the area visually covered do occur.

The results of the Hahn method and the two relative abundance methods do not clearly show which is the best index. The relative-abundance counts are simpler and demand appreciably less work, but would require modification to produce results as consistent as those of the Hahn method. The Hahn method probably better approximates the order of abundance and it certainly allows better evaluation of year-to-year visibility changes. Overall, the Hahn method, as used in this thesis, would seem to be the more accurate index to ungulate populations in the Deux Balé.

Table 9. Ratios of numbers seen per kilometer traveled for five ungulate species compared to ratios of Hahn-method index estimates, Deux Balé National Park, Upper Volta.

	Number Seen Per km Ratios			Hahn-method ratios
	Observer on motorbicycle		2 observers on foot	
Species	1972	1974	1974	1974
Roan antelope	1.00	1.00	1.00	1.00
Hartebeest	0.24	0.24	0.19	0.19
Oribi	0.19	0.14	0.24	0.38
Grimm's duiker	0.05	0.03	0.14	0.23
Bushbuck	0.05	0.03	0.08	0.11
Distance traveled (km)	642	366	702	702

Table 10. Changes in mean visibilities computed from estimated first-sighting distances* and from Hahn-method visibility measurements**, Deux Balé National Park, Upper Volta.

Species	Hahn-method mean visibility (m) (measurements)			First-sighting distance mean visibility (m) (sightings)		
	1973	1974	Change	1973	1974	Change
Grimm's duiker and Oribi	54 (253)	103 (208)	+91%	76 (31)	91 (121)	+20%
Bushbuck	78 (253)	132 (208)	+69%	78 (8)	101 (33)	+29%
Roan antelope and Hartebeest	111 (253)	163 (208)	+47%	117 (30)	180 (89)	+54%

*First-sighting distances were ocular estimates
**The criteria for disappearance differed between years. In 1973, distances to the first point of disappearance were measured, any subsequent reappearances were ignored. In 1974, distances to the last point of disappearance (no further reappearance) were measured.

Principal Species in the Park and Surrounding Areas

Sufficient numbers of roan antelope, oribi, Grimm's duiker, western hartebeest, and bushbuck were observed in the Dibon Forest to permit Hahn estimates. Though known to be present in the nearby Baporo and Laba Forests from spoor and sightings, no hartebeests were seen during the June count; population estimates were calculated only for the other four species.

Densities of all five species were generally lower in the forests than in the park (Table 11). Both the vegetation and water resources in the forests being similar to those in the Deux Balé, it was likely that human pressures--livestock grazing, poaching, fishing in waterholes, human settlement--were responsible for depressed wildlife densities. Mapped wildlife locations in the forests revealed higher animal densities away from human populations there. Certainly wildlife in the forests received much less attention from the Departement des Eaux et Forêts than did the park. Negligible surveillance in the forests undoubtedly encouraged illegal acts within their boundaries. Possibly, they served as buffer areas for the park. Ungulate densities in the park were considered to be well below carrying capacity (Sihvonen, 1974).

The Black Volta River barred most large-mammal movements between the park and the Baporo and Laba Forests although elephants are known to cross the river with impunity even at flood-stage. The intermittent Grand Balé Creek probably permits wildlife crossings between the park and the Dibon Forest over much of the year. With the

Table 11. Comparative Hahn-method densities for five ungulate species in April-June, 1974, Baporo, Dibon, and Laba Forests, Upper Volta.

Species	Index-Densities Per km^2			
	Baporo	Dibon	Laba	Park**
Roan antelope	2.06	0.71	1.09	2.20
Oribi	0.52	0.68	0.40	0.84
Grimm's duiker	0.33	0.36	0.30	0.51
Hartebeest	*	0.75	*	0.46
Bushbuck	0.22	0.18	0.17	0.23
Totals (areas in km^2)	3.13 (81)	2.68 (245)	1.96 (188)	4.24 (566)

*Though known to be present, no hartebeests were seen during the June, 1974 counts in the Baporo and Laba Forests.
**See also Table 1.

exception of the roan antelope, ungulate densities on the north (park) and south (Dibon Forest) banks of the Grand Balé in March-April, 1974 were similar (Table 12). The unequal densities of roans and the restricted grass-flush area in the Dibon strongly suggested an influx of roans to newly-green areas in the park.

Visibility distances in the several areas (Table 13) were similar except that the visibility of the large size-class decreased from the dry- to the rainy-season. Apparently for the small and medium size-classes, the decrease in visibility due to shrubs leafing out was offset by the collapse of dry, partially-burned grasses.

Additional Species: Territorial Mapping

Mapped territories indicated that there were twenty-eight anubis baboon home ranges averaging 20 km^2 in the Deux Balé. This figure is essentially identical to the 20 km^2, 21 km^2, and 20 km^2 average home ranges found by Child (1974), Green (1976), and Heisterberg (1977), respectively. The average troop size in the park was 23 baboons, far below the averages of 40 and 45 animals found by Child (1974) and Green (1976), respectively. The latter authors believed troops split into feeding groups of about twenty baboons, but such behavior was not noted in the park. As only 4 of 88 counts of baboons in the Deux Balé in 1974 exceeded 30 animals, 23 baboons per troop was considered valid and was used to estimate the baboon population (Table 14).

The average home-range size of the patas monkey was determined to be 33 km^2. The average troop size was twenty. Since Dorst

Table 12. Hahn-method population-index (as numbers and densities per km^2) for five species of ungulates on 158 km^2 areas bordering Grand Balé Creek in both the Deux Balé National Park, 25-29 March 1974, and the Dibon Forest, 1-3 April 1974.

Area	Population-Index Numbers (and Densities Per km^2)				
	Grimm's duiker	Oribi	Bushbuck	Western hartebeest	Roan antelope
North bank, Deux Balé National Park	94 (0.59)	120 (0.76)	34 (0.22)	109 (0.69)	775 (4.91)
South bank, Dibon Forest	57 (0.36)	108 (0.68)	28 (0.18)	118 (0.75)	112 (0.71)

Table 13. Averages and 95 percent confidence intervals for distances to which ungulates of three sizes could be seen, February-June, 1974, Deux Balé National Park and Baporo, Dibon, and Laba Forests, Upper Volta.

		Mean Visibility Distance in Meters			
Size-class	Species	Deux Balé Feb-Mar	Baporo May-June	Dibon April	Laba May-June
Small	Grimm's duiker and Oribi	103±6	106±5	103±6	101±6
Medium	Bushbuck	132±7	129±6	132±7	120±6
Large	Hartebeest and Roan antelope	163±8	145±6	163±8	134±6

Table 14. Populations and densities of twenty-two large mammals estimated from the results of Hahn-method counts, animals seen per kilometer indices, and territorial mapping in the 566 km^2 Deux Balé National Park, Upper Volta.

Species	Numbers	Density/km^2
Roan antelope	1250	2.21
Anubis baboon	650	1.15
Oribi	650	1.15
Grimm's duiker	500	0.88
Western hartebeest	450	0.80
Patas monkey	350	0.62
Green monkey	225	0.40
Bushbuck	200	0.35
Red-flanked duiker	150	0.27
African elephant	120	0.21
Side-striped jackal	100	0.18
Western kob	100	0.18
Waterbuck	75	0.13
Warthog	75	0.13
Serval	50	0.09
Bohor reedbuck	50	0.09
African buffalo	40	0.07
Caracal	20	0.04
Leopard	10	0.02
Spotted hyena	10	0.02
Hippopotamus	6	0.01
African lion	2	tr

and Dandelot (1970) list the average home range of this species to be 30 km^2 and the average troop size to be fifteen, the Deux Balé data do not seem unusual.

The average frontage per troop of the best-known green monkey home ranges was 3 km with an average of seven green monkeys per troop. A density of four red-flanked duikers per 3 km of frontage was estimated. Approximately 95 km of frontage suitable for monkeys and 115 km for duikers were identified in the park.

Total Populations of Large Mammals and Ungulate Biomass

The author considered the Hahn-method estimates (Table 1) to be low for the reasons stated. Estimates considered reasonable by the author were made subjectively for those five ungulate species and for thirteen other large-mammal species found in the Deux Balé (Table 14).

In the March, 1974 walking-strip count, few roan on the transect strips were thought to be unobserved. The resulting estimate (Table 1) was considered accurate, but was believed to include about 300 roans from the Dibon Forest (Table 12). The roan population estimate (Table 14) reflects these beliefs.

It was thought that at least two hartebeest herds numbering four or more animals escaped observation during both the February and March, 1974 counts. The Hahn-method estimates (Table 1) were increased 75 percent to give the hartebeest population estimate (Table 14).

It was believed that appreciable numbers of oribi, Grimm's duiker, and bushbuck were not observed during the counts. Particularly, the young of these species were rarely encountered. Further, it was felt that the mean Hahn-method visibility distances probably overestimated the visibilities of Grimm's duiker and bushbuck. The Hahn-method estimates (Table 1) of the oribi, Grimm's duiker, and bushbuck populations were augmented 35 percent, 70 percent, and 45 percent, respectively (Table 14), in consideration of these beliefs.

The population estimates (Table 14) of thirteen infrequently-encountered species were based on sightings, spoor, and species behavior. Their orders of abundance compared to those of more commonly observed species in the foot and motorbicycle counts (Tables 6 and 7) also influenced the estimates.

Because of possible reader interest, the large-ungulate biomass of the Deux Balé was calculated (Table 15) and compared to biomasses in other West African parks and reserves (Table 16). The Deux Balé's biomass was intermediate to those of four other areas, three of which (Comoé National Park (Geerling and Bokdam, 1973), Borgu Game Reserve (Child, 1974), and Pô National Park (Heisterberg, 1977)) were also below carrying capacity. The Arli National Park was considered at carrying capacity only for anubis baboon, buffalo, warthog (*Phacochoerus aethiopicus* Pallas), and western kob (Green pers. comm.).

Table 15. Estimated biomass of large-ungulates, Deux Balé National Park, Upper Volta.

Species	Estimated Population	Average Weights*(kg)	Total Biomass(kg)	Biomass (kg/km^2)
Roan antelope	1250	250	312,500	552
African elephant	120	2100	252,000	445
Western hartebeest	450	150	67,500	119
African buffalo	40	500	20,000	35
Waterbuck	75	150	11,250	20
Bushbuck	200	50	10,000	18
Hippopotamus	6	1400	8,400	15
Oribi	650	12.5	8,125	14
Western kob	100	70	7,000	12
Warthog	75	70	5,250	9
Grimm's duiker	500	10	5,000	9
Bohor reedbuck	50	40	2,000	4
Red-flanked duiker	150	10	1,500	3
Total large-ungulate biomass			710,625	1255

*Estimated from Lamprey (1964) and Geerling and Bokdam (1973).

Table 16. Biomass values for large ungulates in several West African parks and reserves.

Locality	Biomass (kg/km^2)
Comoé National Park, Ivory Coast**	566
Borgu Game Reserve, Nigeria*	703
Deux Balé National Park, Upper Volta++	1255
Pô National Park, Upper Volta+	1995
Arli National Park, Upper Volta***	2202

*Child (1974)

**Geerling and Bokdam (1973)

***Green (1976)

+Heisterberg (1977)

++This study

CONCLUSIONS AND RECOMMENDATIONS

Count Methods

The Hahn method for censusing white-tailed deer was found to be of uncertain value for species with varied herd size and stratified distribution. Transects, too, could not be located in a manner certain to be representative of the Deux Balé region's vegetation. Although the method was not found to be useful as an absolute census, it seemed to provide consistent results as an index to the abundance of the region's rather sparse antelope populations. Calculation of mean visibility distances independent of animal observations made the method particularly useful for assessing changes in low-density populations where animal observations were limited. The continued use of the Hahn method is recommended as an index to species abundance.

The use of relative-abundance counts either from a motorbicycle or on foot as indices to population changes is feasible if the counts are amended to allow for estimation of mean visibility. The averages of the observed disappearance distances of the species encountered during counts could be used to estimate annual changes in animal visibility.

In contrast to relative-abundance counts on foot, those on motorbicycle sample an area biased toward riverine and floodplain vegetation types. Both count methods tended to distort relative-abundance data because of the unequal visibilities of the species counted. Care must be exercised in interpreting such relative-abundance results.

To avoid complications due to weather such as those with roans in the March, 1974 count, successive annual counts should be scheduled at phenologically-similar dates. Meteorological data Appendix 1) indicate that the January-February period normally has the most consistent weather.

In addition to information on population numbers, trends, and distributions, other benefits accrue from walking-strip counts. Poachers may be apprehended or their blinds located and destroyed. Other illegal entrants--fishermen and herdsmen--may be caught or their activities curtailed. The location of waterholes and scenic areas may be noted and the status of vegetation ascertained. The counts serve multiple purposes, and their costs, mainly for transportation, are nearly the same as for routine patrols.

Territorial mapping has been employed by several authors (Child, 1974; Green, 1976; Heisterberg, 1977) to estimate primate populations as well as populations of species demonstrating highly-localized distributions. This method does provide a logical means of estimating population size in such species.

Management Implications

Low wildlife densities and the level of illegal activities--poaching, livestock grazing, fishing, fire--in the park and forests indicate the need for regular surveillance by Eaux et Forêts personnel.

If the protection of natural area values is to be undertaken seriously, the budget allotted to the cadre of rangers must be augmented. In addition to suppression of illegal activities, efforts to educate the local citizenry on the values of parks should be made. Without public support, wild areas in the increasingly-settled Deux Balé region will face a difficult future.

The low wildlife densities indicated by counts (Tables 1, 9, 13, and 14) and the low animal numbers found along the tourist track (Table 14) signal that the Deux Balé National Park is not ready for wildlife-oriented tourism on a large scale. While habituating wildlife to the passage of vehicles, the active promotion of tourism would do little to enhance the park's reputation as a wildlife-viewing area. Only a gradual increase in the encouragement of tourism is recommended.

The present vehicle track cannot accommodate many tourist parties: it is too short, misses many scenic spots, and bypasses several areas with high wildlife densities. The road network should be redirected and lengthened. Additional viewing areas are present in the Dibon Forest since the forest's wildlife densities are similar to those of the park (Table 10). Expansion of the park to include the Dibon is recommended.

SUMMARY

In the Deux Balé National Park, an area of 566 km^2 in the Sudan savanna zone (Keay, 1959) of west-central Upper Volta, West Africa, the populations of twenty-two large mammal species were inventoried during the period January, 1972-June, 1974. The populations of the five most common antelope species also were estimated in three forest reserves which are contiguous to the park and which cover 514 km^2.

The roan antelope, oribi, Grimm's duiker, western hartebeest, and bushbuck populations were inventoried by Hahn (1949) visibility-profile procedures. Visibility distances for three size-classes of antelope were computed and were used to calculate average strip widths. Herd-forming tendencies in roan antelope and western hartebeest resulted in non-random distributions which were partially rectified by the use of two herd-size categories. Bushbuck preference of riverine habitat necessitated the areal stratification of counts for that species. Because some animals were thought to have been missed during counts, the Hahn method was believed to underestimate population numbers. The consistency of successive estimates, however, indicated that it might well serve as a good index to species abundance.

The numbers of individuals of each kind seen per kilometer of travel were inferior to the Hahn method as indices to the five common antelope species. Such tallies distorted the order of abundance

in these species and gave no evidence that they would compensate for year-to-year changes in animal visibility.

The populations of anubis baboon, green monkey, patas monkey, and red-flanked duiker were estimated with modified territorial mapping techniques (Overton, 1969; Green, 1976). The number of thirteen other large-mammal populations were judged from direct observations and spoor.

The Deux Balé's large-ungulate biomass was intermediate to the biomasses of four other West African parks and reserves.

REFERENCES

REFERENCES

Anon. (1966). Apercus sur le climat de la Haute-Volta. Service Météorologique, Ouagadougou, ASECNA, Haute-Volta.

Anon. (1968). Carte de reconnaisance photogéologique. Assistance Technique, Néerlandaise, Hollande.

Anon. (1972). Tableaux climatologiques (Periode 1961-1970). Service Météorologique, Ouagadougou, ASECNA, Haute-Volta.

Begue, L. (1937). Contribution a l'étude de la végétation forestière de la Côte d'Ivoire. Publ. Comité Études Hist. Scien. Afrique Occidentale Francaise, Paris. Série B, No. 4, 127 p.

Child, G. S. (1974). An ecological survey of the Borgu Game Reserve, Nigeria. Kainji Lake Research Project, Technical Report 4, FAO, Rome. 130 pp.

Dorst, J., and Dandelot, P. (1972). Guide des grands mammifères d'Afrique. Delachaux et Niéstle, Neuchatel. 286 pp.

Dupuy, A. (1968). Le Parc National du Niokolo-koba. Mém. IFAN, 3, 443-472.

Geerling, C., and Bokdam, J. (1973). Fauna of the Comoé National Park, Ivory Coast. Biol. Cons. 5, 251-257.

Green, A. A. (1976). Density estimate of the larger mammals of Arli National Park, Upper Volta. MS Thesis, University of Massachusetts, Amherst. 206 pp.

Hahn, H. C., Jr. (1949). A method for censusing deer and its application in the Edwards Plateau of Texas. Texas Game, Fish and Oyster Comm. 24 pp.

Heisterberg, J. F. (1975). Further notes on Pô National Park, Upper Volta: Ecological surveys and development prospects. Unpublished report to the Departement des Eaux et Forêts, Ouagadougou, Upper Volta. 70 pp.

________. (1977). Flora and fauna of Pô National Park, Upper Volta, West Africa. MS Thesis, Purdue University, West Lafayette. 132 pp.

Hirst, S. M. (1969). Road strip census techniques for wild ungulates in African woodland. J. Wildl. Manage. 33, 40-48.

Jacobsen, N.H.G. (1974). Distribution, home range and behaviour patterns of bushbuck in the Lutopé and Sengwa Valleys, Rhodesia. J. South. Afr. Wildl. Manage. Ass. 4, 75-93.

Keay, R.W.J. (1959). A vegetation map of Africa. UNESCO, Oxford. 24 pp.

Kershaw, K. A. (1968). A survey of the vegetation in Zaria Province, N. Nigeria. Vegetatio 15, 244-268.

Lamprey, H. F. (1964). Estimation of the large mammal densities, biomass and energy exchange in the Tarangire Game Reserve and the Masai Steppe in Tanganyika. E. Afr. Wildl. J. 2, 1-46.

Lavieren, L. P. van, and Bosch, M. (In press). Large mammal densities in Bouba Ndjidah National Park, Cameroon. Terre et Vie.

Leprun, J. C., and Moreau, M. (1968). Etude pédalogique de la Haute-Volta région: nord-ouest. O.R.S.T.O.M. 6500-399. 346 pp.

Monfort, A., and Monfort, Nicole. (1974). Notes sur l'écologie et le comportement des oribis (_Ourebia_ _ourebi_ Zimmermann, 1783). Terre et Vie 28, 169-208.

Overton, W. S. (1969). Estimating the numbers of animals in wildlife populations. Page 417 in R. H. Giles, Jr. ed. _Wildlife Management Techniques_, 3rd edition. The Wildlife Society, Washington, D.C. 623 pp.

Plaisance, G. (1936). Avant projet de Forêt Classée des Deux Balé. Unpublished report to the Service Forestier, Abidjan, Ivory Coast.

Robinette, W. L.; Loveless, C. M.; and Jones, D. A. (1974). Field tests of strip census methods. J. Wildl. Manage. 38, 81-96.

*Rosevear, R. D. (1965). The bats of West Africa. British Museum (Natural History), London. 604 pp.

Sihvonen, J. P. (1974). Rapport sur un questionaire d'enquête sur l'historique de la région des Deux Balé. Unpublished report to the Departement des Eaux et Forêts, Ouagadougou, Upper Volta. 11 pp.

Troupin, G. (1966). Étude phytocénologique du Parc National de l'Akagera et du Rwanda Oriental. Inst. Nat. Recherche Scientifique, Butaré, République Rwandaise. No. 2, 293 pp.

Waser, P. (1975). Diurnal and nocturnal strategies of bushbuck *Tragelaphus scriptus* (Pallas). E. Afr. Wildl. J. 13, 49-63.

Wilson, V. J., and Child, G.F.T. (1964). Notes on bushbuck (*Tragelaphus scriptus*) from a tsetse fly control area in Northern Rhodesia. Puku 2, 118-128.

*Quoted in Appendix 2.

APPENDICES

APPENDIX 1

APPENDIX 1.

Summary of weather data from the Boromo Meteorological Station, Boromo, Upper Volta: (A) Average monthly rainfall (mm) from 1921-1974, (B) Monthly rainfall from 1971-1974, and (C) Average monthly relative humidity from 1961-1970 and average monthly evaporation (mm) from 1961-1974. Taken from Begué (1937), Anon. (1966, 1970), and unpublished records of the Boromo Meteorological Station, 1970-1974.

A. Average monthly rainfall (mm) from 1921-1974.

	Period of record			
Month	1921-1932	1933-1960	1961-1974	1921-1974
January	tr	0.0	tr	tr
February	tr	3.5	0.9	2.1
March	8.7	9.8	7.7	9.0
April	23.7	32.9	48.6	34.9
May	112.1	87.8	82.4	91.8
June	136.0	115.7	116.3	120.4
July	159.6	231.3	181.3	202.4
August	249.4	283.4	249.7	265.3
September	159.1	190.0	186.9	182.3
October	70.8	43.9	36.7	48.0
November	6.4	10.6	7.9	8.9
December	0.0	1.4	4.2	1.8
Annual average	925.9 mm	1010.3 mm	922.6 mm	966.9 mm

B. Monthly rainfall (mm) from 1971-1974.

Month	Year 1971	1972	1973	1974
January	0	0	0	0
February	tr	tr	2	0
March	58	tr	0	tr
April	82	48	46	93
May	31	53	94	78
June	77	95	54	75
July	261	146	183	206
August	334	326	205	292
September	173	132	108	191
October	19	77	27	21
November	0	0	0	*
December	16	0	0	*
Annual total	1051 mm	877 mm	719 mm	956 mm**

*Values unknown to author.

**Total incomplete.

C. Average monthly relative humidity from 1961-1970 and average monthly evaporation (mm) from 1961-1974.

	Relative humidity %	Evaporation (mm)
Month	1961-1970	1961-1974
January	23	288
February	22	294
March	27	320
April	42	249
May	58	190
June	70	123
July	78	82
August	84	55
September	83	57
October	67	123
November	45	200
December	29	247
Annual average	52%	2.228 mm

APPENDIX 2

APPENDIX 2.

List of mammals found in the Deux Balé National Park, Upper Volta, based on field observations by the author and on the bat collection of J. F. Heisterberg. Common and scientific names after Dorst and Dandelot (1970) and Rosevear (1965) (Chiroptera).

INSECTIVORA	
African hedgehog	*Atelerix albiventris* (Wagner)
CHIROPTERA	
Straw-colored fruit bat	*Eidolon helvum* (Kerr)
Gambian fruit bat	*Epomophorus gambianus* (Ogilby)
Cretzschmar's free-tailed bat	*Tadarida pumila* (Cretzschmar)
PRIMATES	
Green monkey	*Cercopithecus aethiops* (Linn.)
Patas monkey	*Erythrocebus patas* (Schreber)
Lesser galogo	*Galogo senegalensis* (Geoffroy)
Anubis baboon	*Papio anubis* (Fisher)
LAGOMORPHA	
Crawshay's hare	*Lepus crawshayi* (De Winton)
RODENTIA	
Cane rat	*Thryonomys swinderianus* (Temminck)
Striped ground squirrel	*Xerus erythropus* (Desmarest)
CARNIVORA	
Marsh mongoose	*Atilax paludinosus* (Cuvier)
Egyptian mongoose	*Herpestes ichneumon* (Linn.)
Slender mongoose	*H. sanguineus* (Ruppell)
Side-striped jackal	*Canis adustus* (Sundevall)
Spotted hyena	*Crocuta crocuta* (Erxleben)
Common genet	*Genetta genetta* (Linn.)
Caracal	*Felis caracal* (Schreber)

African wildcat	*F. libyca* (Forster)
Serval	*F. serval* (Schreber)
Lion	*Panthera leo* (Linn.)
Leopard	*P. pardus* (Linn.)
TUBULIDENTATA	
Aardvark	*Orycteropus afer* (Pallas)
PROBOSCIDEA	
African elephant	*Loxodonta africana* (Blumenbach)
ARTIODACTYLA	
Western kob	*Adenota kob* (Erxleben)
Western hartebeest	*Alcelaphus buselaphus major* (Pallas)
Red-flanked duiker	*Cephalophus rufilatus* (Gray)
Hippopotamus	*Hippopotamus amphibius* (Linn.)
Roan antelope	*Hippotragus equinus* (Desmarest)
Defassa waterbuck	*Kobus defassa* (Ruppell)
Oribi	*Ourebia ourebi* (Zimmermann)
Warthog	*Phacochoerus aethiopicus* (Pallas)
Bohor reedbuck	*Redunca redunca* (Pallas)
Grimm's duiker	*Sylvicapra grimmia* (Linn.)
African buffalo	*Syncerus caffer* (Sparrman)
Western bushbuck	*Tragelaphus scriptus* (Pallas)