G CHILD 1968

UNITED NATIONS DEVELOPMENT PROGRAMME

FAO No. TA 2563

Report to the
Government of

BOTSWANA

AN ECOLOGICAL SURVEY OF NORTHEASTERN BOTSWANA

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

ROME, 1968

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Report
to the
Government of
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on
An Ecological Survey
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Based on the Work
of
G. Child

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INTRODUCTION

The present survey followed a request by the Bechuanaland Government to the ood and Agriculture Organization of the United Nations for assistance, in terms of the Expanded Program for Technical Assistance, with a survey of the wildlife industry in the north east of the territory. This arose from the recommendations f the two FAO/IUCN Africa Special Project Consultants, who toured the country at he request of the Government, in October and November 1962, to advise on the wild- life resources.

The terms of reference agreed to between the Bechuanaland Government, now the overnment of the Republic of Botswana, and FAO, in June 1965, were as follows:

> "To advise the Government on and to formulate realistic plans for the conservation and utilization of Bechuanaland's game herds. To survey the Chobe Game Reserve and the surrounding game areas with a view to determining what conservation measures should be adopted, planning the development of the reserve as a tourist facility, ascertaining the permissible annual game harvest and investigating the prospects of game ranching."

These terms of reference were enlarged at the request of the Minister for Mines, ommerce and Industry, the Hon. Mr. A.M. Dambe in August 1965, to include any matters elating to wildlife, particularly in northeastern Botswana. They were further expanded when the author was asked to represent wildlife interests on a team investi- gating the possibilities for expanding the livestock industry in the Northern State lands, early in 1966. This team had the following terms of reference:-

> "To conduct an investigational survey and report on the possibility of opening up areas in the Northern Crown lands for the development of the cattle industry, bearing in mind the desirability of conserving game in areas where game can be sustained, for the purpose of tourism and for the processing and marketing of game meat, without endangering the cattle industry."

In February 1967, the author was honoured to represent the Republic of Botswana as its delegate at the second session of the ad hoc Working Party on Wildlife Management of the African Forestry Commission in Fort Lamy.

The author served on the assignment from its inception on June 1st, 1965 until its conclusion on June 30th, 1967. He was joined by Senior Expert Mr. L.W. Swift for two weeks in August 1965, and by a German Associate Expert, Dr. W. von Richter, from October 1966.

The survey sought primarily to determine the situation regarding various species of large mammals native to northeastern Botswana, and the condition of their habitats, as a basis for suggesting suitable management and for indicating possible lines along which the wildlife industry could be developed. Determining the trends in animal numbers and the conservation values in the habitats required the recognition of syndromes, using evidence from various aspects of the ecosystem and taking into account the detailed history of an area. This information is included in Part I, which reports most technical aspects of the survey, while the remainder of the report covers suggestions for the utilization of the resource.

Some 50,000 miles were covered in and around the mission area, of which over 35,000 miles were by road. Most tracks in northeastern Botswana were driven at least once and several cross-country traverses were also undertaken. Many government

officials, traders, hunters, tribesmen and bushmen were interviewed in English, a vernacular language or through interpreters, and special care was always taken to avoid the use of leading questions. Much of the information in this report is based on their intimate knowledge of specific areas augmented by appropriate cross-checks by personal observation. In the case of bushmen, in particular, this information often included accurate observations over a number of generations from a limited area, and frequently when such people were asked about conditions in places over 30 or 40 miles away, the reply was to the effect that that was another territory about which they knew little and could not therefore offer an opinion. This rendered such unbiased observations especially valuable, despite the difficulty of assigning accurate dates to particular events. If this report contributes to an understanding of wildlife and its problems in northeastern Botswana it is through the recording and limited interpretation of much which is locally common knowledge to many of the rural people.

Acknowledgments

The author is deeply grateful to all those people in Botswana who facilitated the present survey, particularly the Minister of Commerce, Industry and Water Affairs, the Hon. J. Haskins Esq., and members of his Ministry, which includes the Game Department. Mr. C.P. Hepburn, Warden of the Chobe Game Reserve, and his staff, including Game Scout Majoto Mothoiwa and Mr. Tommy Maikano were particularly helpful with the field work and preparation of this report. Mr. P. Henry, Forest Officer, and his staff assisted with the preparation of maps and Dr. M. Bachmann, Chief Tsetse Control Officer, and his staff, especially Mr. P. Smith, were of great help by providing records and material from Tsetse Control Hunting on the Maun Front and by assisting with the analysis of this data.

Mr. R.H. Smithers, Director of the National Museums, Rhodesia, kindly arranged leave of absence for the author and assisted the survey materially by providing the services of a trained technician and by supplying essential equipment, including a land rover, before government transportation became available. The Director of National Parks, S. Africa, and his staff in the Kalahari Gemsbok National Park provided the opportunity for a valuable, if brief, survey of desert conditions.

To these individuals and organizations the author is most grateful.

SUMMARY

The controlled exploitation of wildlife has become the primary form of land use in northeastern Botswana during the six years since the Chobe Game Reserve was proclaimed and the region was opened up for organized recreational hunting. The present ecological survey of the wildlife potential was requested by the Government as a basis for appropriate forms of management and the planned development of the resource.

The area is sparsely peopled, but the contrasting habitats, ranging from permanent swamps, through grassland to variously wooded types, including well developed woodland, has a varied and locally dense large mammal fauna. The erratic rainfall and generally poor sandy soils renders the habitats sensitive to modification by past land use. The mismanagement of fire and domestic livestock and the commercial exploitation of timber in the northeast, are three important factors leading to the widespread deterioration in conservation values, which are usually evident from the declining vigour of perennial grasses and the accompanying widescale scrub encroachment. These

changes in the habitat are reflected by changing trends in the dependant animal populations. The future numerical strength of sensitive grazing species is threatened through the disappearance of their specialized habitat. Certain stages in the process of deterioration are beneficial to other species which may prosper, at least temporally, but this induced prosperity often leads to overpopulations and further destruction of the habitat.

The technical basis for these generalizations is elaborated in Part I of the report, which also describes the vegetation in the Chobe Game Reserve and includes pertinent information on the distribution and general biology of the individual species, together with specific recommendations for further investigation and for management. A list of the avifauna known to occur in the Chobe Game Reserve is included in an appendix to this part. Parts II, III and IV of the report indicate ways in which the wildlife industry could be managed and developed in accordance with the results of the survey.

Part II outlines the history of the Chobe Game Reserve since its inception in 1961, and describes moves to elevate it to full national park status. This requires certain changes in the arbitrary straight line limits of the Reserve in order to exclude other forms of land use and so that the National Park contains a more truly representative selection of the flora and fauna of northeastern Botswana.

An additional strip of easily developed land including attractive plains country should be added along the eastern border, but two areas should remain as game reserves outside the proposed national park. The Magwigwe sand ridge should form the western boundary south of the Tsantsana Molapo, thus excluding the northwestern corner of the reserve, and an area of relatively good woodland adjacent to the southern border of the Kachikau Enclave, should remain a game reserve so as to allow for logging. A meeting of representatives of interested Government Departments recognized that the rational form of land use for the Chobe flats within this enclave would be to incorporate them into the national park/game reserve complex. This would, however, create sociological difficulties unless the 3,000 inhabitants could be persuaded to move to alternative agriculturally attractive areas. Bound up with this problem is the need to consider including more of the Linyanti swamp and swamp edge in the park. The Mababe depression is an obvious ecological unit which, it is recommended, should all come under the control of the Game Department, although it might be premature to extend the national park to encompass the whole depression at this stage. The sourthern Mababe is a hunting area earning valuable revenue from the safari industry; conventional tourist development will not penetrate this far for some time, so it is suggested that the area should become a game reserve or controlled hunting area in the meantime. Finally, it may be advisable to exclude certain areas of Kalahari woodland in the southeast of the park, if the timber justifies commercial logging.

A clearly defined policy is needed as a framework for the administration, management and development of the future park and a tentative policy statement is suggested as follows:

(1) Biological management should be based on present knowledge. Further detailed exploration should be designed to describe the flora and fauna and to determine the trends in conservation values and in animal numbers.

(2) Improper burning practices are perhaps the major depressive element in habitats throughout the Chobe Game Reserve and surrounding areas. It is suggested that the control of fires should have high priority in the biological management of the future national park. To be effective fire protection needs to be adequate to prevent all or the great majority of undesirable burns. It is therefore proposed that major emphasis should be directed towards excluding fire from two areas in the northeast and east of the park, and that firebreaks should be developed in conjuction with game

viewing roads in order to minimize expense. Cooperation should be sought with the Forest Department in order to gain maximum coverage, and strict control is needed over people using roads through the park, and the areas where they may be permitted to have camp fires.

(3) There is little need for specific erosion control in the Chobe Game Reserve except along the face of the sand ridge area overlooking the Chobe flats. Here attempts should be made to stabilize the soil shifted by game descending to water, through the protection of the worst affected areas by laying felled vegetation along the contour, to encourage the recolonization of these areas by perennial grasses.

(4) It will be necessary to manipulate habitats to some extent to counteract the harmful results of past land use. This should be directed towards improving the habitats of endangered species, diversifying the modified vegetation near the Chobe flats and to limited improvement of visibility along some roads. These aims may sometimes be met simultaneously and an opportunistic approach is advocated wherever labour or fire are to be employed, in order to reduce costs and favour more effective burns.

(5) Development of much of the interior of the park will depend upon the provision of artificial waterholes for game during the dry season. However, this can lead to rapid deterioration of the habitats in the vicinity of such waterholes. It was therefore suggested that six bore holes should be sited around the headwaters of the Ngwezumba river, in order to gauge the effectiveness of providing water on a rotational basis. These holes are in relatively resilient grassland and a system of testing holes from pumping and of checking the effect on neighbouring vegetation is urged. It is also suggested that a better knowledge of the water resources and the ability for game to use mineralized waters would help the planning of tourist development in the Mababe depression and elsewhere.

(6) Finally, the need to keep records of all management procedures, as well as of changing trends in the habitats and their dependent animal populations, is stressed. The need for biological management and the desirability of entrusting the Game Department with the day-to-day administration of the Moremi Game Reserve is mentioned, and the suggestion that Nyai pan should form the nucleus of a third sanctuary is supported.

(7) Botswana is well placed to benefit from the rapid worldwide growth in tourism, and the Chobe Game Reserve is not far from the famous Victoria Falls. The attractiveness of the region would be enhanced if this and the Moremi Reserve, together with the Okavango swamps and Nyai pan could be incorporated in a single coordinated industry, and if Botswana and her neighbours could promote tourism on a regional basis. Suggestions are therefore made for the development of the Chobe and Moremi Reserves with these objects in mind.

Part III of the report considers certain aspects of recreational hunting in north-eastern Botswana, where it is organized on a system of concession areas, which are leased to safari companies who have exclusive non-resident hunting rights. The system has several advantages but requires that operators should report to the Government their detailed hunting successes, so that the safari business can be coordinated and a check kept on the animal resource upon which it is based. It is also desirable that the concession areas should be surveyed in more detail than has been possible during the present assignment.

This industry is very dependent upon the availability of lion as a trophy animal and a strong plea is made to avoid the unnecessary destruction of this valuable "problem animal" on a nationwide basis.

Part IV deals with subsistance hunting and the commercial exploitation of wild

animals and stresses the need for full control to be exercised over all hunting activities. The recent increases in the prices being paid for the hides and skins of wild animals makes the need for proper control of animal off-take rather urgent. A survey of the hide and skin industry is now in progress, with a view to recommending appropriate means of perpetuating this valuable harvest. The potential value of wildlife as a commercial source of protein is noted and, although there will be difficulties in realising this potential, it is urged that full consideration should be given to integrating wildlife management into the general patterns of land use.

The final section describes the recent encouraging steps towards better administration of the wildlife resource. It urges in-service training of Game Department personnel, outlines the conduct which should be expected from visiting wildlife research workers and emphasizes the need for making the results of past investigations readily available to future workers.

PART I

The Environment

Botswana is a land-locked country of some 220,000 square miles, in the center of the Southern African plateau and is occupied by 543,105 people (1964 Census: Campbell 1965). It is generally around 3,000 feet above sea level, but is separated from the coast by higher plateaux and mountain ranges, so that the climate is mostly arid or semi-arid. Coupled with the poor sandy soils and limited exploitable minerals so far developed, this has led to an economy dominated by the livestock industry, but in which wildlife is playing an increasingly significant role.

The Study Area

Most of the country is very flat and in the north this has caused an interesting series of interconnected river systems, which have a marked influence on the ecology of northeastern Botswana, the area with which this report is principally concerned. It is enclosed by the Chobe and Okavango rivers in the north and west and has a common boundary with Rhodesia in the east, while the old main road from Maun to Nata forms a convenient southern limit (fig. 1). Most of it is State Land, which is separated from Tribal Land in Eastern Ngamiland by a longitude passing through Makalamabedi. The State Land north of parallel 19°S is administered from Kasane, while the rest falls under the control of the District Headquarters in Francistown or Maun.

The distribution of the sparse human population is shown in figure 2, while figure 1 indicates the thin network of roads and motor tracks serving the area, the route by which Ngamiland cattle are exported on the hoof to Zambia via Kazungula, and the limits of the tsetse fly advance. Figure 3 illustrates existing hunting concession areas and game reserves.

The exploitation of wildlife has become the primary form of land use in northeastern Botswana since 1962, when the Government created the Chobe Game Reserve and encouraged safari hunting. The relative value of this industry, in terms of direct revenue to the Chobe District, is summarized in table 1. Crop production is largely of a subsistence type, and is limited to the settled areas. Livestock production is centered on settlements outside the tsetse fly belt, where both nagana and human sleeping sickness are endemic.

Maun is linked to Francistown on the Rhodesian/South African railway system, by a new all-weather gravel road, and there is a second made-up road penetrating 30 miles along the Chobe river in the north east, joining the Rhodesian and Zambian networks to a new road from Ngoma to Katima Mulilo in the eastern Caprivi Zipfel. Other motorways in northeastern Botswana are mostly sandy tracks in the dry season and many are impassable in wet weather, even to lorries or four-wheel-drive vehicles, which are more or less essential for travel in this region.

The only post offices are at Kazungula and Maun, and only Kasane and Kazungula have telephonic communication with the outside world, by means of a party line from Livingstone. There are police radios at Kasane, Kazangula, Panda ma Tenga, Kachikau and Maun, and several of the safari companies are in radio touch with their bases at Maun, Kasane and the Victoria Falls during the hunting season. These companies also maintain a number of bush landing strips during the dry season which augment those at Maun, Serondela, Kasane and Panda ma Tenga. The first two are regular stops on the weekly Botswana National Airways flights between Francistown and Livingstone.

TABLE 1

Revenue collected by the Revenue Officer, Kasane for the financial year 1965/66 and the 1966 Hunting Season (in Rand)

Item	From presence of Reserve	From other Wildlife use	Other Sources
Income Tax			267 1/
Personal Tax			260 2/
Graded Tax			1,063 2/
Ordinary Tax			3,120 2/
Trading Licences etc		20	445
Trophy Dealer Licences	20		
Leases and Rents	2		549 3/
Road and Road Traffic			1,697 4/
School Fees			171
Medical Fees			381
Sale Government Property			190
Judicial			614
Hides		300	53
Forest			92
Agriculture			59
Liquor Excise etc.	2,990 5/		
Arms/Ammo. Licences		160	
Other			12
Game Reserve Entrance	1,324		
Package Licences etc. (Hunting)		12,464 6/	
Safari leases		900 7/	
Total	4,336	13,844	8,973
% Total	16.0	50.4	33.2

1/ Obviously low but Income Tax from District benefits from Reserve.
2/ Benefit to same extent from presence of Reserve.
3/ Some Serondela properties only leased because of presence of game.
4/ Benefits considerably from presence of Reserve.
5/ Hotel built to serve Reserve.
6/ Low as it does not include licences for Bechuanaland Hunters Ltd., which earned government an added ± R 10,000 p.a. from hunting in Chobe District.
7/ Approximately only as does not include Bechuanaland Hunters Ltd., Nunga Area, but includes White Hunters Ltd.'s little used southern area south of parallel 19°S.

TABLE 2

Average Monthly Temperatures for Kasane, Francistown and Maun

Month	Kasane[1]		Francistown[2]		Maun[3]	
	Max°C	Min°C	Max°C	Min°C	Max°C	Min°C
January	30.4	18.8	30.7	18.1	31.5	19.0
February	30.1	18.7	30.1	17.7	31.3	18.7
March	30.3	17.8	29.3	16.0	30.9	17.4
April	30.1	16.0	28.6	13.3	30.6	14.4
May	28.5	12.0	26.1	8.8	28.1	9.5
June	26.0	9.1	23.1	4.8	25.0	5.9
July	26.2	8.4	23.6	5.1	25.2	5.7
August	29.1	10.5	26.1	7.4	28.6	8.6
September	33.0	15.0	29.7	12.0	32.5	13.3
October	35.2	18.5	32.3	16.1	34.9	18.0
November	32.9	19.1	31.7	17.6	33.8	18.9
December	30.8	18.8	30.9	18.0	32.2	19.1
Ave. year	30.2	15.2	28.5	12.9	30.4	14.0

1/ Kasane average based on 24 years.
2/ Francistown average based on 30 years.
3/ Maun average based on 30 years.

There are small trading stores at Kazungula, Kasane, Mucheje, Kavimba, Kachikau, Satau, Panda ma Tenga, Nata and Maun and hotels at Kasane and Maun. The importance of Kachikau as a commercial center has declined greatly since the early fifties, when each of the four trading stores are said to have had a wage bill in excess of the gross turnover of the only survivor in 1966. A similar decline occurred in Panda ma Tenga with the closing down of the Colonial Development Ranch in this area in the early sixties.

A limited amount of fish is exported from the Lake Liambezi area by Zambian fish buyers. This industry boomed in 1963 when approximately 30 tons of fish were exported in the month of May, but has since declined to a mere trickle. The upsurge in the fish population was apparently a response to high floods in 1957 and 1958 and again in 1962 and reports indicate that a large proportion of the fish now exported through Botswana are in fact caught in the Caprivi.

Climate

Summer temperatures are high (table 2) and the mean annual rainfall declines from northeast to southwest from around 27 inches to about 18 inches per annum. Precipitation is almost exclusively during the summer months (November to March) and is somewhat unreliable, as shown by the extremes for Kasane/Kazungula, Francistown and Maun (table 3).

These climatic factors give rise to generally dry marginal country which is interspersed with swamp and seasonally inundated grassland along the Chobe and Okavango rivers, and it is this mixture of contrasting habitats which accounts for the remarkably varied fauna.

Physiography and Drainage

Major Drainages - The Okavango and Chobe river systems rise in the Angolan highlands while the Zambesi, which supplies water to the Chobe, has it source in western Zambia. The Okavango flows in a southerly and then easterly direction from the western slopes of the highlands, before cutting southwards across the Caprivi Zipfel into Botswana. Here the flow slackens and the river divides into the finger-like distributaries of the Okavango swamp, often aptly described as an inland delta (fig. 1).

In the southwest the swamps drain towards the shallow depression giving rise to Lake Ngami, but little water has reached the lake by this route during the last century, as most of it now enters via the Ngabe river. The Thamalakane, which links the fingers of the delta along the southeastern fringe of the swamps, divides south of Maun and one arm, the Ngabe river, augmented by other distributaries, flows west into Lake Ngami, while the Botletle river flows in an easterly and then southerly direction into Lake Dow, en route to the Makarikari pans. These are also fed in the northeast by the Nata river flowing out of Rhodesia.

The Kwando or Mashe river, as the upper reaches of the Chobe are variously known, rises on the eastern slopes of the Angolan highlands and after flowing in a southerly direction across the Caprivi, turns north of east through the Linyanti swamps, to form the border between the Caprivi and Botswana as far as the Chobe-Zambezi confluence. Here the four territories of Botswana, Rhodesia, South West Africa and Zambia have a common meeting point in the river at Kazungula (fig. 1).

The Chobe system is flanked by swamp above Lake Liambezi but, east of here, most of the swamp and swamp grassland is in the Caprivi. A series of molapos, or open grassed drainage lines, feed flood season water from the Zambezi into the Chobe east of Lake Liambezi. These molapos coalesce in the eastern Caprivi to form seasonally

TABLE 3

Annual Rainfall in mm at weather Stations in and around northeastern Botswana

YEAR July - June	Francis-town	Maun	Kasane (Kazungula)	Gweta	Kachikau	Panda ma Tenga
1921/2	349.7					
1922/3	561.1	504.4	721.3			
1923/24	302.5	312.4	444.7			
1924/25	821.1	624.5	1035.8			
1925/26	580.2	299.9	541.5			
1926/27	274.8	273.7	563.6			
1927/28	418.5	402.3	558.0			
1928/29	674.1	338.2	886.8			
1929/30	560.5	346.9	767.9			
1930/31	416.3	439.4	395.8			
1931/32	707.1	802.7	747.0			
1932/33	321.5	191.7	427.9			
1933/34	477.2	501.1	669.2			
1934/35	355.5	274.3	570.2			
1935/36	282.4	641.3	862.0			
1936/37	484.3	379.7	902.2			
1937/38	237.2	312.4	456.6			
1938/39	708.1	574.0	575.3			
1939/40	537.7	539.2	826.2			
1940/41	434.5	294.3	793.7			
1941/42	342.1	414.2	660.2			
1942/43	426.2	372.8	671.8			
1943/44	455.9	705.1	818.7			
1944/45	354.0	310.0	362.9			
1945/46	632.9	623.3	997.7			
1946/47	113.7	286.0	433.8			
1947/48	652.5	795.0	795.5			
1948/49	424.6	334.5	476.9			
1949/50	228.6	534.4	808.2			
1950/51	510.7	678.1	594.6			
1951/52	336.5	441.8	1054.9			
1952/53	910.0	512.2	882.4			
1953/54	250.5	560.5	835.5			
1954/55	779.2	872.6	907.9			
1955/56	331.7	438.6	602.5			
1956/57	486.8	408.0	514.0			
1957/58	436.9	602.4	1395.8			
1958/59	496.2	483.0	600.0			
1959/60	285.7	312.7	631.2	286.2		
1960/61	523.0	618.2	832.0	788.0		
1961/62	351.2	314.9	491.5	462.7	508.2	467.5
1962/63	416.9	551.2	564.0	546.3	670.9	845.7
1963/64	253.3	504.6	510.0	366.4	545.9	483.2
1964/65	225.6	206.0	496.2	280.2	329.3	420.2
Annual average	448.3	463.7	690.3	454.9	513.5	554.1

inundated grassland and swamp, through which the Kasai (Kasaiya) channels feed water into the Chobe throughout the year so that the bulk of the water flowing out of the Chobe at Kazungula originates from the Zambezi overflowing its sourthern bank.

The Linyanti swamp, besides being fed by the Kwando, also receives water in some years from the Okavango, via the Makwegana or Selinda spillway, which descends almost 100 feet over 75 miles according to Mackenzie (1946), making the suggestion of a flow in the opposite direction impossible. This sporadic flow is the only means by which the Okavango loses water to the sea, and normally its whole annual flow of 7½ million acre feet is dissipated in Botswana, chiefly through evaporation and transpiration from the swamps.

The southern edge of the Mababe depression, an ancient lake bed, is fed by the Kwaai, a distributary of the Okavango, while the Savuti channel slopes towards the northern edge from the Chobe system. Although water has flowed into the depression from both sources during the past decade, the minimal gradients have prevented it becoming a lake during historic times.

The inconsistent nature of flooding in areas affected by the Chobe and Okavango systems is likely to have important ecological implications, which need to be taken into consideration in any management program involving wildlife. The effects may be of relatively short duration and may apply for a single season, or they may influence the ecology of an area over much longer periods. For example, the Savuti channel, which can have a marked bearing on the seasonal dispersion of game in the northern Mababe and surrounding areas, held water when Livingstone discovered and named it the Sunta in 1853. The channel was dry by the time Selous visited the Mababe in 1879 and remained thus for almost 100 years, during which time large Acacia giraffae (mean girth of 10 at 3 feet = 66.5 inches, range 43 to 104 inches) grew up in the sandy bed. West of the sand ridge, however, the channel may have held water for longer as Stigand (1923) noted that the bed had been dry since 1888. It was again reported flowing in 1960, and local information from villagers, interpreted against aerial photographs, suggests it broke through in 1957 or 1958 during the exceptionally high floods in the Chobe and Zambezi.

This flow, which killed the large trees in the bed, continued until 1964 and gave rise to swamp conditions in an area of about 10 square miles just south of the Gubatsa hills (fig. 5), but by early 1965 the flow had slackened and by October the channel was dry away from the Linyanti swamp, except for one small elephant-maintained seep near the hills which persisted until October 1966. The game populations, that had built up while water was available, largely collapsed or dispersed, but during 1966 the channel again began to fill. By October the water was seven miles west of the hills, which were reached in February 1967, and water was again spilling into the "swamp" by early April.

Both short and long-term changes occur along the edges of the Okavango swamps. Hundreds of square miles may remain waterless for wildlife in one year, while other areas flood excessively, due to changes in the aquatic vegetation, which regulate the flow of water along some of the important distributaries. This causes concern at the possible effects of the spread of the exotic floating fern Salvinia auriculata. It is already established on the Chobe system where it has spread west to within eight river miles of Lake Liambezi. It was first reported in this region in 1947 and has since colonized many square miles of river and swamp. The possibility of it invading Lake Liambezi and the Linyanti swamp, and then spreading into the Okavango swamp via the Makwegana spillway promoted an informal invitation to Mr. D. Mitchell, of the University College of Rhodesia and Nyasaland, to carry out a preliminary survey of the problem in March 1967. The results and conclusions of

this survey were contained in a report submitted to the Government by Mitchell in 1967.

Topography and Soils

Northeastern Botswana is characterized by heavy Kalahari sand around the northern fringe of the Makarikari basin. The Chobe-Linyanti system is separated from this inland drainage system by an extensive sand ridge. Between Kasane and Ngoma the Chobe flows against the foot of this ridge and there is no swamp on the Botswana side of the river, although there is limited seasonally inundated grassland between the meanders, and centered on Serondela there is an elevated flood plain on limestone.

West of Ngoma the channel of the Chobe is less well defined and there are areas of swamp merging with large areas of grassland, subject to seasonal inundation between Kachikau and Lake Liambezi, a shallow lake at the eastern end of the Linyanti swamp, 15 miles north of the sand ridge (fig. 5). To the west, the grassland narrows into a series of wide winding molapos, which fill from the Chobe only during exceptional floods. These are separated by low sandy ridges, some of which are paved with limestone, and the molapos become less and less conspicuous towards the Savuti.

Limestone comes to the surface along the lower edge of the sand ridge, which is formed by an overburden of Kalahari sand on a basaltic core which breaks the surface from Ngoma, to Kachikau as a low but distinct escarpment. In the east the sand ridge slopes gently in a southerly direction towards the Kakulwani plains and Ngwezumba river, while in the west it forms the watershed between the Chobe flats and its system of molapos, and the Mababe depression, before curving southward across the Savuti to form the Magwigwe sand ridge around the western lip of the depression. A similar but less distinct ridge forms the eastern edge of the Mababe.

The Kakulwani plain is one of several stretches of black "cotton" soil draining in a southwesterly direction into Botswana from the Rhodesian border, from the basalt areas around Panda ma Tenga. It has a series of pans in a weak watercourse along sections of its northern edge and feeds into the Ngwezumba river.

This seasonal river rises in the Chobe Game Reserve and after 42 miles within clearly defined banks spills into the Mababe depression, giving rise to a very sandy plain which, from the air, has all the appearances of an inland estuary losing itself in woodland. There are permanent pools, fed by seeps, at Ngwezumba Bridge and water can be obtained from the riverbed or sandy plain well into the dry season in most years.

South of the Ngwezumba river there is a weak system of drainage lines in a southwesterly and then westerly direction into the Mababe, while the Nunga river, which arises from the Nunga plains in much the same way as the Ngwezumba does from the Kakulwani plain, flows southwest towards Nyai Pan at the northwestern tip of the Makarikari system.

The Savuti channel sloping into the northwestern Mababe from Zibalianja on the Linyanti swamp has already been described, but south of it there is a second molapo known as Tsantsara. It also cuts through the Magwigwe sand ridge from the general direction of Zibalianja but has not been known to flow in historic times.

The sand sheet between the Chobe river and the Kakulwani plain or Ngwezumba river consists of heavy Kalahari sand, but is interspersed with numerous small glades which generally have heavier soils and one or more seasonal pans. In addition, there are several significant molapos, with fairly hard bottoms, which converve on the

Ngwezumba river. South of this river there is generally less sand to the northeast of the Shinamba hills and libalas are more common. These are shallow drainage lines with reasonably compact soils supporting perennial grassland, but unlike molapos, they are less well defined and contain fair numbers of characteristic bushes and trees. They are most common around the southern edge and to the southwest of the black "cotton" soil plains. Mopane veld is often associated with them and there is a broad belt of this veld type on fairly hard ground draining from the libalas, to the southwest of Kakulwani, towards the Shinamba hills.

The floor of the Mababe depression is generally sandier in the north and harder in the middle and south, but this trend is interrupted by a number of sandy "estuaries", similar to that described at the tail of the Ngwezumba river, where molapos enter the depression. There are also a number of low sandy ridges, north of the central open grassland.

Elsewhere, except along the fringes of the Okavango swamp, northeastern Botswana is generally sandy and there are few hills to break the monotony of the landscape. The Shinamba hills which rise about 300 feet above the surrounding country in the southeastern corner of the Chobe Game Reserve have already been mentioned. These are less impressive than the Goha hills which overlook the northern Mababe, rising 600 feet above the floor of the depression. Between these hills and the west bank of the Savuti channel there are seven smaller hills shown in figure 5.

History of Land Use

Past land use has had a marked effect on the habitat of wildlife in northeastern Botswana. The suppression of perennial grasses and bush encroachment are widespread symptoms of past human activity,especially through fires and overgrazing. These, and associated changes in the ecosystem, have led to an imbalance in the delicate animal-plant relationships, which accounts for several existing animal problems in the region.

The general deterioration in conservation values has created conditions which are less suitable for some species while others have prospered in response to conditions which, at least temporarily, suit them better. The pattern is similar over large areas and is not confined to wildlife. It is well documented for tsetse fly, and certain changes leading to an increase in annual grasses, and to a considerable increase of seeds, may have accounted for the eruptions of several species of rodent which started in 1966 and continued into 1967. There are also several areas where quelea habitat has improved over the past two or three decades.

In area after area, old residents described a general decline in the numbers of the most sensitive grazing species of wildlife. Other grazers benefited, or are benefiting, from the particular level to which the sere has descended, while browsing species are generally on the increase. It is therefore useful to develop a syndrome from different aspects of the ecosystem in order to provide a general understanding of the trends in the plant and animal communities, as a background for planning the management of wildlife.

Agriculture and Settlement

Selous (1881) travelled extensively in northeastern Botswana, including much of the present Chobe Game Reserve, in 1874 and 1879. The only people he mentions in Botswana were Masubia living in the southern Mababe, and stray bands of bushmen in this area and near Panda ma Tenga. He made contact with people on the Imparira island, at the eastern tip of the Caprivi, who, according to early writers, were also Masubia,

and with refugees from the Barotse, who had established themselves along the north bank of the Chobe in 1873 or 1874. The latter appear to have been linked with the Mambakush, who now reside near Kabamakuni at the apex of the Okavango delta.

Around the turn of the century, Masubia settled in the north of the district in the Kachikau Enclave. Several reports describe these as the people from the Mababe, but at least some originated from the Caprivi, as a number who made the move are still alive.

The Masubia were followed into the north of the district by a group of Batawana from Ngamiland in about 1912, led by Sekume, who had broken away from the parent tribal authority. The numbers of people built up and with them their herds of livestock. The headquarters of the Batawana element, at least, moved several times but eventually it became necessary to establish cattle posts away from the Chobe flats. Nevertheless, a portion of the Batawana element appears to have emigrated around 1920 to 1921 as old people at Gweta claim they moved from Kavimba to the Botletle river about this time, prior to moving to the Gweta area. These people indicated the move was motivated politically, although the underlying cause was a lack of suitable grazing for their cattle.

Stock posts belonging to the people of the enclave were scattered along the Chobe, in the present game reserve, spread west along the Linyanti swamps, and in the south were centered on large pans and the Ngwezumba river. The last occurred along the edge of Kakulwani to the east of the national park boundary (extension A, fig. 14) and south from here to the Shinamba hills and the Masame area. Many of these outposts were dependent on seasonal pans so that the livestock became concentrated near permanent water during the dry season.

People with stock also settled along the Linyanti in the Savuti area, and down the Magwegana spillway. They appear to have been a mixture of Batawana and Mambakush, but were the first to have had to shift in the face of advancing tsetse. Indications are that they moved many years before the cattle posts were closed along the Ngwezumba for, whereas old cattle kraals and wells are still recognizable near Ngwezumba, they have disappeared near the Linyanti. Lewis and Krog (1962) indicate tsetse recolonized the Zibaliaja area between 1922 and 1942.

There was limited cultivation near some of the cattle posts, most agriculture being on the alluvial flats to the north and east of Kachikau. This cultivation fluctuated according to the flooding of the area and two main systems of planting were employed, involving orthodox dryland cultivation and the so-called "water-gardens" where crops were sown in the damp soil left by the receding floods.

Some spectacular crops were reaped, but the productivity of the area was very dependent on the behaviour of the floods as the average gradient for many miles may be as little as three to six inches per mile. Miller (1945) reports that, until 1925, all the lower-lying areas were regularly submerged by the Chobe and maize was grown on the sandy soils away from the river. "These periodic inundations doubtless improved the moisture content of the soil and by the deposition of silt assisted in the maintenance of fertility, and they would also retard the effects of overgrazing and burning."

By 1945 these sandier areas were used for sorghum, a more drought-resistant crop. Miller attributes the rapid deterioration of the country, after the flood waters receded, to overgrazing by domestic stock. By 1937 wind erosion was such that Miller (1937) requested the assistance of a sand dune stabilization expert from South Africa and recommended the evacuation of the people from parts of the Chobe flats. This recommendation was reinforced by the District Commissioner, Maun, in 1945.

However, during the late forties and early fifties very large herds of cattle were still centered on the enclave and the cattle posts were estimated at over 20,000 head. This period also saw a boom in crop production, but by 1953 tsetse fly was rapidly spreading from the west. The domestic stock and people were compressed into an ever-decreasing area, aggravating the already acutely down-graded veld, and an outbreak of Senkobo, Streptothricosis, among the impoverished cattle, possibly aided by Nagana, killed all but about 600 head and led to the closure of all the cattle posts. The first disease is seldom fatal to livestock and was probably a secondary manifestation of the extremely poor condition of the animals.

The absence of draft oxen coupled with the gradual conversion to permanent swamp of the most fertile soils, which had been available for cultivation since the floods began receding in 1925, was the cause of great hardship to the people. Many found conditions intolerable and moved back to Maun after 50 years in the Chobe district, while others went to Gweta and Nata. Those who remained cultivated by hand and subsisted on very meagre crops.

Gradually, aided by an exchange scheme by which oxen were bartered for cows, the cattle population was built up and now numbers some 1,600 head. Conservation values are, however, already declining again (table 4), mainly as the result of too frequent burning which is held to be necessary to provide palatable grazing for the cattle, many of which were very thin in October 1966 (Child and Hepburn 1967).

Sampling was carried out by means of step-point-transects described by Evans and Love (1957) and elaborated and tested by Riney (1963) in neighbouring parts of Rhodesia, in similar habitats to those found in the Chobe district. The exact procedure adopted follows Child (1965). This method provides a measure of the status of the vegetation, the extent of its use by animals, as gauged by the incidence of their droppings per unit area, effects on the vegetation of fire, and a series of separate individual assessments of the trend in conservation values along a transect. The last, when related to the known land use history of an area, allows an assessment of a series of simple syndromes, where certain combinations of facts can only indicate certain, sometimes very specific, phenomenae. Although the evidence from a single series of observations may not be altogether specific, that from several groups of observations in different localities with slightly different land use histories very often is. This method can therefore obviate the need for elaborate field trials and the laying down of fixed transects which cannot be expected to yield results for a number of years and may be useless unless continuity of observation is assured.

The results of some of these stransects are set out in table 4. Transects 32, 33, 35 and 35a were run in examples of the least disturbed flood plain grassland between Kachikau and Lake Liambezi, while transect 34 was in a similar habitat near a village with fair numbers of livestock. The status of the perennial grasses was generally fairly high, except near the village where they were heavily trampled, but conservation values were not being maintained. This was largely due to the practice of frequent early burning.

The remaining transects were in tsetse country, which had not been grazed by livestock since the early fifties. The first was sited in a molapo, or open grassed drainage line leading from the flood plain grassland on the edge of the tsetse distribution. Cattle are occasionally grazed up this molapo, but the chief cause of veld deterioration was again fire and this applied at numerous other points well within the fly belt, checked along this system of molapos. Line 37 was on a sandy elevation adjacent to the molapo sampled by line 36. Tsetse were present and use by grazing and browsing animals was light. The status of the vegetation was generally low but was not as clearly downgrading as in the molapo, apparently chiefly as the result of the natural protection from fire afforded by the poor grass cover.

Transect 38 was in most healthy grassland located in the enclaves. The area had been very heavily grazed until 1953, and well-grown scrub was in evidence in country which Livingstone (1857) described as open grassland between the sand ridge at Goha and the Chobe river, but it had not been burnt for several seasons when the transect was run. Even here slight differences in slope, near the edge of the poorly defined molapo, reflected in the ecological stability of the area, which was critically balanced between patches that were gradually improving and others which were clearly deteriorating.

The last transect was placed in well-developed mopane woodland near the western extremity of the enclave where reinvasion by tsetse took place about 20 years before. The status of the grasses was low and conservation values were deteriorating. This was attributed to past land use, previous to the reinvasion of the fly, coupled with more recent burning and possibly the fairly heavy use made of the area, within five miles of the Linyanti swamp, by wild ungulates, although the intensity of this use would not have been excessive had the grasses been in a healthy state.

The land use history of the Kachikau enclave is described in some detail as it is fairly well documented and illustrates the type of changes in the vegetation which may result from improper land use. Similar, although less spectacular changes occurred as the result of a Colonial Development Corporation ranching scheme in the Panda ma Tenga area, which operated between 1950 and the early sixties. These alterations of the habitats have led to changing trends in the dependent wildlife populations.

In addition to resident livestock in the Chobe district the number of cattle grazing certain parts of the range is greatly augmented by cattle being exported on foot to the north.

Cattle Export Trade

Cattle exported from Ngamiland to Zambia and Katanga have been trekked along a number of routes converging on Kazungula. The reinvasion of large areas of Ngamiland and the Chobe district by tsetse fly was the primary reason for shifting the route further and further east to its present position. The stock routes may themselves have been partially responsible for this spread of the fly, and the ecological basis for this suggestion is elaborated in the section on tsetse.

The general practice when exporting cattle through Kazungula was for traders, who had purchased and held cattle throughout Ngamiland, to move large herds, numbering several hundreds, towards the Chobe flats just after the rains and while the seasonal pans in the Mababe depression still held water. Initially they were moved fairly quickly, covering the distance of some 180 miles from say Maun to Makwarana in about three weeks, during which time they were walked and grazed on alternative days. They were "drifted" the final 70 miles from Makwarana to Kazungula taking several months, thus allowing time for them to gain weight along the Chobe flats before they were sold.

This method of moving cattle led to heavy grazing along the stock route south of Makwarana by successive mobs of cattle for several months every year, beginning toward the end of the growing season, before most perennial grasses had completed building up root reserves for the dry season. Trampling would have further reduced the vigour of these grasses and so encouraged the scrub invasion now evident along most old stock routes. This invasion can be very rapid on sensitive soils such as those in much of northeastern Botswana, and can transform open grassland into dense thicket. The area around Bushman Pits provides a good example of this phenomenon which has taken place during the past 20 years.

TABLE 4

Results of Vegetation Transects run in the Kachikau Enclave

Transect No.	Date	Status of Vegetation as % Ground Cover								Conservation Trend		Animal Droppings in Milacre Plots											Vegetation Type
		BG	L	C	F	G	A	P	Wood	↑ → ↓	Total	Plots	Cow*	Reedbuck	Hare*	Springhare	Duiker	Elephant	Zebra	Eland	Impala	? Antelope	
32	4.10.65	94	25	20	2	6	0	26	0	30	30	30	1	1									
33	4.10.65	85	37	25	0	15	0	40	0	2 18	20	20	3		9	5						1	
34	4.10.65	96	18	2	0	4	0	6	0	10	10	-											Flood plain grassland
35	5.10.65	92	19	8	1	8	0	16	0	25	25	25				Nil							
35a	5.10.65	88	52	32	0	12	0	44	1	10	10	10				Nil							
36	5.10.65	77	41	16	4	20	0	32	0	10	10	10	1		7		1					2	Molapo
37	5.10.65	88	48	21	1	12	14	19	38	1 9	10	10			1				1	1			Sandy area between molapos
38	5.10.65	92	70	49	4	7	1	55	12	10 6 14	30	30								3	1	1 1	Lightly wooded molapo edge
39	6.10.65	99	36	5	0	1	2	4	45	10	10	10								2		1 1	Mopane woodland
Total										10 9 136	145	145	5	1	17	5	1	1	6	1	2	5	
Average		90	38	20	1	9	2	27	11														

BG = bare ground; L = Litter; C = grass canopy; F = forbs or forb canopy; G = rooted grass (i.e. basal grass cover); A = annual grass (canopy or rooted); P = perennial grass (canopy or rooted); wood = wood plant or its canopy; ↑ = conservation values improving, → = conservation values stable or trend not clearly apparent; ↓ = values downgrading. * = pellets of this species, as opposed to complete defecations, present in plot.

The area takes its name from some old shallow wells which had water at a depth of 24 feet and yielded a strong supply when the area was established as a C.D.C. cattle post late in 1949. The stock manager entrusted with opening up the post, describes the country around the old homestead as open grassland similar to that now found on the waterless Kanyu flats, and this is confirmed by others who knew the area two decades ago. The open country stretched south to the riparian fringe along the Botletle river, west 30 miles, and east to Nyai Pan, also a distance of 30 miles.

Wildebeest and springbok, both of which are grazers preferring open grassland, were common around the homestead. The road to Panda ma Tenga skirts the northwestern corner of Nyai Pan, and this stock manager reported that the mile and a quarter of dense bush, now separating the two, did not exist in 1949.

Trade cattle was introduced to the post almost immediately and at times numbered 10,000 head, of which a portion was periodically walked to Panda ma Tenga along the present road via Dodo Crossroads. Initially there were difficulties with the watering of this large number of cattle and many were held along the Botletle, until other wells came into operation. The Botletle had itself been dry for several years before this, when very little water had come down from the swamps.

The wells were sunk by six gangs of well-diggers who were usually able to obtain water within 30 feet, and sometimes at as little as 12 feet.

Today there is dense scrub north of the Botletle river and most of the area, which covered some 500 square miles, shows advanced srub encroachment and the widespread replacement of perennial grasses by annual species. To the west of Nyai Pan the bush forms almost impenetrable thickets about seven feet tall. It is composed chiefly of Dichrostachys cinerea, Commiphora edulis, Grewia flava, G. retinervis, Terminalia sericea, T. prunioides, Mundulea sericea, Combretum spp., Acacia spp. including A. ataxacantha and A. mellifera, with mopane (CM3)* and Catophractes alexandri locally common. Occasional large trees include mopane (CM2)*, T. prunioides, A. gillettiae and on some of the sand ridges Burkea africana while Combretum imberbe is conspicuous on heavier soils, especially towards Kanyu. Grasses are sparse or absent and include mostly annuals.

A gemsbok flushed from the road, and unable to escape more than 15 yards from a vehicle, demonstrated the density of the scrub, through which a path has had to be bulldozed to enable cattle to pass along the stock route which was reopened in 1956, for the exporting of Ngamiland stock, after the route across the eastern Mababe became unusable.

With the exception of some of the largest trees, M. sericea, and Boscia albitrunca, which are evidently relatively fire-resistant, and some of the youngest bushes, most plants have a well-developed fire induced ground-level coppice (see sub-section on Fire). A sample of 63 plants were dug up and the annual rings in the coppice or tap root and in the aerial stems were counted. The results are shown in table 5, which indicates two important thresholds in the process of scrub invasion; it is significant that these were determined before the history of the area was known.

Most of the plants were between 14 and 17 years old judging from the rings in the coppice and roots and the stems of M. sericea. This scrub was therefore established soon after the cattle post at Bushman Pits was opened, although for some years fires were of sufficient intensity to kill the aerial stems, but since about 1958 or 1959

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* Describes various growth forms of mopane defined below.

TABLE 5

Age Determinations of the Ground Level Coppice and Stems of the Scrub Invasion west of Nyai Pan

Species	Sample	Ground level coppice or root			Stem		
		Max	Min	Mean	Max	Min	Mean
Grewia retinervis	9	19	12	15	9	7	8
Grewia flava	13	20	11	15	12	7	8
Combretum sp.	10	22	11	15	11	7	8
Commiphora edulis	7	22	14	16	8	7	8
Unidentified species	4	17	16	17	8	6	7
Acacia mellifera	3	19	15	17	7	7	7
Acacia ataxacantha	2	16	16	16	10	8	9
Mundulea sericea	10	16*	9*	12*	16	6	12
Acacia giraffae	2	-	-	-	40	13	28
Boscia albitrunca	3	-	-	-	34	14	25
Total	63						
mean age excluding last 3 spp.				17			8

* Rings in root - no coppice.

this has no longer been possible. That such fires should have become ineffective for a variety of species, spread over three quarters of a mile sampled, would indicate a sudden change in the vegetation inhibiting fires, so that it is pertinent that this threshold follows closely the reopening of the stock route in 1956.

Earlier stages of this type of veld deterioration are evident south of Nyai Pan, where there is a progressive gradation from dense scrub, through scrub whose aerial growth is still controlled by fires to open grassland with mild scrub encroachment among the Kanyu pans. It is to be expected, however, that fire and/or grazing east from the stock route will hasten the process and that thickets will eventually occupy the whole area between the old main road and Nyai Pan, and will eventually spread on to heavier soils nearer the stock route.

The heavy overstocking by resident herds and the seasonal influx of export cattle, along the Chobe flats was at least partly responsible for the crash in the livestock industry based on Kachikau. It also led to bush encroachment on parts of the flats which do not become inundated, as well as in adjacent areas along the sand ridge.

While this method of exporting cattle operates smoothly and would be difficult to replace, it should be recognized that it has, and will continue to have, a harmful effect on the ecological stability of a large area of state land.

Logging

The "Enumeration Report on the Maun Chobe Block" submitted by the Forest Department in May 1966 (Henry, 1966) crystalized the differences which were bound to arise between this Department and the Game Department over the independent responsibilities for interdependent natural resources in overlapping areas. Commercial logging took place in the Chobe district between 1935 and 1938 and again between 1944 and 1955. The first concessionaires exploited the best pockets of woodland in the extreme northeast of the territory, between Kazungula and Kalwizikankanga, in conjunction with similar forest across the Rhodesian border, but withdrew when it was obvious that it was uneconomic to exploit timber further west (Kelly - Edwards, 1960). The second concern, based on a mill at Serondela, also encountered financial difficulties and, despite diversification into crop production and other ventures on the Pookoo and Chobe flats, went into liquidation. This may have been partially due to bad management and over-capitalization, but also resulted from the low yield of timber possible in the local Kalahari woodland, coupled with the distances from the railway line.

The activities of the first concessionaires only just extended into the present Chobe Game Reserve, but those of the second firm were almost wholly within its limits. The resulting modification of the habitat, through interference with the dominant floristic element, was one of three important influences, which include burning and past over-populations of livestock, which have altered the delicate animal/plant relationships in this region. These set the stage for many current wildlife problems and the Game Department was anxious to avoid aggravating the ecological situation by having further logging in the game reserve, as was advocated by the Forest Department.

The Game Department was able to present a strong case against logging in the northeast of the reserve (see for example Hepburn 1966, Child 1966), in view of the relative economic and aeothetic importance of the two industries. It was finally decided at a series of meetings between the two ministries concerned in Gaberones, that logging should not take place in the game reserve east of Ngoma, but would be

allowed south of the existing boundary of the Kachikau enclave (Area F, figure 14). In the meantime the author was asked to comment on proposed forestry legislation which would have effectively placed habitats within the reserve under the jurisdiction of the Forest Department. In view of the disagreement already evident between the two departments in separate ministries, it was recommended that the Forest Act should not apply within established game reserves. In effect this meant only the Chobe Game Reserve, as the proposed Forest Act would have been effective only on state land.

This suggestion met the immediate needs of the Game Department in order to prevent further avoidable modification of the habitats in the Chobe Game Reserve, but was not entirely satisfactory as it is proposed to have additional game reserves for the rational exploitation of wildlife and in such areas multiple land use might be desirable. It was therefore recommended that the Chobe Gambe Reserve, with certain changes to its existing limits, should be elevated national park status, thus automatically precluding logging within its borders. The results of this suggestion are elaborated later in Part II of this report.

Fire

Past and present burning practices have undoubtedly had a very marked and widespread effect on the habitats of northeastern Botswana. Future veld management should take these changes into account, as they have altered the composition of the plant communities and this is reflected by changing trends in animal populations. The harmful effects of improper burning can be accentuated by the changes they induce in wild animal populations and are often reinforced when associated with domestic stock production, but it should be borne in mind that these effects can result solely from an ill-considered burning policy.

Effects of early or improper burning - The doubt expressed by several people and included in the Forest Report, as to the reported effects of annual early burning should not go unchallenged. It has been suggested that it does not favour scrub at the expense of grasses and that there is no evidence of scrub invasion in the Kalahari woodland in the Chobe Game Reserve. The ecological importance of fire and its correct use need not be dealt with in this report, as it is well documented, but the general lack of understanding of the subject makes it necessary to outline very briefly some of the principles which have emerged from years of painstaking research. This general background theory is also relevant to other parts of the present report and frequent reference is made back to this sub-section.

The relative effects of fire on the vegetation vary with climate, soil fertility, other local conditions and the time of year and frequency of burns. Generally fire is most damaging to woody vegetation late in the dry season in areas favouring a luxuriant grass growth and is most effective against grasses early in the season where the rainfall is low or erratic and where soil fertility is low. The latter includes dry marginal areas such as occur away from the river in the Chobe Game Reserve. Here early burning, such as is advocated by the Forest Department (and which was introduced in 1938), destroys the aerial parts of perennial grasses, often before they have had time to translocate essential food reserves to the storage organs in the roots. This places an added burden on the plant at the onset of the critical dry season when there is inadequate soil moisture to allow for the synthesis of nutrients. A further deleterious result of early burning, even somewhat later in the season, is the well-known flush or "green-bite" induced by fires, which stimulate the grasses to produce new leaves, and thus to draw on their food and moisture reserves at a time when true growth is not possible.

TABLE 6

Results of Vegetation Transects in Kalahari Woodland

Transect No.	Date	Status of Vegetation as % Ground Cover								Conservation Trend			Animal Droppings in Milacre Plots					
		GB	L	C	F	G	A	P	Wood	↑	→	↓	Total	Plots	Duiker	Springhare*	Sable	Eland	Zebra
9	10.9.65	93	73	27	0	4	0	31	40	5	2	3	10	10	1	2			
40	20.10.65	97	82	10	1	0	10	0	82			10	10	10			1	2	1
41	20.10.65	96	56	10	0	1	5	6	30			10	10	10	2				
Total										5	2	23	30	30	3	2	1	2	1
Average		95	70	16	-	2	5	12	51										

Symbols as for Table 4.

* Droppings, as opposed to complete defecations, present in milacre plot.

The result of repeated early burning is that the perennial grasses, on which ecological stability is dependent, lose vigour, are at a disadvantage in competition with woody plants and eventually disappear. Early burns are less hot than those later in the season and do little more than singe woody vegetation, so that burning to promote grasses usually takes place as late as possible, when hot fires can be achieved and when woody plants are mobilizing nutrients and are therefore most vulnerable.

The claim in the Forest Report that there is no bush encroachment in the Chobe forest block is difficult to reconcile with the findings from field work in this area. Although sampling in this part of the reserve was curtailed by fire during the 1965 and 1966 dry seasons, results obtained (table 6) give clear indications of bush encroachment, and a general deterioration of perennial grasses (see also section on Kalahari veld).

The status of the perennial grasses was generally low, and along two of three transects the grass cover was deteriorating, while in the third area, which had not been burned for at least four seasons, signs of early recovery were apparent. In addition to the clear signs of bush encroachment along these transects, particularly transect 40, scrub was judged to be invading 59 of 61 glades in the Kalahari woodland. These results are similar to those of Riney (1963) who worked on similar problems in the Gwai and Gwampa forest areas in adjacent parts of Rhodesia. He summarizes the results of his transects in the forest area thus:- "From the transects run in the forest areas (most of which were run in forest experimental areas) it was clear that areas associated with frequent burning were poorer with respect to present status and less satisfactory with respect to trend, than transects protected from frequent burning." He notes that the worst affected areas were the vleis and grassland areas which have counterparts in the Chobe Game Reserve. However, Riney concludes by noting that, "it is only fair to the Forestry Commission to mention that since these observations were made the Commission has discontinued its policy of annual burning and adopted a plan of rotation burning similar to that suggested by Kennan, Staples and West (1955) in which they recommend spelling from burning for a period of three to four years. This may prove to be an important forward step to forest management and especially to any schemes of multiple use within the forests that may develop, using either wild animals or cattle".

Bush encroachment is generally widespread in the Chobe Game Reserve. It probably became established as the result of overgrazing, by cattle in particular, as it is best developed along old stock routes and around old cattle posts, but in other areas with a light game population which have apparently never been heavily grazed by cattle, because of the nature of the veld or the presence of toxic weeds, it can be attributed to fire alone, as Riney found in Kalahari woodland in a tsetse area in Rhodesia. He selected this area, which had never been grazed by cattle and where wild animal numbers were low, because he hoped to gain a measure of really healthy Kalahari woodland for comparison elsewhere. He was careful to select the very best areas so that his results are worth quoting as they illustrate the destructive effects of regular burns.

"The results of this transect series completely nullified the hope that the area could be used as a standard for comparison. For these nine transects the average percentage of bare ground was 90 percent litter plus grass 51 percent and the average height of the grass at the end of the dry season was about 9 inches - seven out of the nine transects were characterized by bush encroachment, - and all but one of the transects were downgrading in condition. Some areas showed active recent gully erosion.

"The one exception was in a moist vlei area under water for several months of the year in which it is possible to get a fire through only late in the season. Only in this one transect - has annual burning apparently not detracted from conservation values and the transect was assessed as stable.

"Since this tsetse area has never been subjected to any type of land use prior to the shooting operations (because the presence of tsetse fly precluded the use of cattle) and because the numbers of animals, judging from the number of droppings left on the ground, were nearly as scarce as those occurring in Livingstone Game Park - the present unsatisfactory status and trend can only be attributed to the policy of annual burning that has taken place for at least the previous twelve years. The reason for the burning was to increase the visibility for tsetse area hunters.

"It is not within the scope of the present paper to discuss pros and cons of tsetse shooting. Since the present transects were deliberately located in the best areas that could be found, it does seem appropriate to emphasize the potential value of this kind of information to administrators dealing with tsetse operations, for the practice of early burning has not only already resulted in a fairly advanced stage of deterioration, including bush encroachment, but the trend at the time the transects were taken was still clearly downgrading. It is suggested that this type of evidence is important to consider particularly if one is concerned about the future use of this country for agriculture, or if there is any reason to be concerned over the ecological implications associated with increasing bush encroachment and a decreasing proportion of perennial grasses. Radical changes in habitat,not only for game animals but also for tsetse flies, have already taken place."

Riney's results are quoted in some detail as there are strikingly similar parallels between the problems of early burning in similar country in the Chobe district. Here too there is the problem of deteriorating grassland for game, and cattle in the Kachikau enclave, and the danger of further spread of the advancing tsetse front, on the control of which large sums have already been spent.

Irrespective of the primary cause of bush establishing itself, too frequent fires of insufficient intensity are encouraging its growth and spread. There appear to be two important thresholds in the deterioration of grassland towards thicket formation. The first was reached in most areas when the vigour of the grasses was reduced enough to allow the bush to establish itself. At this stage the grass growth was, or still is, sufficient to allow a fire hot enough to burn back the branches without killing the roots, which continue to grow and coppice afresh from ground level after each fire. The second threshold is arrived at when the vigour of the grasses is further reduced by fire and competition from the scrub, so that there is no longer sufficient combustible material to allow a hot enough burn to kill the stems. These grow rapidly into uniform stands of multistemmed trees and bushes. The pattern is very evident in mopane, but is also discernible in most of the important species involved in scrub encroachment (see discussion on bush encroachment in the Nyai Pan area).

Three types of mopane are recognizable and are designated as CM1, CM2 and CM3, which include two distinct growth forms. CM1 describes normal single-boled trees and their saplings, but CM2 and CM3 are derived from a ground-level coppice and are multistemmed. CM3 describes this type in the scrub form, when aerial shoots seldom measure over three inches in diameter, over bark at the base, and are rarely over seven feet tall. At this stage the aerial shoots are still very susceptible to fire, but in the case of CM2 this is no longer the case, with the result that the stems are thicker and taller and may exceed 40 feet.

CM2 and CM3 often represent mopane encroachment into areas that were better grassed in the past. Thompson (1962) found that mopane does not establish readily in vigorous grassland, but that once established it tends to suppress grass growth, and Child (1965) describes how the removal of mopane led to very significant improvement in perennial grasses within one season in the Zambezi valley. CM3 apparently results from seedlings establishing when the vigour of the grasses is reduced, but while there is still sufficient combustible material for fires to kill off the aerial shoots at ground level.

At this stage CM3 may still be susceptible to hot late burns after an interval of several seasons, which would in any case kill young plants where they did succeed in germinating in healthy grassland, but such fires are suppressed by early burns or trampling by livestock. CM3 persists, while fires, possibly aided by frosts which tend to kill the leaves and make them more combustible, are still hot enough to kill the aerial shoots, but are not of sufficient intensity to kill many of the roots. Under these conditions the roots coppice many times while they continue to grow at ground level. One such plant, chosen at random along the edge of the Kakulwani plain had a long axis at ground level of 34½ inches and the greatest width at right angles to this was 24½ inches. In the CM3 stage this does not form a solid platform and some grass may grow between the prostrate "branches". In this plant the tap root was still well developed and had not yet been superseded by the lateral roots, as is usual in older mopane. The tap root had a cross-section of 2 5/8 inches, six inches below ground, and was about 30 years old judging by annual rings visible in the root. There were well over 100 scars, up to 2 3/4 inches in diameter, from burnt off aerial shoots, but many others were masked by subsequent growth. The oldest of the 43 living shoots had five rings, was 44 inches high and had an over-bark diameter of half an inch, 3 inches above ground level.

A CM2 tree 20 yards from this plant,and no longer subjected to effective fire, had a basal diameter of about two feet. There were nine stems of which four were over 25 feet high. The greatest number of visible rings was 46 in a stem 5¼ inches in diameter three feet above ground level, indicating the plant had been protected from damaging fire for about 50 years.

Uniform stands of CM2 often have an abrupt edge, giving way to CM3, and often contain an occasional old CM1. In such cases the encroachment is not evidenced by bushes diminishing in height progressively out into grassland, but by a decline in the density of CM3, which further investigation may show is also correlated with a decline in the age of the coppices (see section on vegetation in the Mababe).

This explanation of the encroachment of grassland by mopane based upon numerous inspections of CM2 and CM3, in all stages of development, is an over-generalization, as local soil factors, including surface drainage, are obviously of great importance in accelerating or depressing the process. It does, however, contradict the conclusions reached in the Moremi Game Reserve by Tinley (1966). He argued that scrub mopane of the CM3 variety results from the destruction of better woodland by fire and that the multistemmed form of CM2 was derived from CM1 damaged by elephant.

Elephant seldom break trees at ground level and their use is characterized by coppicing at an irregularly higher level so that it would be unlikely to result in uniform stands of trees with regrowth from basal coppice. Under exceptional circumstances fires may burn back CM2 stems, but of the hundreds of CM3 examined out in grassland not one has been found to have a scar left by a large stem such as would occur if a CM1 was burnt down. In addition, most CM2 show very old fire scars, but at most only singeing of the bark from later burns. Further, many CM3 have tap roots, which disappear in older plants and their anatomy shows clearly they are a coppice of

distorted horizontal stems with roots, and none of the numerous burnt out adult CM1 stumps investigated showed signs of regrowth. Finally, evidence in the sub-section on elephant shows that this species was uncommon in northeastern Botswana when much of the encroachment took place.

Fire alone, although it has modified the growth of CM2 and CM3, may not always have been responsible for the spread of scrub mopane, which may have resulted from over-use by livestock, or in a few areas to an overabundance of game, although the build up in wildlife has usually been a manifestation of previous changes in the habitats. The importance of livestock in promoting uniform stands of CM2 or CM3 containing an occasional old CM1 tree was evident near Panda ma Tenga. Here the scattered CM1 trees out in otherwise open grassland attracted cattle which had trampled out the grasses beneath them and invasion by CM3 was well advanced, particularly around the trees near the edge of the plain.

Similar growth forms and patterns of encroachment were evident for other species. These thresholds in the deterioration of perennial grasses and the consequent scrub invasion are very important, as a reversal of downgrading trends is generally a relatively simple matter above a threshold, but becomes much more difficult once conservation values have slipped over the threshold. This is best illustrated with a local example. The only practical method of controlling scrub economically in large grazing areas is by the use of hot late burns in a properly planned burning program but, once the bush becomes too dense, there is never enough grass at the end of a season to allow for such a fire. Several fires in the Chobe District in October 1965 were ineffective against bush although they eliminated the grass and generally had an effect on the vegetation similar to that of an early burn. This was due to insufficient combustible material following a series of dry years in areas where previous burning had been too frequent. In several of these places an adequate spell without fire may allow its future use against scrub, but in some areas this will not be possible. Where extensive thickets have developed, the scrub has shaded out the grass to the extent that fires are no longer possible, let alone hot enough to kill the scrub. Here reclamation of the country will probably be very slow and may be expensive.

These examples stress the need for proper control of fire, not only in the Chobe Game Reserve, but throughout most of northeastern Botswana. This does not mean that no fires would be preferable, as fire properly used with clear objectives is a valuable management tool. Much vegetation has been modified through past land use and occasional fires are accepted as an important ecological factor in the evolution of most African habitats. The Game Department is therefore correct in insisting upon its right to use planned burning for management purposes. It was also justified in questioning the Forest Department's right to burn early annually because economics mitigated against proper fire control, and to suggest the need for a clearly defined policy considering all interests where there are overlapping forms of land use.

Tsetse Fly

The history of tsetse fly infestation in eastern Ngamiland and the Chobe District is summarized by Lewis and Krog (1962) and Wilson et al (1963). The only species known to occur in Botswana is Glossina morsitans and until the latter part of the nineteenth century the Botswana fly belts were linked to the Zambezi belts at Kazungula.

It has been suggested that the recession of the fly last century was due to the rinderpest epidemics which swept through this part of Africa between 1894 and 1896 killing many of the vertebrate hosts of the fly. Historical evidence recently

compiled by Summers (in press), however, indicates that the fly belts in Rhodesia and the Kazungula area of Botswana receded before the outbreak of rinderpest, and the trader Westbeech was able to move waggons right up to Kazungula by 1881, whereas before this he had had to leave them first at Panda ma Tenga and later, according to Mohr (1876), at Lesuma.

Summers also found that areas which are known to have been densely settled with Shona people, but which were laid waste by raiding Matabele and allowed to lie fallow, encouraged the reinvasion of tsetse. Similar habitat conditions would have resulted from the movements of large numbers of people and their stock in Botswana during the first few decades of this century, which is circumstantial evidence that this form of land tenure also favoured the spread of fly. Old people, involved in two such moves, affirm that the main reason for migrating was the decline in grazing, and grazing of this intensity would certainly promote scrub encroachment leading to improved tsetse habitat.

It is pertinent that Pole Evans (1948) reporting on a survey carried out along the present main road between Maun and Kazungula, remarks upon the spread of scrub generally and particularly mentions that dense thickets of Acacia giraffae and A. litakunensis (?)* were invading the open spaces between the molapos and threatened to overrun much of the country along the Mogogelo river. He attributes this to incorrect land use and to overgrazing by domestic stock in particular.

Lewis et al (Ms) found, as the result of their tsetse fly resting-site studies, that Acacia woodland is especially important to fly in Ngamiland during the latter part of the dry season. Most species of Acacia, including the two mentioned above, grow quickly, so that it is significant that one of the greatest advances in the fly front recorded between 1942 and 1962 took place in the Mogogelo river area. Here a large area of Acacia woodland, including at least some of that described as scrub in 1937 by Pole Evans as it occurs in dense stands on sandy elevations between the molapos, was ring-barked by the Tsetse Fly Control Department in 1965.

Livingstone (1857) provides another example of where modification of the habitat preceded the invasion of fly. Descending the sand ridge north of the Goha hills, he describes the country from there north to the Chobe river as open plains. There are still a few old people in the Kachikau enclave who remember when the whole eastern section was open grassland with occasional large evergreen trees and numerous palms on the sandy ridges which are today well wooded by Acacia and other species.

The area north of Goha was a favoured grazing area for traders from Kachikau, one of whom claims to have had several thousand head near Makwarana at times. These cattle evidently overgrazed the area with the result that bush became established on the more sensitive soils along the edges of the molapos and by 1952 provided suitable habitat for fly. The cattle then had to be moved to an area east of Kachikau and the vacated area now has a very dense fly population.

The recolonization by fly of much of northeastern Botswana has taken place where cattle numbers were high and where the results of the consequent scrub invasion are still apparent. It would thus appear that the reinvasion of fly was made possible by ecological conditions resulting, at least in part, from the mismanagement of livestock. Once begun, the process would have snowballed, as livestock was compressed

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* probably A. tontilis.

from areas threatened by fly into areas which were already overstocked, so accelerating the destruction of perennial grasses and bush encroachment. In addition, this would set the stage for a crash in the cattle population, which from O.B. Miller's evidence, is exactly what happened to the livestock industry centered on Kachikau.

This would also explain the tsetse fly invasions across the stock route from Ngamiland to Kazungula as it was moved further and further east in the Mababe; these are areas with Acacia woodland, which has been modified through the proximity of the stock route.

Vegetation

The vegetation of northeastern Botswana consists typically of tree and bush savannah with woodland on Kalahari sand in the extreme northeast and plains in the Makarikari depression. A well-developed riparian strip occurs along the Chobe east of Ngoma, along the Linyanti swamp west of Lake Liambezi, and lines many of the molapos of the Okavango system. There is open grassland on black "cotton" soils in the east, on areas subject to seasonal inundation along the Chobe river or in molapos, and in the central Mababe.

The vegetation in the state land section of this region has been described by A. Blair Rains, the leader of a team investigating the possibility of opening up parts of the area for the cattle industry, on which the author represented wildlife interests. This author's map was based on groundwork and physiognomic units which could be distinguished on aerial photographs.

The vegetation of the northeastern corner of Ngamiland between the Linyanti and Okavango swamps is not well known. It is described as "Sandbelt wooded with mopane and mosheshe" (Burkea africana), away from the molapos, on Stigands' map of 1921. Smithers (1964) indicates it has areas with an avifauna typical of the central Kalahari, with an intrusion across the Caprivi in the central region of tree and bush savannah. There are also broad belts of Acacia and mopane woodland, which is more typical of northwestern Botswana.

Pole Evans (1948) described deteriorating conservation values in many habitat types in Ngamiland and the Chobe district from his 1937 survey. Many of his statements are still very pertinent, although veld deterioration has continued during the intervening 30 years of continued mismanagement. Specific instances are mentioned elsewhere in this report, but it is important to bear in mind the widespread influence on the vegetation of past land use, particularly of the livestock industry and too frequent burning early in the season. These, and the influence of local seasonal overpopulations of game and past logging activities, have altered the vegetation from its pristine state and need to be taken into account in any management program designed to preserve or restore ecological stability, or to promote the essential habitats of any endangered species of wildlife.

The effects of past land use are discussed in greater detail in the following description of the vegetation of the Chobe Game Reserve.

The Vegetation of the Chobe Game Reserve

Figure 5 is a preliminary generalized vegetation map of the Chobe Game Reserve, summarizing the detailed surveys of Kalahari woodland areas being undertaken by the Forest Department, augmented by similar work in other vegetation types by the author and warden of the reserve. The work has been based on cross-country traverses recorded on 1:50,000 aerial photograph print laydowns, but is not complete due to the lack of even the most primitive motor tracks leading into the more remote areas.

Further investigations are needed south of the Ngwezumba river, between the Shinamba hills and the eastern Mababe, south from these hills, and in the northwestern corner of the reserve, as well as filling in gaps elsewhere.

The Forest Department is presently workin the Shinamba area and it is recommended that the Game Department should continue this work in other areas as it will provide a useful basis for biological research and the management of wild populations of animals and plants in the Chobe district and will facilitate future land use planning.

The Chobe Flood Plain

Most of this area is subject to seasonal inundation and consists of attractive open grassland which provides valuable grazing for resident large mammals and those which concentrate along the river during the dry season. The following grasses and cyperuses have so far been identified, but grazing is so heavy that most had to be matured in seed boxes and several important plants have not yet flowered or still await typing. Acknowledgment is made to the Government Herbarium of Rhodesia for carrying out these identifications: Cyperus digitatus, C. articulatus, C. esculentus, Setaria sphacelata, Hemarthria altissima, Echinochloa stagnina, Panicum manicatum, P. maximum, Dactyloctenium giganteum, Digitaria setivalva, D. adscendens, Digitariella remotigluma, Brachiaria nigropedata, B. deflexa, B. brizantha, Eragrostis rigidior, E. jeffreysii, E. lappula, Eragrostis sp. and Paspalum commersonii. H. altissima, E. stagnina, and S. sphacelata are important species so far identified from moist depressions and P. commersonii, is dominant under similar conditions in a breached rice paddy, while D. setivalva, D. adscendens, E. rigidior, E. jeffreysii, B. deflexa, B. nigropedata, B. brizantha and P. maximum are conspicious on drier sandier elevated portions of the flats. The depleted nature of the grassland on these elevations is very apparent from the air and on two point-line transects there was 91 percent bare ground, only 64.5 percent grass canopy plus litter; these areas, which were selected as having a better grass cover than most, were clearly downgrading.

The grass Cynodon dactylon is spreading on parts of the flats, while the reed beds along the river mentioned by Miller (1939) have been reduced to a few relic patches, but one area, prepared for irrigation by Chobe Concessions Ltd., in 1950/51, is well grassed over, as is a rice paddy constructed by this firm.

The Chobe flats form a habitat type in which perennial grasses are relatively resistant to abuse, but nevertheless large areas are downgrading. Past overgrazing by domestic stock may have initiated this process, and the heavy grazing and trampling to which it is subjected by wildlife may have a bearing on it, but an important factor suppressing the habitat is too frequent burning. These fires are difficult to control as they are mostly started by people crossing from the Caprivi, and are associated with their poaching activities.

Similar fires can be observed in the Caprivi during most of the year. In this type of grassland they lead to very hot burns, particularly toward the end of the dry season. This explains the depletion of the fringe of woody vegetation, composed chiefly of Syzygium guineense along the main channel of the Chobe opposite Kasane which is shown in a photograph published by Mackenzie (1946). There is little doubt that they also tend to suppress woody vegetation in depressions on the flood plain, where soil moisture is particularly favourable for grasses, but on the slight elevations, which tend to be sandy, grasses are more sensitive to fire, and in the absence of bush the ground is bared to wind erosion.

This process is apparent along the Botswana side of the Chobe and in the Caprivi, and is of particular importance to the future of lechwe, an important tourist

attraction in the game reserve and a significant source of protein and skins to the people of the Caprivi. This is dealt with more fully under Ichwe, so that here it is adequate to stress the need for the closest possible cooperation between the Botswana and South African authorities over the control of fire along this margin of the Chobe Game Reserve.

The Riparian Strip

There is a narrow riparian strip along the edge of the flood plain. It seldom exceeds seventy yards in breadth and varies from having a closed canopy to fairly scattered evergreen to almost evergreen trees. The most conspicuous of these include Acacia nigrescens, A. albida, A. tortilis, Diospyros mespiliformis, Garcinia livingstonei, Croton megalobotrys, Lonchocarpus capassa, and Trichilia emetica.

This fringe has been badly damaged through the activities of elephant and is discussed at greater length in the subsection on that species.

"Pookoo" Flats

The elevated flood plain around Serondela was christened "Pookoo" Flats by Selous (1881) who described the area as "a flat ..... in some parts over half a mile broad, lying between the steep forest-covered, jungly sand-belt and the bank of the river". He continued that, "this flat might be from six to eight miles long, and lay in the form of a semi-circle, in a bend in the sand-belt, that rose abruptly behind it, and ran down to the water at each extremity". He concluded significantly, that "the greater part of this extensive tract - once no doubt the ancient bed of the river - was open, though here and there patches of bush were scattered over its surface, and nearer the river grew many very fine wide-branching camel-thorn trees (Acacia giraffae)".

To day the most characteristic feature of the vegetation is the dense bush which covers most of this area. It is composed chiefly of Dichrostachys cinerea, with other species such as Acacia tortilis, Ziziphus mucronata and Combretum mossambicense locally common. Scattered through the bush there are large trees such as Acacia tortilis (which, judging from his description of their form, Selous mistook for A. giraffae - a species more typical of sandier soils), A. nigrescens, Phyllogeiton discolor and Croton megalobotrys with, occasionally, other trees of the riparian strip, and west of Serondela a few Boscia. The encroachment of bush was caused by heavy grazing and as in the riparian strip, many of the large trees show extensive recent elephant damage.

There are also open patches supporting the grass Cynodon dactylon which signify old cattle kraals or other human disturbance. The most notable of these are around the old sawmill site at Serondela and in old cultivations opened up by Chobe Concessions (Pvt) Ltd., to the east of the mill, and at Kabulabula, where at various times there has been a police station, a trading store and a veterinary control post, to prevent contact between cattle from Botswana and the Caprivi.

Elsewhere over large areas perennial grasses have been largely replaced by annuals such as Panicum maximum, Dactyloctenium sp. and Urochloa sp. Conservation values are generally low and in many parts still deteriorating, transects 10, 11, 14 and 15, but in the extreme east the status is reasonable and the veld is improving, line 13 (table 7). The area is heavily used by game, but fires which enter the area from outside or are started by residents of Serondela are also an important suppressive element. The grass cover is so poor in most parts that even a late burn has little

TABLE 7

Results of Vegetation Transects on the Pookoo Flats

Transect No.	Date	Status of the Vegetation as % Ground Cover								Conservation Trend				Animal Droppings in Milacre Plots											
		BG	L	C	F	G	A	P	Wood	↑	→	↓	Total	Plots	Elephant*	Buffalo*	Bushbuck	Waterbuck	Baboon	Hog/Pig	Kudu	Wildebeest	Sable	Puku	? Antelope
10	13.9.65	99	52	6	0	0	4	2	40			10	10	10	3	1	3	1	2						
11	13.9.65	78	68	48	0	21	1	68	5		3	7	10	10		7		4		4	2	1			1
13	16.9.65	82	73	42	0	15	1	55	26	5	2	3	10	10	2						1				2
14	16.9.65	93	49	36	0	6	1	41	3	2	3	5	10	10		5		2		1	1		1		
15	16.9.65	95	55	25	0	4	8	19	45	1		9	10	10			1	1	1	4				3	
Total										8	8	34	50	50	5	13	4	8	3	9	4	1	1	3	3
Average		89	59	31	-	9	3	37	24																

Symbols as for table 4.

*Droppings of these species as opposed to complete defecations, present in the plots.

effect on the bush, although it removes all plant litter and annual grasses so holding the vegetation at a low successional stage.

The eastern section near the base of the sand ridge is protected from fire and here perennial grasses such as Cymbopogon sp. and Heteropogon contortus are well represented. Trampling by elephant and other game is considerable, but does not appear to harm the grass unduly and is tending to open up the dense stands of scrub. Dichrostachys cinerea here and elsewhere along the edge of the flood plain is dying in significant quantities, having apparently reached the end of its life span, and a deliberate late burn through a part of the eastern section in 1964 had the beneficial effect of opening up vistas through the bush. Not only did this hot fire remove much of the dead scrub, but it also killed a proportion of the healthy plants, including young regeneration.

Kalahari Sandveld

Selous (1881) describes the vegetation along the northern face of the sand ridge between Sidudu valley and Pookoo flats in June 1874 as dense jungle in which visibility was reduced to a few yards, but indicates that further from the river the country was more open. Although the area may have had good rains that year, as the river was still high, and allowing for some poetic licence, this description nevertheless indicates that the vegetation on the face of the sand ridge has been opened up.

This is borne out by the recollections of older residents one of whom in particular, visited a logging camp at Sidudu between 1936 and 1938. On this occasion his party had to make their way through very dense bush that lined the narrow track, but when he returned to this particular area some 20 years later he found a very noticeable reduction in the density of the bush.

Conspicuous trees in the area include Acacia giraffae, A. nigrescens, Phyllogeiton discolor, Commiphora spp., Lonchocarpus nelsii, Prerocarpus martinii, while the tall bush is made up chiefly of Combretum eleagnoides, C. mossambicense, Baphia obovata, Bauhinia macrantha and Commiphora spp.

Perennial grasses are limited to relic patches and annuals such as Panicum maximum, Urochloa sp. and Dactyloctenium sp. are conspicuous during the rains.

Conservation values are deteriorating (table 8) and high populations of elephant are very important in this respect, masking harmful effects of fire or past livestock activities east of the Pookoo flats, except in the immediate vicinity of old cattle kraals.

Open woodland, tending toward forest in the east between Kasane and Lesuma, stretches south from the crest of the sand ridge to the edge of the Kakulwani plains or Ngwezumba river, but is interrupted by a series of molapos, south of Ngoma to Kachikau, and by the numerous small glades with more compact soils, only a small proportion of which are shown in figure 5. The woody vegetation of this area is described by Miller (1939) and recently in considerable detail based on a two-to-five percent coverage forest enumeration, by Henry (1966). It is therefore only necessary to generalize here.

The woodland has a well-developed shrub story near open water, particularly within four to six miles of the Chobe river and near old cattle posts, but the herbaceous layer of grasses and forbs varies. The most important trees include Baikiaea plurijuga, Pterocarpus angolensis, Burkea africana, Erythrophleum africanum, Ricinodendron rautenii, Guibourtia coleosperma, Entandrophragma caudatum, and in the Mandabuzi area towards the east of the reserve Brachystegia boehmii. The relative

importance of these trees varies with soils, and Colophospermum mopane appears on harder ground near glades, along the northern edge of Kakulwani and along the upper Ngwezumba river and in the west towards the Mababe, while Acacia giraffae, Kirkia acuminata and Sclerocarya caffra are more conspicuous towards the Chobe river.

Dichrostachys cinerea, Combretum eleagnoides, Acacia spp., Diplorhychus condylocarpon, Baphia obovata, Commiphora sp., Combretum mossambicense, Bauhinia macrantha, Popowia obovata, Ochna pulchra, Diospyros batocana, Grewia flavescens and Terminalia sericea, which may grow into small trees, are important elements of the scrub layer, together with seedlings of the larger trees. The distribution and local abundance of this scrub has been influenced to a marked extent by past land use. Miller (1939) advocated a policy of regular early burning in order to suppress grasses and prevent the accumulation of litter necessary for hotter burns later in the season, which would have endangered useful timber trees, then being exploited for the first time near Kazungula. As already noted, this type of burning, not only suppresses perennial grasses, but also promotes bush growth and probably accounts for the widespread encroachment of moderate to low density scrub in Kalahari woodland. Its systematic nature would have made it more detrimental to habitats than the fires caused by wandering groups of bushmen hunters which it sought to prevent. The bushmen's fires would have varied through the season and would not have affected exactly the same areas year after year.

Although Riney's work in tsetse areas, quoted above, shows that fires alone can induce dense bush on Kalahari sand, the densest bush in this type of country in the Chobe Game Reserve is correlated with the main areas of past overgrazing by domestic stock. Dichrostachys cinerea and other species form thickets along old stock routes and the fringe of dense bush along the Chobe was probably caused by stock, as old residents confirm that cattle used to graze out this distance from kraals and water along the edge of the flood plain. Here the species composition varies locally, but often includes D. cinerea, Baphia obovata, Combretum eleagnoides and Bauhinia macrantha while locally other species including Commiphora sp., Terminalia sericea, Acacia spp. and even young Ricinodendron rautenii are dominant. Near old cattle posts around the headwaters of the Ngwezumba D. cinerea, Acacia spp., C. eleagnoides are conspicuous, while scrub mopane and scrub C. imberbe in particular, which occur along the edges and out into Kakulwani plain, probably became established while grazing was heavy in this area.

The grasses vary with local soil differences, the extent of bush encroachment and the interval since an area was burnt, ranging from predominantly annual species to fairly well-developed perennial grasses. Important species include Tristachya superba, Schmidtia bulbosa and Heteropogon melanocarpus.

The glades in Kalahari veld are characterized by open grassland into which scrub is encroaching as the vigour of the perennial grasses continues to be reduced through fire. As already mentioned, scrub was clearly invading 59 of 61 glades inspected. The species vary but often include mopane, while Combretum hereroense and occasional Lonchocarpus capassa bushes or trees are often present and Diospyros mespiliformis trees mark many of the pans.

The Kakulwani Plain

The northern edge of this plain resembles a weak discontinuous drainage line culminating in Kwikampa pan and contains Lonchocarpus capassa, Piliostigma thonningii, Combretum imberbe, Diospyros mespiliformis, near pans, and "strangler" Ficus species, while mopane scrub and trees are also conspicuous along this margin which has a very sensitive grass cover of annuals. Out in the grassland there are occasional L. capassa and mopane, Combretum imberbe and other scrub occurs in clusters, which in the case of mopane may represent well grown trees usually of the CM2 type.

TABLE 8

Results of Vegetation Transects on the Face of the Sand Ridge overlooking the Chobe Flats

Transect No.	Date	Status of Vegetation as % Ground Cover								Conservation Trend				Animal Droppings in Milacre Plots																
		BG	L	C	F	G	A	P	Wood	↑	→	↓	Total	Plots	Elephant*	Pig/Hog	Sable	Kudu	Buffalo*	Bushbuck	Duiker	Zebra	Eland	Waterbuck	Wildebeest	Baboon	Tsessebe	Impala	? Antelope
3	9.9.65	99	39	6	0	0	6	0	30			10	10	10	6	1	2	1												
4	9.9.65	98	46	7	0	2	7	2	37			10	10	10	7	1	1	1	5	1										
5	9.9.65	98	41	7	0	0	5	2	28			10	10	10	1			2	8	2	1									
6	9.9.65	97	45	5	0	1	4	2	16	1	1	8	10	10	3	1	1	1	5		1	1								
7	10.9.65	100	68	5	1	0	5	0	22			10	10	10			1			1	1		1							
17	21.9.65	99	47	2	0	1	3	0	16			10	10	10	4				7		1		1	1	1					1
18	21.9.65	98	66	3	0	1	4	0	41			10	10	10	3				2			1				1				
19	21.9.65	100	35	1	0	0	1	0	35			10	10	10				2	1			3	1			1				2
20	21.9.65	99	43	0	1	1	0	1	10			10	10	10	2	1					4			1			2	3	1
Total										1	1	88	90	90	26	4	5	7	28	4	8	5	3	2	1	2	2	3	4
Average		99	48	4	-	1	4	1	26																					

Symbols as for table 4.

*Droppings, as opposed to complete defecations, present in milacre plots.

Schmidtia bulbosa, Eragrostis superba and Digitaria sp. are common along the northern edge, but elsewhere the grasses are generally tall except in the clusters of mopane, as here and in certain other areas the significance of which requires further investigation, they are replaced abruptly by sparse short annual grasses and forbs. The tall grasses include Tristachya superba, Heteropogon melanocarpus, Cymbopogon excavatus and Andropogon gayanus. It was interesting that the first of these was more dominant in 1967 than in 1966, following two good rainy seasons and a rainy seasons and a reasonably hot September fire in 1966.

The status of perennial grasses on the Kakulwani plain was generally high at the end of the 1965 dry season (table 9), but conservation values were not always being mantained. Perennial grasses were losing vigour on all but the first two transects and the incidence of woody plants was increasing, particularly near some edges of the plain. Wild animal numbers were not high enough to overgraze the area, neither had livestock favoured the plains previous to the early fifties, according to several witnesses who had manned the old cattle posts. The chief cause of veld deterioration was therefore too frequent burning or burning at the wrong time of the year. Transects 25 and 26 were in a portion of the plain protected from a proportion of these fires and here conservation trends were generally satisfactory.

The mopane bush and trees and the other scrub apparently represent the type of encroachment discussed in the subsection on fire further below, and may have become established while cattle numbers were high as it is best developed near the largest pans. Much of it is, however, susceptible to the hot burns which can be achieved late in the season and,while the process of encroachment is clearly advancing locally, in some areas it has halted, and scrub is receding in others, particularly in those protected from a proportion of the fires, so that the remainder are particularly severe.

Libala Country

Leading from the southwestern corner of the Kakulwani plain toward the Shinamba hills there is a mosaic of libalas interspersed with islands of Kalahari sand supporting Kalahari woodland elements which in this area have mopane as an uncharacteristic species.

The libalas themselves generally support a good perennial grass cover in which Tristachya superba and Schmidtia bulbosa are often conspicuous, although the actual species composition varies considerably. Woody plants include mopane, Lonchocarpus capassa, Combretum hereroense, with Diospyros mespiliformis or C. imberbe at many of the pans, but this vegetation is also very variable. Conservation values range from stable or improving in some libalas to downgrading on most of the Kalahari woodland "islands". Here scrub encroachment by such species as C. eleagnoides is advanced near the Ngwezumba pools, and elephant and fire damage is widespread.

These libalas coalesce towards a broad belt of mopane (CM1) which drains towards the Shinamba hills. Here too, conservation values are better and there is a reasonable cover of perennial grasses, apparently because of the protection this area receives from fire, as the only charred stumps located were from a very old burn, and the area is protected by scrub in adjacent areas.

Vegetation South of the Ngwezumba River

Little attention has been paid to the vegetation in the area between the Shinamba hills and the Mababe depression, and south and southwest from the hills. The area is rather inaccessible and a survey is currently being undertaken by the Forest Department.

TABLE 9

Results of Vegetation Transects in the Kakulwani/Kwikampa Area

Transect No.	Date	Status of Vegetation as % Ground Cover								Conservation Trend			Total	Plots	Animal Droppings in Milacre Plots												
		BG	L	C	F	G	A	P	Wood	↑	→	↓			Elephant*	Sable	Kudu	Giraffe	Eland	Zebra	Hare*	Pig/Hog	Buffalo*	Taessebe	Steenbuck	Oribi	?Antelope
25	28.9.65	87	54	22	3	13	0	35	0	6	4	3	13	10	2	1	2			4	1						1
26	28.9.65	78	36	33	0	22	0	55	6	10			10	10						Nil							
26a	29.9.65	-	-	-	-	-	-	-	-			10	10	0													
26b	29.9.65	-	-	-	-	-	-	-	-		1	9	10	0													
26c	29.9.65	-	-	-	-	-	-	-	-			10	10	0													
27	29.9.65	87	16	20	0	13	0	33	7			10	10	10						Nil							
28	29.9.65	95	54	6	1	4	0	9	12			10	10	10			2		1	12	4	1	1	1	2	2	
29	29.9.65	75	40	25	3	25	0	50	1			10	10	10										1		1	
30	29.9.65	90	54	20	0	10	0	30	21			10	10	10				1									1
Total										16	5	72	93	60	2	1	4	1	1	16	5	1	1	2	2	3	2
Average		90	28	14	1	10	0	24	5																		

Symbols as for Table 4.
*Droppings as opposed to complete defecations present in milacre plots.

South of the river there is a mixture of Kalahari woodland, some mopane and more open country as far south as the Ghautumbi molapo. To the south and east of this there is well developed woodland of a remarkably homogeneous nature in which Pterocarpus angolensis, Ricinodendron rautenii and Burkea africana are conspicuous from the air, while nearer the Shinamba hills there are areas of Kirkia acuminata, presumably on poorly drained soils, and mopane, which lead toward the last vegetation type. Bush encroachment is apparent along some of the sandy molapos.

Mababe Depression

The Mababe depression is an ancient lake bed enclosed by sand ridges, except in the south where the lip is ill defined. The dominant trees on these ridges are usually Acacia spp., often A. giraffae, but in the north and northeast they are superseded by species typical of the Kalahari woodland described above. The scrub layer is variable but often includes Combretum eleagnoides, Dichrostachys cinerea, Grewia spp., Boscia sp., Baphia obovata, Acacia spp., Lonchocarpus nelsii and Croton gratissimus, while the herbaceous layer is chiefly annual grasses and forbs.

The vegetation of the floor of the basin varies from closed woodland to open grassland with very scattered trees. The most common woody vegetation types are Acacia spp., such as A. giraffae, A. gillettiae and A. tortilis, of which the first two, which are usually in looser sands, are often associated with Terminalia sericea. Mopane of the CM1, CM2 and CM3 types are also widespread and abundant, while other important trees are Lonchocarpus capassa and Boscia albitrunca.

There are four major areas of grassland. The moderately heavy sands in the extreme north give rise to open plains country with scattered clumps of trees, chiefly CM2 associated with pans and Acacia/Terminalia woodland on sandier minor elevations. The grasses identified by Rains et al (1967) included Diheteropogon amplectans, Hyperthellia dissoluta, Schizachyrium sanguineum, Andropogon schirensis, Tristachya superba and Aristida spp. Scrub is limited to scattered CM3, Bauhinia macrantha, Acacia sp., Combretum hereroense, C. imberbe and Lonchocarpus capassa, but table 10 indicates conservation values were not being maintained. Many tufts of perennial grasses were dying and these and the small bushes were on distinct pedestals resulting from increasing wind erosion. The first point-line transect (table 10) was situated some three miles west of old stock routes and wildlife use was light, but the area had obviously been burnt repeatedly. This occurred again in 1966.

A number of fingers of this grassland spread southward (figure 5). In the east CM3 is dense near the stock routes and made up all the 31 percent wood canopy on transect 43, while towards the tail of the Ngwezumba river Dichrostachys cinerea is very evident in the grassland which includes Digitaria sp., Eragrostis rigidior, Eragrostis sp., and Schmidtia bulbosa. In thickets along the eastern stock route the grass cover is sparse and restricted to annuals while the scrub includes Acacia spp., D. cinerea, Grewia spp. , Lonchocarpus nelsii, Combretum eleagnoides, Boscia albitrunca, Croton sp., and occasional mopane of both CM1 and CM3 types. Acacia gillettiae and D. cinerea form dense patches, while the only large trees are provided by the scattered CM1 in this area which has the appearance of having been markedly downgraded while the eastern stock route was in use. The soils are light and would have been sensitive to trampling and under such conditions bush encroachment tends to proceed rapidly.

West of the Maun-Kasane road there is a large area of Acacia woodland separating the eastern and central southern extensions of the northern plains. Here the main woody species include Acacia spp., Terminalia sericea, Combretum sp., Grewia spp. and Boscia albitrunca, while the herbaceous layer comprises mainly annual grasses with Schmidtia bulbosa conspicuous along some edges. The plains along the central stock route and arms

from it support dense to fairly dense CM3,while the western limits of the northern plains end in Acacia-Terminalia or mopane woodland. These two veld types form a matrix east of the Savuti with large areas of Acacia-Terminalia in which D. cinerea and other scrub is well developed, merging with strips of mopane,between most of which there is well grown CM3.

Around the Savuti channel there is predominantly Acacia woodland with areas of mopane and moderate to dense scrub encroachment. A giraffae trees are conspicuous as are Acacia spp., C. eleagnoides, CM3, L. nelsii, L. capassa and Grewia spp. in the shrub layer, while annual grasses predominate in the herbaceous layer.

In the east of the Mababe, the Ngwezumba "estuary" gives rise to the very sandy Gxlegcauka plain. This plain floods from the Ngwezumba and in exceptional years, like 1966, fairly extensive areas may be covered by a foot or more of water. Scrub is limited chiefly to the saplings of the scattered large trees such as Combretum imberbe, Albizia sp., Burkea africana, Acacia spp., and Lonchocarpus capassa. The perennial grasses are generally tall.

Similar sandy "estuaries" result from other molapos entering the Mababe. For example, the Tsantsara molapo gives rise to such an area some 10 miles south of the Gubatsa hills. Here there is moderate to dense low scrub of Acacia spp., D. cinerea, T. sericea and occasional mopane (CM3), with scattered small trees, chiefly Lonchocarpus nelsii, while the grasses include many annuals and the perennial Schmidtia bulbosa, possibly as the result of the proximity of the old waggon road.

The central Mababe grassland is divisible into two regions shown in figure 5. In the northeast there is very little scrub and only occasional large trees, mainly mopane. There is a good perennial grass cover in which the trend in conservation values varies locally from stable or improving to the early stages of deterioration. Charred stumps of large trees indicate that fire is a factor in limiting the number of trees in this well-grassed area, while dead scrub Acacia had apparently been killed as the result of poor drainage in the heavy soils. It was not possible to visit this area during the wet season to determine the grasses, but most species occurring in the south central region were represented.

The north central Mababe ends abruptly in mopane woodland in the north and east and is enclosed by the south central Mababe scrub savannah to the south and west, which separate it from the Savuti "swamp" to the northwest. The mopane in the north forms a well-developed band of woodland composed largely of the CM1 type. This extends in a narrow belt around the east and is followed by the road from Tsotsoroga to Jovorega, while to the northeast of Tsotsoroga it extends some 10 miles to the base of the sand ridge. Once again it is composed largely of CM1, but the numerous glades in it contain varying densities of CM3, with CM2 well represented in intermediate areas and along the western edge, against the central Mababe grassland.

Southeast from the tail of the Ngwezumba river there is a spur of mixed Kalahari woodland surrounded by open plains country with CM3 and scattered groups and tongues of CM2, with occasional CM1 trees extending north from the better woodland. Similar country occurs between the narrow belt of woodland and the eastern lip of the Mababe further south.

The best woodland contains mostly annual Aristida spp. with perennial grasses limited to slight depressions and around the numerous seasonal pans, many of which are marked by large trees such as L. capassa, C. imberbe or Diospyros mespiliformis. Acacia spp. including A. nigrescens are scattered through the woodland and occur at the pans but most have been killed by elephant and a sample of over 300 showed that 90 percent or more of the trees were dead. Ximenia americana is very noticeable in this country during the dry season when most of the ground is bare or littered with dead mopane leaves.

TABLE 10

Results of Vegetation Transects in the Mababe Depression

(Lines 42 and 43 were in the northern grassland region, and lines 44 and 45 were among the Gubatsa Hills)

Transect No.	Date	Status of Vegetation as % Ground Cover								Conservation Trend		Animal Droppings in Milacre Plots										
		BG	L	C	F	G	A	P	Wood	↑→↓	Total	Plots	Elephant*	Zebra	Hare*	Ostrich	Eland	Wildebeest	Hog	Tsessebe	Springhare	Buffalo
42	27.10.65	83	26	11	2	18	-	28	2	15	15	10	1	1	1	1						
43	27.10.65	84	37	6	1	4	-	10	31	10	10	10			3		2					
44	27.10.65	100	42	-	-	-	-	-	1	10	10	10	3					10	3	1	1	
45	27.10.65	100	33	2	-	-	2	-	7	10	10	10	2				2	5				1
Total										45	45	40	6	1	4	1	4	15	3	1	1	1
Average		91	35	5	1	6	1	10	10													

Symbols as for Table 4.
*Droppings, as opposed to complete defecations, present in milacre plots.

Bush encroachment was investigated briefly in the Mababe depression by comparing the number of annual rings in the ground level coppice and in the oldest surviving stems arising from the coppice. This involved digging up whole plants and, although rot and distorted anatomy tended to minimize age determinations for some of the coppices, it nevertheless provided a useful indication of the age of the plant.

The difference in the ages of the coppices and the aerial branches in different areas gave the approximate time lag between the scrub becoming established and the last effective fire that burnt back the stems to ground level. In some cases adequate fires are no longer possible, while in others they could now only be achieved by protecting an accumulation of litter for a number of years.

In one area, five miles south of the Gubatsa hills on the old waggon road to Maun, 18 CM3 plants had coppices between 15 and 31 years old (mean 22 years) and stems ranging from eight to 15 years (mean 10 years). There was still plentiful grass and much of the latter variation was due to the relative protection from fire of the various plants. The coppices of five Lonchocarpus nelsii ranged from 20 to 38 years (mean 27), but no stems had more than eight or nine rings. This species was more widely spaced and did not afford itself as much protection as some of the mopane. Five Combretum hereroense coppices average 26 rings (range 18 to 35), but with the exception of one heavily charred stem with 12 rings, none had more than 9 or 10.

The grasses had obviously been more sensitive in a neighbouring area due to soil factors. Here 15 CM3 coppices ranged between 22 and 35 rings (mean 29) and the stems varied from 21 to 27 rings (mean 23). The coppices were much smaller and the lower number of vertical stems were much taller.

One and a half miles south of Goha pan on the central stock route (figure 5), 20 CM3 had coppices with between 17 and 34 rings (mean 29). Ten, with less protection from fire, had stems showing 4 to 6 rings (mean 5), while the remaining 10 had stems with 8 to 11 rings (mean 9). The average coppice of four C. hereroense was 19 years (range 15 to 24), but none had stems over five years old, and like the first group of mopane none had much protection from fire.

A sample of 21 CM3 in a glade near Goha pan on the eastern stock route contained three plants 38 or more years old and none under 18 years, the average age being 27. Four had the oldest stems with five rings, one had but three rings and the rest had four. This area was burnt in April 1966, but the fire was not adequate to kill back the coppicing stems. CM3 near the edge of the glade was older. Ten plants ranged from 31 to 34 rings, with one older plant having 43. A fairly well-grown CM2 away from the effects of fire had 20 rings, while a CM1 had 52. Nine other protected CM2 had stems with 26 to 30 rings (mean 29). Young CM1 growing away from grass around the edge of this glade had from 27 rings to over 70 rings, while the largest CM2 with fire-charred ground-level coppices had 58 and 62 rings and were 28 and 31 feet tall, but older portions of the coppice had rotted away.

A fourth station was sited in a glade 1½ miles south of Tsotsoroga pan in the midst of well-developed CM1. Ten CM3 coppices in the centre of the glade had from 15 to 31 rings (mean 23) while the stems had 5 to 7 rings (mean 5.5). Near the edge of the glade five CM3 coppices had 22 to 41 rings (mean 30) with stems with five to eight rings (mean 6). Four large CM2 on the abrupt edge of the glade had ground level coppices with 51 to about 70 rings, but a single large CM1 inside the woodland, selected as being of average age, had 7171 rings in addition to a hollow center. This tree had an overall diameter, three feet above ground level, of 32 cm, of which 2 cm was bark, 12 cm contained the rings (6 cm sapwood, 6 cm heartwood) and the hollow center accounted for the remaining 18 cm.

According to Mr. Tom Kays of Maun, the eastern stock route across the Mababe was pioneered by his father in 1922 or 1923, but the old waggon road along the Magwigwe sand ridge was already in existence, as Stigand (1923) shows. Bushmen drovers working on the new route claim that various operators did not always use precisely the same route, or water and graze their stock at the same pans. This would explain the widespread occurrence of CM3 in the Tsotsoroga - Goha pan area.

Mr. Kays clearly remembers some CM3 when he travelled with his father in 1921, but this was probably less dense as the above observations indicate much of it has established in the glades since then. This suggests that overgrazing, possibly accompanied by early burning, was the primary cause of mopane becoming established under conditions which were less favourable for it. Sufficient grass, however, continued to survive to allow fires of adequate intensity to kill back the aerial shoots and so give rise to CM3. The glades probably have soils less well suited to mopane, while in areas less marginal to the species, around the best woodland, this process has proceeded to the CM2 stage.

Deterioration in the herbaceous layer of the mopane woodland and adjacent areas may have been initiated by the proximity of the eastern stock route,but recovery is being prevented by repeated fires started along the road between Kazungula and Maun. The whole area was burnt out during the 1963 and 1965 dry seasons and, although these fires were late in September, there was insufficient combustible material to affect woody growth so that their only result was to prevent the accumulation of litter which would be necessary to promote trends toward the recovery of perennial grasses.

The southeastern Mababe supports large areas of Cynodon dactylon, Cenchrus ciliaris, Chloris virgata, Urochloa sp. and Bothriochloa sp. which are short grasses occuring between stands of tall Sorghum verticilliflorum. Scattered through it there are bands or thickets of Acacia spp. Proceeding west from Jovorega pan out of mopane woodland (CM1), a belt of CM2 or CM3 is entered where there are more perennial grasses. This ends abruptly in an area of open Cenchrus ciliaris before a band of large dense Acacia tortilis which scrub of the same species is entered, prior to passing into the more open short grassland with the patches of Sorghum and Acacia, mentioned above. Similar zonation is apparent around the west of this area near the Magwigwe sand ridge. It may therefore be significant to quote Pole Evans (1948) who described this country 30 years ago. He crossed from Jovorega to Shaleshanto and notes that "on emerging from the belt of mopane forests on the (Mababe)* flats,open grass country is encountered in which Cenchrus ciliaris is the dominant grass," which is illustrated by a photograph. While this grass still dominates in some areas, a photograph such as this, showing virtually no bush, would be difficult in this part of the Mababe now. He continues, "apart from a belt of dense Acacia litakunensis (?) which protrudes into the grassland, the country becomes more and more open grassland towards the west ... In the obviously lower lying portion tall Cymbopogons flats Cenchrus ciliaris dominate with Chloris gayana, Digitaria spp., and bush extends to the west until it meets the Magwikwe sand ridge. No fringing forest was seen along the eastern or western edge of the flats ..., only in the distance to the extreme south could fringing forest be seen in the neighbourhood of the Mababe (Kwaai) River".

Although Pole Evans' exact route cannot be traced and, although it would be possible to obtain similar photographs to three of his five plates of this area, the other two show conditions much more like the northern central Mababe now. His description of the vegetation indicates that there has been an increase in woody vegetation, mainly Acacia spp. This has apparently transformed the open grassland of the southern and western Mababe into scrub savannah. This encroachment is discussed in relation to tsetse fly and probably results from past mismanagement, as the deterioration process is most marked along the old

* Author's brackets.

waggon road in the west where Acacia scrub with relic patches of C. ciliaris extends to the southern fringe of the Savuti "swamp" (figure 5). Here the chief species are A. tortilis, A. hebeclada and A. mellifera with intrusions of CM3 near stands of CM2 which, with some CM1 woodland forms a mosaic with plains type country, containing CM3 or other scrub, between the central Mababe and the Magwigwe sand ridge. Here the country may not differ significantly from conditions in about 1920, judging from the occasional annotations included on Stigand's (1923) map, butby then tsetse had cut the stock route and had encroached across the southern Mababe.

The Savuti "swamp" arose as the result of the channel filling in about 1958 to 1960 when swamp conditions prevailed until early 1965. Since then it has reverted to grassland with Cynodon dactylon dominant around the margin of the "swamp". Here the tree Croton megalobotrys is conspicuous with occasional L. capassa on the eastern side on higher ground, while L. capassa is a constituent of the margins of well-developed A. giraffae woodland on the west. The vegetation in the center of the "swamp" is changing rapidly, but still retained relics of aquatic vegetation including Phragmites etc., by the end of 1966 and whether these trends will continue or whether the area will revert to swamp for a further period will depend upon the behaviour of the Savuti.

The habitats near the Savuti (transects 44 and 45, table 10) suffered generally from the concentrations of game including elephant, buffalo, hippo, impala, warthog etc., which built up near water in the channel and swamp. They may not have been in a stable state prior to this radical change in the habitat, however, as old cattle kraals along the waggon road signify past overgrazing by domestic stock. Overbrowsing by giraffe on such species as L.capassa and Boscia albitrunca is marked, but perhaps less so than along the edges of the south central Mababe.

Thus the vegetation of the Mababe depression includes open plains interspersed with areas of woodland. Conservation values are generally deteriorating due mainly to fires, but this process was probably initiated in many cases by mismanagement of livestock, accompanied by incorrect burning. In this respect stock routes between Ngamiland and Kazungula have had a significant effect. Wildlife concentrated around the Savuti while there was water, had a marked depressive effect on the vegetation locally, and there are indications of overgrazing in the south central Mababe.

North Goha Plain

There is a small area of plains country in a depression on the sand ridge immediately to the north of the Goha hills. It is much larger than the usual glades in Kalahari woodland and is encircled by a band of mopane. Common grasses include Schmidtia bulbosa, Cenchrus ciliaris and Aristida spp., while Sorghum versicolor in the central region is indicative of poor drainage. Besides the widespread mopane, which occurs in all its forms, there are also a few Acacia giraffae, Lonchocarpus capassa and an occasional baobab, Adansonia digitata. Patches of Dichrostachys cinerea occur in the CM3 dominated scrub invasion and pans are numerous in the west and east of the area.

A photograph of the area by Pole Evans taken in 1937 indicates this encroachment was well advanced by then.

LARGE MAMMAL FAUNA

The remarkably varied fauna of northeastern Botswana results from the merging of several distinct ecological associations, ranging from the swamp and swamp grassland of the Chobe and Okavango systems, through the general woodland-plains country matrix, to elements similar to the central Kalahari. Not only do these vegetation types provide

strikingly different habitats, due to the variation within them and the ecotones between them, but the varying effects of flooding in this remarkably flat country give rise to further differentiation.

Although all the species of large mammals occurring in the region are not represented in the Chobe Game Reserve, notably springbok and hartebeest, it can still boast 38 species, jackal sized or larger, which makes it the equal of some of the best in the world. Past land use and the modification of the habitats, both in and outside the reserve have, however, influenced the relative abundance of most species, although the only one which has entirely disappeared during historic times is the white rhino and this is being reintroduced.

As the result of the low effective rainfall, most habitats are dry and marginal and therefore sensitive to changes. The easily demonstrated deterioration in conservation values over large areas has led to an imbalance in the animal/habitat relationships, which accounts for several urgent current problems in the reserve and has set certain trends in motion which will have to be carefully watched.

Wildlife populations are very sensitive, and such changes can detonate chain reactions which lead to a decline and eventual disappearance of some species while the same conditions may favour an increase in others. Such a buildup is usually only temporary. It depends upon a given level of habitat deterioration, which is especially favourable for a species. With further change these optimal conditions are not maintained, and in this respect a species, which has become too numerous, may itself hasten the process by overutilization of its essential requirements. The result is an eventual crash in the population, usually to a level below the original carrying capacity of the area, particularly if the downgrading process has proceeded beyond one or more critical thresholds, similar to those described when considering the effects of fire, and this may make reversing the process difficult. Even when an area is stabilized with regard to conservation values this may have been achieved through a deflection in the vegetative sere, so that the resulting habitats may differ from those in the area prior to the disturbance.

These facts need to be taken into account in any wildlife management program in northeastern Botswana, which should comply with clearly stated policies for land use in specific areas. The spectacular die-off among wildebeest in the Makarikari region, discussed more fully in the species account below, was an example of one such eruption followed by a crash in the population. There are several other species in an eruptive phase and some may have reached a point where numbers are declining. These populations threaten their own habitats and those of some associated species, but the answer to the problem will depend upon how an area, and the wildlife populations within it, are to be used.

The following accounts include relevant information on the species' biology obtained during the present survey, as well as suggestions for future research highlighted by this broad investigation. In many cases it has not been possible to follow up these problems to any depth, neither would it have been justified, when the priority was to attempt to recognize and define the broad problems confronting wildlife management in a large area with limited economic and human resources.

The distributions of the following species are described in terms of the one sixteenth degree square grid illustrated in figure 6. The nomenclature and systematic arrangement follows Ellerman et al (1953).

BABOON — Papio ursinus

Baboons were recorded along the Chobe River between Kasane and Ngoma in 1724-D-4 and 1725-C-3 around the headwaters of the Ngwezumba river in 1824-B-4 and 1825-A-3, near Kasinka in 1824-A-2, at Goha hills in 1824-A-3, on the Savuti "swamp" in 1824-C-1, at Tsotsoroga in 1824-C-2, and along the Linyanti swamp in 1824-A-1 and 1823-B-4. They were also noted along the edge of the Okavango system in the Moremi Game Reserve in 1923-B-1, 2 and 3 and along the Thamalakane and Mogogelo rivers in 1923-D-1 to 4, while there were reports that a troop at Nunga in 1825-D-1 had recently established itself in this area.

The species did not occur in numbers in well-developed Kalahari or mopane woodland, or in the mixture of scrub and woodland south of parallel 19°S, except where these bordered other vegetation types, and they were not known along the Botletle river east of about Makalamabedi. Along the Chobe river baboons ranged at least 3.1 miles on to the sand ridge in highly modified Kalahari woodland, making extensive use of fire traces to do so, but generally returned in the late afternoon or early evening to roost in trees along the river, although at the end of the dry season this return was sometimes delayed for up to three hours after dark. After the vegetation flushed at the beginning of the rains there was a tendency for fewer troops to be contacted on routine game counts between Kasane and Ihaha. An average of 16 contacts per count in October and November 1965 declined to 5.3 in December and then gradually rose to about eight in July and over 15 in November before the 1966/67 rains broke and the pattern was repeated.

Baboons occurred in large numbers along the Chobe and Linyanti, but elsewhere were resident only in watered areas and disappeared from much of their range as the pans dried up. This was particularly evident during the severe dry season in 1965 and may have explained the buildup along the Chobe and the subsequent decline when the rains started as vacated range soon became reoccupied, although in the east of the Chobe Game Reserve this would have required a move in either direction of at least 25 to 40 miles. There were, however, three or more troops on the Savuti "swamp" in October 1966, when the only known water within 12 miles was a small seep in the Savuti channel at the foot of one of the Gubatsa hills. This was not visited for at least four days while the baboons made extensive use of the swollen rhizonetous roots of a burnt-off "bullrush" which had survived from when the "swamp" held water.

It was difficult to obtain numerical data on baboons as troops were large and tended to spread out so that when contacted on routine game counts along the Chobe they were simply noted as "troop". There were at least 12 such troops resident for most of the year along the count route and this represented at least 750 to 1,000 individuals along this 20 mile stretch of riparian vegetation as three counts of troops varied from 66 to 92 (mean 75) individuals, and these were by no means the largest troops in the area.

Repeated observation indicated a peak of oestrus females in April through June, with most births around the end of the year in 1965, although there was some breeding in all months in 1966 and the first half of 1967, and there were a great many oestrus females in February to May 1967. A very high proportion of the adult females were in oestrus in April through June 1965, when there were very few carried infants, and of those noted all were adult coloured and therefore probably at least five months old (Prof. R. Hall, pers. comm.). It was not until July 18 that the first small dark infant was recorded, but from then their numbers gradually increased to a peak in November - December. According to Hepburn (pers.comm.), a similar pattern was evident during 1963 and 1964. In 1966 and early 1967 small numbers of newly born infants were noted in all months except November to February when they were numerous, even while a proportion of the females were in oestrus. It was, however, noticeable then that males, including large adults, frequently carried young from the vicinity of danger.

Oestrus females were recorded, at least in small numbers, in every month between June 1965 and June 1967. The absence of small youg during the middle of 1965 was therefore probably due to pre-or post-natal mortality due to severa habitat conditions in the dry season following a series of dry years as Hall(1962) and Child (1965) have observed similar effects elsewhere.

As a result of the more or less seasonal breeding pattern previous to 1967 it was possible to separate juveniles into size classes representing annual age classes, from which it was evident that some females reached sexual maturity in their third year and similar aged males were noted mounting receptive females.

Early maturity of females taken together with high numbers in oestrus indicated a high reproductive potential. This was borne out by an oestrus female, collected during copulation in July 1965, which had just ovulated and had milk indicating that mature females can breed annually, as young over about six months became progressively more independent of the females, and the gestation period in baboons is about six months (Asdell, 1964).

Baboons fed extensively on fruiting trees in the riparian strip including Garcinia livingstonei, Diospyros mespiliformis, Phyllogeiton discolor, Markhamia acuminata, Strychnos stuhlmannii and Capparis tomentosa, and on the flowers and buds of species such as Acacia nigrescens, A. tortilis, Lonchocarpus nelsii and the leaves of Croton megalobotrys and Baphia obovata. Almost all trees of S. stuhlmannii showed extensive scarring of the bark where baboons had scraped it away with their teeth. They made considerable use of the roots, in particular, of swamp and semi-swamp plants, including several grasses and sedges, and entered water to recover the roots of water lilies, an activity which sometimes necessitated their submerging the whole body, although more often the head remained dry. The young leaves of the annual grass Panicum maximum were grazed extensively by groups of baboons, as were the mature heads later in the season, and the small weed Tribulus terrestris was used before the thorny fruits hardened.

Species often associating with baboons included mongoose, warthog, impala and bushbuck. The association with the latter was a positive relationship which is discussed later in the report when considering bushbuck, and this may have been true in the case of the mongoose, although the associations with impala and warthog were probably of a more casual nature, although baboons benefited to some extent from roots loosened by warthog on the Chobe flats and Savuti "swamp".

Although Selous (1881) remarks upon the high population density of baboons along the Chobe in 1874, which was higher than he had encountered anywhere else on his travels in southern Africa, and although old residents of the area all agree that baboons have always been especially common along the Chobe, it appeared that the population was approaching dangerous limits by 1965. They became very thin from July onwards, when they showed a remarkable lethargy in the presence of danger. Large areas of rocky hillsides near Kasane and Ngoma were worked over repeatedly in their quest for food concealed beneath stones, to the extent that up to six inches of soil had been shifted over some 70 percent of an area sampled by means of a point line transect. All grasses and lesser plants were destroyed unless protected by fallen trees and even well-established bushes were endangered when their roots were exposed. Similar but less intense activity was widespread and, although not as marked during the less severe 1966 dry season, it appears safe to conclude that baboons are too numerous for the habitats presently available to them along the Chobe river, especially when, for one reason or another, their food supply is reduced.

Control of the population would, however, require fairly sophisticated management techniques if this valuable tourist amusement is not to become unduly disturbed, and it would appear that under prevailing conditions there is little likelihood of the problem being solved except by the general protection of the habitat from such destructive agencies as fire.

WILD DOG — Lycaon pictus

Wild dog were recorded in 1724-D-4; 1725-C-3; 1824-B-4; C-1,3 and 4; 1923-B-2 and 4; and 2025-A-2 and B-2, in groups of one to 25. They move about a good deal and are probably more widespread than these contacts imply. Fourteen animals killed by wild dog included two young of their own species, four kudu, four impala, two waterbuck, one lechwe and a bushbuck.

The species plays a useful role in wildlife areas where, in addition to its value as a selective agent tending to eliminate weaker individuals, it temporarily disperses browsing and grazing species and so helps achieve more even use of the veld. It is, however, imcopatible with livestock production and for this reason often becomes a problem animal in ranching areas.

BROWN HYAENA — Hyaena brunnea

Brown hyaena have been recorded in parts of Rhodesia bordering northeastern Botswana, and their possible occurrence in adjacent parts of this territory requires investigation.

SPOTTED HYAENA — Crocuta crocuta

Hyaena were noted from 1724-D-4; 1725-C-3; 1824-B-4; C-1,2 and 4; 1825-A-1 and 3; C-1 and 2; 1823-B-1, 2 and 3; 1924-D-4, with a breeding record of three small brown cubs in 1924-A-1 on June 27, 1966. The species is generally rather inconspicuous but judging from spcor is widespread in northeastern Botswana.

LEOPARD — Panthera pardus

Leopard are seldom seen in northeastern Botswana, although their presence has been confirmed in 1724-D-4; 1725-C-3; 1824-A-1; 1825-A-3 and 4; 1823-B-1, 2 and 3; and 2024-B-1. They may occur throughout the Okavango swamps and are probably more widespread than these sparse records suggest.

Thirteen skulls were recovered by the author, members of the Game Department and Game Scouts in the Moremi Game Reserve from leopard kills. These included four adult female duiker, in the youngest of which permanent tooth replacement was almost complete; three big adult male baboons; two adult impala rams; and adult male tsessebe with all permanent teeth; a well-grown bushbuck ram; a very young male roan calf, and a full-grown antbear.

The hunting of leopard, often with the aid of traps, is a very profitable occupation due to high prices paid for skins. The decline in the leopard population suggested by local people, in a number of areas, may be partially due to this, and the Game Department is seeking appropriate control over the exploitation of this valuable species.

LION — Panthera leo

Lion are widespread in northeastern Botswana where they have been recorded from 1724-D-3 and 4; 1725-C-3 and 4; 1824-A-1, 2 and 3; B-2 and 4; C-1, 2 and 4; 1825-A-1 and 3; D-1 and 4; 1923-B-1, 2 and 3; 1924-A-1 and 2; D-4; 1925-B-2; and 1926-A-1 and 3. They are also reported from the Okavango swamps, the edge of the Linyanti swamp and

are troublesome to livestock owners on the stock route and in the Panda ma Tenga area.

Buffalo and wildebeest, with 16 each, headed the list in a smaple of 105 kills. These were followed by lechwe and warthog with 14, eland with 10, waterbuck and zebra with eight, sable seven, kudu six, puku two, tsessebe two and roan and giraffe one each. This method of recording the predatory preferences of lion, while useful for gaining a picture of the main species preyed upon, has limitations in that larger species are easier to find, not only on account of their size but also because more meat remains to attract vultures for longer. Further, many small or hornless skulls are completely eaten.

The species has become more conspicuous along tourist routes in the Chobe Game Reserve during the past two to three years but it is diffucult to obtain a true picture of trends in the population here or elsewhere in the region, as the apparent increase may be due to conditioning to tourist traffic. The species is very important to the safari hunting business and the need to afford it maximum protection commensurate with legitimate defence of livestock is discussed more fully later in the report.

CHEETAH — Acinonyx jubatus

Cheetah are very inconspicuous in the area with which this report deals, and the Game Department's decision to afford them absolute legal protection on a nationwide basis, seems fully justified, especially in view of the high prices offered for their skins.

They have been confirmed in 1724-D-4 and 1725-C-3, where they are occasional visitors to the Chobe flats, and in 1824-C-2; 1825-A; 1923-B and 1924-D-4. Four kills included two adult impala rams with permanent teeth, a male impala calf and a female duiker with exchanging premolars and incisors, while Mr. P. Brown reported their killing an ostrich in the Tsau area.

ELEPHANT — Loxodonta africana

Elephant occur throughout northeastern Botswana, and they, or their signs, were recorded in 1724-D-3 and 4; 1725-C-3 and 4; 1823-B-3 and 4; D-1 and 2; throughout A, B and C and in D-2 and 4 in 1824; throughout A, C and D, with the exception of D-2, in 1825; in 1923-B-1 and 2; D-4; 1924-A-1, 2 and 3; B-4, and D-2; 1925-A-1 and 3, and B-4; 1926-A-1 and 3; 2023-B-2; and 2025-A-2. The species is, however, subject to considerable seasonal movements depending upon the availability of surface water and the seasonal fruiting of trees like morula, Sclerocarya caffra, and mugongo, Ricinodendron rautenii.

The widespread activity and well developed elephant paths, linking up pans, are very conspicuous from the air and on aerial photographs. Many lead southward from the Chobe across the Ngwezumba river where there are many well-developed paths radiating out east and southeast from the Mababe towards the Rhodesian border between Panda ma Tenga and the Sibanini river.

History of Elephant Population

There is general agreement among local people, living as far apart as Gweta, the fringe of the Okavango, Kachikau and in the eastern Caprivi, that the elephant population has increased very rapidly, especially during the last 10 years. In 1966, for example, they were reported for the first time from areas to the eastern Makarikari, where they have not been known for many years.

One man living along the Chobe, after a long absence, noted that in 1933 there was a well-known herd of 20 to 25 head between Kazungula and Kasane, but that otherwise the

species was scarce along the river. In the same area several old people have remarked that it is now no longer safe to walk along the main road. Another man doubted that natural increase alone could have accounted for the rapid buildup in numbers, in spite of the high proportion of juveniles in the breeding herds.

Elephant had been unknown to the bushmen living around the source of the Ngwezumba river for several generations until about 1945. Then within a single year the whole area to the north, as far as the Chobe "filled" with elephant which came from the direction of Masame, moved towards Lesuma and then across to the Chobe west of Kasane.

The warden of the Chobe Game Reserve counted the number of elephant tracks going to and from the Chobe across 19 miles of road, during two 24 hour periods in October 1963. The road was first swept and if animals going to water crossed the road in tight groups, so obliterating each others spoor, the groups were counted on the flats. This problem seldom arose with animals drifting back from water as then they are usually in more open formation. These counts yielded 485 and 508 (mean ± 500), but similar counts in 1965 (table 11) indicated a considerable increase in elephant. These were both years in which all the seasonal pans in the reserve dried up.

Heavy late rains in 1966, augmented by widespread rain amounting to about 50 mm during the first week in June, resulted in many pans retaining water throughout the dry season. In spite of the number of elephant that remained away from the river, a spoor count on October 7 and 8 gave 619 head.

The seasonal pans were dry or almost dry by the end of July 1965 when they were inspected from the air. During the same week the elephant in the 240 square miles of game reserve along the Chobe west of Sidudu were counted from a Cessna-Wren aircraft, with automatic pilot and capable of speeds down to 40 m.p.h. The area was flown in strips parallel to the Chobe, and in addition to the pilot there were three observers, one of whom acted as recorder. Visibility among the leafless trees was good and a height of approximately 500 feet above the ground and a speed of 100 m.p.h. was found most suitable while searching for elephant. Large groups were circled at much lower speeds just above the trees.

Most elephant were contacted within six miles of the river, between 0900 and 1200 hours, and counting was discontinued 9 miles from the Chobe as there were very few elephant thus far from the river. Ground observations indicated a very marked peak in elephant activity on the Chobe flats during the 1965 dry season, between 1400 hours and sundown (1815 hours in July). Some animals may have moved out of the count area at night, although the herds were all very static, with several individuals lying down, when observed during the morning.

An increase in elephant along the Chobe during the past decade was confirmed by evidence from the Caprivi. The Magistrate at Katima Mulilo kindly supplied the following information on the numbers of "garden raiders" which had had to be destroyed, and provided the author with a guide to the eastern Caprivi. Between 1940 and 1945, "very few elephant were shot, perhaps three or four, but certainly not many more". About 12, or an average of one per month, were shot in 1946, and this satisfied the need for crop protection. However, 256 tusks (i.e. ± elephant) were collected, mostly from the eastern Caprivi, in the 21 months between November 1962 and July 1964, giving an average of 12.2 per month, and 94 elephant, or an average of 7.4 per month, were shot in the 13 months between September 30, 1964 and November 8, 1965. This rapid increase was confirmed by careful interrogation, avoiding any leading questions, of more than 60 villagers scattered over the eastern Caprivi.

Seasonal Fluctuations in Numbers

The regular standardized counts between Kasane and Ihaha, show the seasonal influx of elephant along the Chobe toward the end of the dry season (figure 7). It was possible to establish the route followed by a proportion of these elephant which cross into the Caprivi, by carefully questioning the occupants of successive villages.

These animals move into the Caprivi each dry season around June or July and return to Botswana at the onset of the rains in November or December. This movement which involves males, females and juveniles, is differentiated in figure 8 from the dry season, which are mady by males only, which do not apparently remain long or penetrate deep into the Caprivi.

Many of the elephant, including visitors to the Caprivi, disperse away from the Chobe during the rains. This can be very sudden and took place in November 1966 before the rain fell along the Chobe but when thuderstorms were visible to the south of the sand ridges. There are also several records of elephant at small pans, over 20 miles from permanent water, within days of their filling for the first time in the 1965/66 and 1966/67 rainy seasons.

The seasonal distribution of elephant and their signs indicate that many disperse to temporary pools throughout much of northeastern Botswana during the rains and then gradually coalesce towards the larger pans and eventually to permanent water as the dry season progresses. The permanent water at which elephant end up at for the dry season is probably influenced by the sequence in which the pans dry up in any year.

This phenomenon, which was evident for several species that made relatively more use of small pans, so long as they held water, suggests a useful adaptation towards the spreading out of feeding pressure and more efficient use of vegetation.

Cause of Rapid Increase in Elephant Numbers

The pattern of elephant paths and the history of the population along the Chobe river, indicated that the rapid buildup in numbers was partially due to an influx of elephant, possibly augmented by increased successful breeding and greater protection. Similar patterns have been noted in the Savuti- Linyanti area, the Kwai-Moremi area, and toward Nata and Odiakwe, while elephant died in appreciable numbers in the Tamafupi-Jari pan area along the borders of the Wankie National Park during 1965. This die-off was reported to have extended well into the park, and along the border affected mainly young animals.

The elephant were in very poor condition with markedly accentuated spinal ridges, sunken temples and dull grey hides with numerous callous-like lumps on the skin and around the orafice of the mush gland. There were few small post-lactating calves, and most of those observed were alone. Fifteen carcasses were located in a single day in thick bush near pans without the aid of vultures and included one adult tuskless female, another female which was very old with well-worn final molars; one calf carcass measuring 80 inches at the shoulder; eight fresh carcasses of calves with shoulder heights between 60 and 42 inches (mean 50 inches); three older carcasses in this age group, and one that measured 35 inches at the shoulder, had very soft bones and may have represented a stillbirth.

The following account of competition for water between individuals in a small group, was typical of that observed among larger groups in several areas in northeastern Botswana in October 1965, but was particularly noticeable near Tamafupi. Four individuals were slightly removed from the rest of a herd of 16 animals drinking at a small water hole.

TABLE 11

Spoor counts of Elephant crossing the Main Road between the Game Reserve Headquarters and Ihaha in 24 hour periods in 1965

Date	Number of spoor crossing road			
	To River	From River	Mean	Monthly Mean
Sept. 10	481	451	466	
Sept. 22	735	791	763	
Sept. 23	634	676	655	
Sept. 24	890	769	830	679
Oct. 16	681	775	728	728
Nov. 26	95	49	72	72*

*After rains had set in.

These four animals consisted of an adult female, a well-grown female, a male calf of about four feet at the shoulder and the adult's small calf. The first three were drinking from a small hole two feet deep dug by elephant, while the young calf pulled at a fallen tree a few yards away or suckled from its mother.

The animals were observed for 50 minutes while the adult female stood in the best position from which to reach water and attempted to prevent the other two animals from doing so. While she was sucking up water she could do little more than impose her body between the hole and the male and lean against the young female so that it was difficult for them to insert their trunks into the hole, which the young female did by going down on her "wrists". As the cow squirted water down her throat she tried to hook the other animals' trunks out of the hole with her front feet, or pushed them away with her head or shoulders. This led to considerable impact between the tusks of the older animals and for some time discouraged the male who wandered about with a partial erection. The male and young calf left with the adult female, when the herd moved away from water, suggesting they were both her calves.

The biggest individuals were usually best placed when larger herds watered, while the four to five foot age group were seldom able to drink in the most critical areas. They could be seen standing in the shade near most pans, but if they attempted to approach the water they were challenged and chased off by older individuals. On one occasion a herd was chased away from water with difficulty, using a vehicle, whereupon one of these young animals immediately rushed to the water and stood its ground until the vehicle and its shouting and banging occupants were within two yards.

No water and very little wet sand was placed on the body which might have explained the callouslike swellings on the skin of most of the 300 to 400 animals observed in the Tamafupi area.

There were also reports of competition for water between elephant and sable or buffalo. At least two adult sable were charged and killed at water while others were chased from it. This also applied to buffalo on many occasions, although sometimes a herd of buffalo was successful in driving away the elephant.

The vegetation around the pans in the Tamafupi area was heavily used and it was interesting that the elephant droppings did not possess their usual cohesive properties at this time of the year and soon broke down as they dried, apparently partially as the result of containing more woody tissue. It is also possible that the shortage of water impaired digestion.

It is therefore evident that elephant were overpopulated along the border with the Wankie National Park, at least during the unusually severe dry season in 1965. The area in northeastern Botswana where elephant populations have increased all radiate out from here and are linked to the park by well developed paths. Elephant have been very numerous in the park for many years and large-scale culling, with the object of reducing numbers, was started in 1966. There are areas with extensive recent elephant damage between Wankie and the Chobe river. This and reports by bushmen from the intervening areas, of a buildup of elephant during the past three decades, originating from the general direction of Wankie, suggests that the increase in elephant along the Chobe is at least partially attributable to an overflow from the park.

The Role of Elephant in Habitat Destruction along the Chobe

Elephant are the most important factor now suppressing the sensitive habitats along the face of the sand ridge and in adjacent vegetation types. Herds spilling down the ridge toward water or digging for roots destroy much of the poor ground cover every year and

extensive damage is caused to the bush, while several species of large trees in the riparian strip are threatened.

Table 12 summarizes the utilization of woody plants along point line transects within four miles of the Chobe river during September 1965. If a quick but careful inspection did not reveal any use, a plant was classed as IV; if the use did not exceed a season's growth it was put in III; and if more than a season's growth was judged to have been removed, in II, unless the plant was severely mutilated, ring barked or pushed over, when it was classed as I. Some of this use was due to species other than elephant, particularly in the case of Capparis tomentosa, an evergreen creeper highly favoured by kudu and bushbuck but, with the exception of this plant, use seldom exceeded class III.

The effects of elephant on scrub were also measured in two pairs of 100 feet sqare plots in December 1965, after the bush had come into leaf (table 13). The eastern pair was situated in an area of heavy use while the western pair was sited to sample unusually light use. All the bushes were assigned into one of three use classes; if the plants were virtually untouched by elephant they were rated as 'a', those noted as 'b' had the tops browsed off but the rest of the plant healthy, while plants in 'c' ranged from those with tops and lateral branches removed and shooting from the base or main stem, to those coppicing from an established root, from which elephant had removed or destroyed the stem.

The results of these two sampling methods are not strictly comparable as, although the plots were sampled only 10 to 12 weeks after the transects were run, it was necessary to set much more lenient limits to the use classes as there had been heavy elephant activity during the last 6 to 8 weeks of the dry season. Nevertheless, both sampling methods indicated a shift in the species composition of the scrub in favour of less desirable forms such as Dichrostachys cinerea and Combretum mossambicense which are not valuable browse. C. mossambicense has a straggling form and, when in leaf, tends to shade out other plants and restrict visibility, but it is very deciduous and provides poor protection for the soil through the long dry season.

A reduction in the extent of elephant use now would probably lead initially to a thickening up of the bush through coppicing but, if the use continues desirable, species may be eliminated. Trampling is also destroying much of the litter and herbaceous layer and preventing the stabilization of the face of the sand ridge, but it is the damage to the large trees in the riparian fringe which gives greatest cause for concern.

The trees in this strip are generally slow growing and are an attractive element along game-viewing routes on the edge of the Chobe flats. Elephant use was assessed between the warden's house and Serondela. All trees over 5½ inches d.b.h. were considered for the first one mile (table 14), but thereafter a more limited range of species was taken (table 15). Class I contained ring-barked specimens while those in class II had over half the bark around any circumference removed, class III had less than half the bark removed and class IV were untouched or had scars which had healed. A fifth class recorded trees felled by elephant. Each tree was classified for damage caused before 1965 and that caused in 1965, and a number of individuals received two ratings when barking was followed by felling in either the pre-1965 or the 1965 category. The data in table 14 was collected by the author and the warden of the reserve, while that in the second table was gathered by junior staff under the supervision of the warden.

A fair proportion of Acacia nigrescens was badly damaged. Of the 840 trees in the pre-1965 group, 41.7 percent had been more than half ring-barked or pushed over and 13.6 percent of the 619 in the 1965 group (which included 11 trees that had previously been felled but in which one or more branches were still alive) were in these heavy-use classes. This fast growing species is, nevertheless, becoming more conspicuous in the

TABLE 12

The extent to which woody vegetation had been used by game along transects within one mile of the Chobe river

Species	Sample	Use Classes							
		I		II		III		IV	
		No.	%	No.	%	No.	%	No.	%
Dichrostachys cinerea	266	71	26.7	41	15.4	99	37.2	55	20.7
Combretum eleagnoides	259	143	55.2	70	27.0	43	16.6	3	1.1
C. mossambicense	117	35	29.9	28	24.0	46	39.3	8	6.7
Baphia obovata	88	36	41.0	44	50.0	8	9.1	0	0.0
Croton megalobotrys	51	11	21.6	23	45.0	16	31.4	1	2.0
Acacia ataxacantha	40	33	82.5	3	7.5	2	5.0	2	5.0
Securinega virosa	34	21	61.8	9	26.5	3	8.8	1	2.9
Trichilia emetica	25	5	20.0	6	24.0	13	52.0	1	4.0
Capparis tomentosa	20	4	20.0	11	55.0	4	20.0	1	5.0
Markhamia sp.	15	6	40.0	5	33.3	4	26.7	0	0.0
Lonchocarpus capassa	16	10	62.6	2	12.5	4	25.0	0	0.0
Acacia spp.	19	4	21.0	5	26.3	7	36.8	3	15.8
Combretum apiculatum	13	9	69.3	1	7.7	3	23.1	0	0.0
Ziziphus mucronata	12	4	33.3	5	41.6	2	16.7	1	8.3
Popowia obovata	13	0	0.0	7	53.9	4	30.8	2	15.3
Acacia giraffae	10	5	50.0	4	40.0	0	0.0	1	10.0
Other spp. (30 spp.)	107	34	31.8	19	17.8	26	24.3	28	26.2
Total	1 105	431	39.0	283	25.6	284	25.7	107	9.7

TABLE 13

Species composition and its use by elephant in 100 feet square plots on the face of the sand ridge

Species	Eastern Plots						Western Plots							Total	
	Sample	Class a		Class b		Class c		Sample	Class a		Class b		Class c			
		No.	%	No.	%	No.	%		No.	%	No.	%	No.	%	No.	%
Combretum eleaegnoides	593	2	0.3	29	4.9	562	94.8	558	118	21.2	440	78.9	0	-	1151	155.1
Baphia obovata	390	0	-	14	4.5	376	96.4	52	9	17.3	25	48.2	18	34.6	442	21.2
C. zeyheri (?)	0							121	82	67.8	39	32.3	0	-	121	5.8
Bauhinia macrontha	194	13	6.6	88	45.4	93	48.0	42	16	38.1	26	61.9	0	-	236	11.3
Dichrostachys cinerea	38	34	89.5	3	7.8	1	2.6	42	41	97.6	1	2.4	0	-	80	3.8
C. mossambicense	21	15	71.5	4	19.0	2	9.5	0							21	1.0
Acacia spp.	5	5	100.0	0	-	0	-	8	7	87.5	1	12.5	0	-	13	0.6
Popowia obovata	2	1	50.0	0	-	1	50.0	6	3	50.0	3	50.0	0	-	8)	
Grewia spp.	0							1	0	-	1	100.0	0	-	1)	
Lonchocarpus capassa	0							1	0	-	1	100.0	0	-	1)	
Phyllogeiton discolor	1	0	-	1	100.0	0	-	0							1)	1.2
A. giraffae	1	0	-	1	100.0	0	-	0							1)	
Markhamia acuminata	9	4	44.5	0	-	5	55.5	0							9)	
Ximenia caffra	4	0	-	4	100.0	0	-	0							4)	
Total	1258	74	5.9	144	11.5	1040	82.7	831	276	33.2	537	64.6	18	2.2	2089	100.0

TABLE 14

Elephant damage to large trees in a sample of the riparian strip one mile long

Species	Pre-1965 Use					1965 Use					Sample
	I	II	III	IV	Felled	I	II	III	IV	Felled	
Kigelia pinnata			2	2					4		4
Acacia nigrescens	19	29	34	45	25	6	19	32	52	18	152
A. albida		1	1				1	1			2
A. giraffae	1		8	8				2	14		17
A. galpinii (?)	6	1						1			7
Ziziphus mucronata			2	1	1			2	1		4
Trichilia emetica			5	9					14		14
Lonchocarpus capassa	3	4	9	17	7		2	7	21		40
Phyllogeiton discolor	1	4	9	12			1	6	18		26
Lannea kirkii		4	6	2	2		2	3	6	1	14
Garcinia livingstoneii		3						2	1		3
Diospyrus mespiliformis	1		1	2				2	1		4
Croton megalobotrys	1			2	2				2		5
Strychnos stuhlmannii	1	2		3	1				5		7
Total	33	48	77	103	38	6	25	58	141	19	299