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EFFECTS OF ELEPHANT AND OTHER WILDLIFE ON VEGETATION ALONG THE CHOBE RIVER, BOTSWANA

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Constant human pressures and restriction of game populations to limited areas are demanding more careful husbandry of natural resources in Africa. This is especially true when large numbers of animals are seasonally concentrated and deterioration of vegetation causes significant changes in the carrying capacity of an area over the long term. Thus, the degree of vegetation use by herbivores and its long-term effect on the ecology of the diverse wildlife populations in reserves is one of the key management concerns of game department administrators.

This problem is a major concern in the northern section of the Chobe National Park in Botswana. At the height of the dry season, the only surface water available to wildlife is along 23 miles of river in the northern portion of the park. High densities of game animals, especially elephant (*Loxodonta africana*) and buffalo (*Syncerus caffer*), along the river in the dry months are rapidly destroying the riparian and riverine vegetation. This destruction of already restricted habitats poses a threat to some localized wildlife species, as well as detracting strongly from the aesthetic value of this unique tourist attraction.

Prior to any management decision, the degree of vegetative change in the area due to wildlife damage, as well as quantitative information on the numbers of animals involved, their past history and their movements, should be documented. Accordingly, this study examined the wildlife use of woody vegetation to find out the effects of these large animal concentrations on riverside habitats.

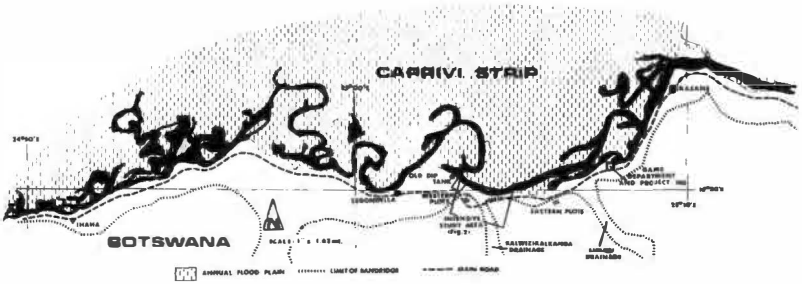

FIG. 1.—Part of the northern boundary area of the Chobe National Park, Botswana, showing the area covered during this evaluation and the pertinent geographical and topographical features.

STUDY AREA AND METHODS

Characteristics of the northern boundary area of the Chobe National Park have been described in detail by Child (1968) and Simpson (1972, 1974*a*, 1975). The distance from Kasane to Ihaha along the Chobe River (Fig. 1) is approximately 19 miles, and the total length of the census route use in game counts was 33 miles. The intensive study area evaluated by Simpson (1974*a*), in which data for this study were collected, centered around Kalwisikalkanga. It had approximately 1.8 miles of river frontage, was 214 acres in extent, and had 4 miles of census roads.

Weekly counts along the 19 miles of river frontage between Kasane and Ihaha 1969-71 were used to determine the number of animals using this water source through the year. In addition, counts were made almost daily over 18 months along the 4 miles of road in the intensive study area, which gave a precise picture of the animal pressures on a limited stretch of river. These data were tabulated on a monthly basis to determine changes in concentrations of animals through each season.

Simpson (1975) made a survey of the plant species along the Chobe River and has presented detailed quantitative data for the woody vegetation in the intensive study area. Four 6-foot-wide belt transects were run through this area (Fig. 2) and 10 by 10-foot quadrats were evaluated at each substation along the census route (see Simpson, 1974*a*). Wildlife utilization of, and consequent damage to, vegetation was classified into four categories following criteria established by Child (1968).

In addition, two sets of paired 100 by 100-foot vegetation utilization trial plots were established on the sand ridge above the river in 1965, and the species and numbers of all woody vegetation present

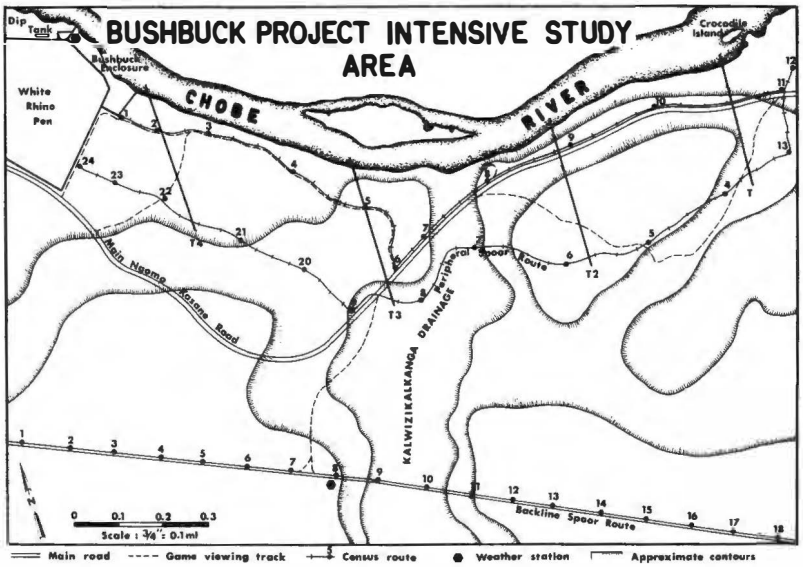

FIG. 2.—Detailed map of the intensive study area centered on Kalwizi kalganga showing the census route, transects, and quadrat substations used in vegetation assessment.

were recorded (Child, 1968). One pair of plots was 0.9 miles west of Sidudu (Fig. 1) in Regrowth *Combretum/Baphia* Scrub where wildlife use, especially by elephant, was heavy in 1965. The second pair of trial plots was located in an area of light wildlife utilization 0.6 miles southeast of the Old Dip Tank in Riverine *Acacia* Tree Savanna. Woody vegetation on these two sets of plots was re-evaluated again in December 1970 following the same grid technique described by Child (1968). Long-term residents of the Kasane district were questioned extensively on their recollections as to past game status.

RESULTS AND DISCUSSION

Past and Present Status of Wildlife

The numbers and species of game occurring in the Kasane District before human settlement are impossible to assess. At best, an estimate of the status of game prior to the timber extraction period can be made, and this only on a purely qualitative level based on memory of game abundance in the past compared to the present status of each species. Most people questioned during this study claimed there were many more plains animals than presently occur

along the Chobe, but that some species have increased in abundance in recent years. The present status of each species was determined from sightings by the author as well as by the Game Warden during the period 1969 to 1971.

With the possible exception of cheetah (*Acinonyx jubatus*) the abundance of predators has remained about the same during the last 50 years. Cheetah might have decreased along the River due to the disappearance of the open country and game species associated with it but are still occasionally reported near the river.

All local residents said that there had been a decrease in the numbers of ungulates with the exception of buffalo. Species of the more open country have shown the greatest decline, with zebra (*Equus burchellii*), giraffe (*Giraffa camelopardalis*), steenbok (*Raphicerus campestris*), lechwe (*Kobus leche*), roan (*Hippotragus equinus*), tsessebe (*Damaliscus lunatus*), wildebeest (*Connochaetes taurinus*), and eland (*Taurotragus oryx*) being the most affected. Some species such as duiker (*Sylvicapra grimmia*), impala (*Aepyceros melampus*), and the two common tragelaphines (*Tragelaphus strepsiceros* and *T. ornatus*) declined for a time, but their populations have recently increased. Baboon (*Papio ursinus*) and warthog (*Phacochoerus aethiopicus*) apparently also have increased.

Reasons for the decline in numbers of plains game are uncertain, but there is little doubt that several factors were contributory. From what is known of the ecology of African grasslands, a general explanation is that the habitat of the plains game animals was altered by encroachment of shrubs (bush) following overgrazing by cattle and the cessation of burning (Simpson, 1974*a*). River stretches thus became inhospitable for the continued survival of large numbers of native ungulates.

Buffalo.—Buffalo historically have occurred along the Chobe (Selous, 1881), but in former times they were not nearly as common as they are at present, nor were they as widespread. According to older residents of the area, buffalo were found predominantly in the woodland above the sand ridge in the mid-1930's, when much of the presently thicketed alluvial flats along the river was open country. Lozeides (personal communication) recalled that by the late 1940's the buffalo population was increasing; animals were common in the woodland and beginning to frequent the denser vegetation developing on the flats below the sand ridge. By the 1960's, this species was abundant and thrived in all of the thicket habitats along the river as well as in the woodland to the south (Child, 1968). By 1969, buffalo represented the most abundant species along the river.

Herds of 200 animals were common, and in 1970 most herds showed a high proportion of calves. However, buffalo census data showed that sightings of these animals were too irregular to obtain an estimate of either current population size or seasonal fluctuation.

Elephant.—Lozeides (personal communication) moved to Serondella in the Kasane District in 1946, but it was not until 1949 that he saw an elephant in this region. Child (1968) reported that elephant were scarce in 1933 but moved into the area after about 1945. Lozeides recalled that this movement was from west to east, starting in the Siyele area west of Kachikau and Ihaha and spreading eastward into the present national park by the early 1950's.

A 19-mile spoor (track) census made for a 24-hour period in October 1963 showed approximately 500 elephant; October 1965 counts gave 728; in 1966, the count for the same period was 619 (Child, 1968). During 1970, elephant were censused weekly between Kasane and Ihaha. The spoor count technique (which entailed counting tracks left by elephant crossing the road in a 24-hour period after it had been dragged to erase all previous tracks) used in the past on this route was found impractical due to the heavy increase in vehicular traffic, so the actual number of animals seen was recorded. In October 1969, a single census gave 640 elephant between 1400 and 1850 hours, whereas the maximum count for October 1970 (a wetter year than 1969) was 973 with a monthly mean of 670. This annual seasonal concentration of elephant along the river remains unchanged at the time of writing (Von Richter *et al.*, 1974).

Figures obtained during the present study cannot be compared directly to data given by Child (1968) due to differences in evaluation techniques. However, data for the period 1968 to 1970 show a great increase over the figures available from earlier years irrespective of census methods employed.

Seasonal Changes in Wildlife Populations

Wildlife utilization of the river strip changed distinctly through the year, with minimal use during the rainy months and highest population pressures at the end of the dry season, prior to the advent of the main rains. Child (1968) has shown the seasonal variation in animal numbers along the river for several wildlife species. During the present study, a monthly list was maintained of all species seen along the general census route and is summarized in Table 1.

TABLE 1.—*Monthly records of ungulate species observed along the Chobe River strip, 1969-1970. R = resident species, C = casually move through area, D = dry season only. For more detailed quantitative data on population concentrations, see Child (1968).*

Species	J	F	M	A	M	J	J	A	S	O	N	D	Remarks	Category
Elephant	X	X	X	X	X	X	X	X	X	X	X		Common; see Figs. 3 and 4	C
Zebra									X	X			Small herds only; common	D
Bushpig								X					Mainly nocturnal (1 sighting)	R
Warthog	X	X		X	X	X		X	X	X	X	X	Common	R
Giraffe								X	X	X			Occasional	D
Duiker		X	X		X			X		X			Occasional (7 sightings)	R
Reedbuck		X					X			X			Floodplain (5 sightings)	C
Waterbuck	X	X	X	X	X	X	X	X	X	X	X	X	Floodplain / ecotone	R
Puku		X	X	X		X	X	X	X	X			Floodplain	C
Lechwe			X	X	X			X	X	X			Floodplain	C
Impala		X	X	X	X	X	X	X	X	X	X		Common in west	R
Sable	X			X		X	X	X	X	X			Woodland species, from sand ridge	C
Roan				X				X	X	X			Occasional	D
Tsessebe								X	X	X			Occasional	D
Wildebeest							X	X	X	X			Common	D
Bushbuck	X	X	X	X	X	X	X	X	X	X	X	X	Common	R
Kudu		X	X	X	X	X	X	X	X	X	X	X	Common	C/R
Eland									X				Occasional	D
Buffalo	X		X	X		X	X	X	X	X	X	X	Common; mainly nocturnal	R

Certain species, such as bushpig (*Potamochoerus porcus*) and duiker, were recorded only in a few months, but the habits of these animals and their sparse distribution in the river strip indicate probable residency throughout the year. Other species (the Reduncini) are usually residents of the Chobe floodplain outside the National Park, using the river strip above the high water line very little. Their scattered distribution is a function of the distribution of water over the flats, and as the water level rises and falls, the animals move toward and away from the census route. There is no doubt, however, that these animals are year-round residents of the floodplain ecotone with the river strip.

Those species generally considered to be woodland dwellers, sable (*Hippotragus niger*) and elephant, show some seasonal movement toward and away from the river. As these animals' ranges varied considerably in size through the seasons, it was inevitable that a few would be recorded along the river strip as casual visitors throughout the year. However, the number of animals seen during the dry season was considerably greater than the few sightings in other months. Species that frequent the tall grassland or open savanna habitats are clearly absent from the river strip in all but the driest months of the year. Their appearance at the river during the dry season is a good indication that the intermittent ponds in the open habitats south of the sand ridge have dried up; these species seldom

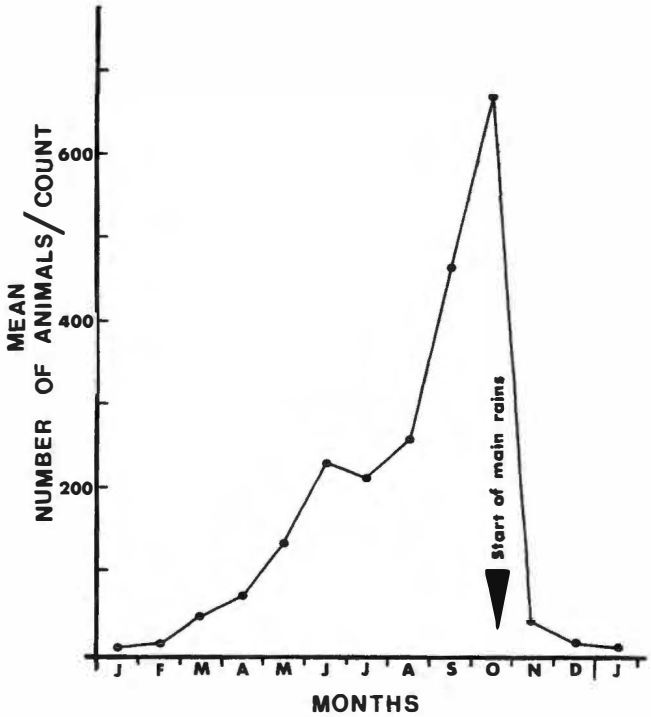

FIG. 3.—Progressive buildup of elephant numbers along the Chobe River and their subsequent dispersal with the coming of the rains as shown from monthly census counts.

remain in the river strip after watering but move back above the sand ridge.

Child (1968) found peak concentrations of buffalo along the river in November of 1965 and 1966, with relatively few animals present the rest of the year. In 1969-1970, there was a build up of buffalo at the end of the dry season, but figures obtained over other months indicated a large resident population on the river strip or in the woodland in the immediate vicinity of the Chobe.

Regular elephant census figures from January 1970 through January 1971 permitted monthly evaluation of numbers. These data clearly show the gradual concentration of elephants at the river as the dry season progressed and their subsequent dispersal with the advent of the rains (Fig. 3). Monthly data also were collected in the intensive study area during 1970 and gave a more accurate picture of the seasonality of elephant distribution (Fig. 4). Although the two sets of data are mutually exclusive, they have similar patterns. Both show a change in the rate of animal concentrations during the

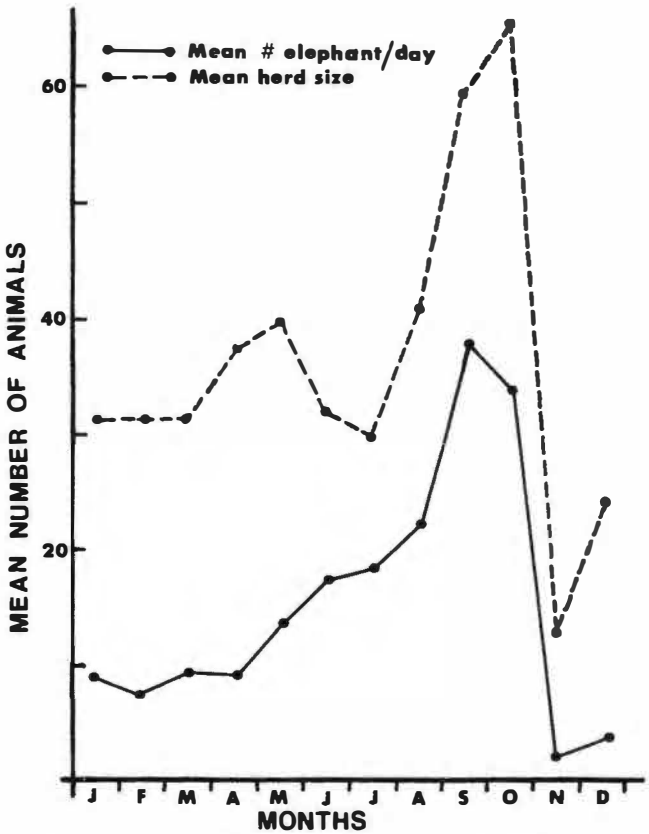

FIG. 4.—Seasonal change in status of elephant recorded in the intensive study area, 1970 through 1971.

winter months, further indicating the influences of cold air drainage as a limiting factor in animal distribution at this season (Simpson, 1972).

Habitat Utilization

Utilization by wildlife of each of the 15 most common plants in the belt transects showed considerable variation between species. Whereas some species had the majority of their numbers heavily used by ungulates, others were moderately or even lightly used; *Dichrostachys cinerea*, for example, showed a high percentage of individuals in the "no use" category. Interpretation of much of these data is difficult, especially in light of the small samples that have obvious inconsistencies. In those species where sample size is

FIG. 5.—A small monodominant stand of *Baphia obovata* in the intensive study area showing sprouting from ground-level stumps left after elephant damage.

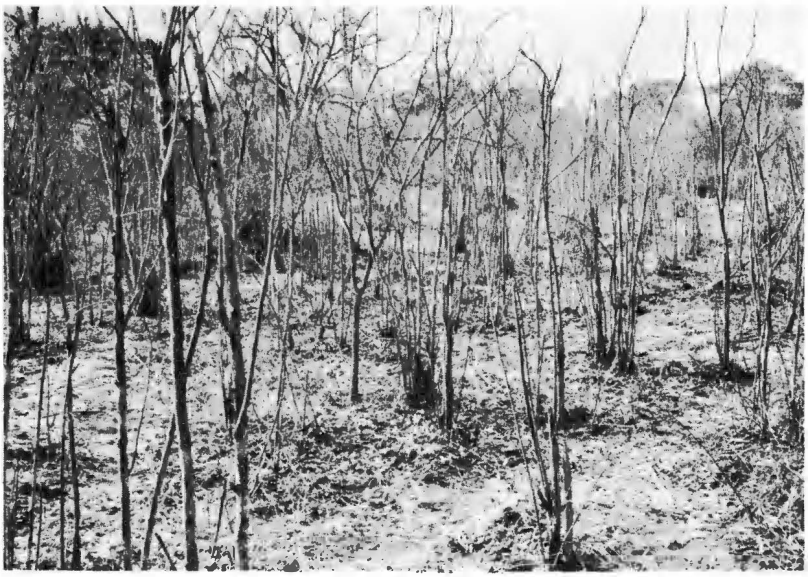

FIG. 6.—Localized pure stand of *Combretum elaeagnoides* "poled" by elephant defoliation techniques. Again, coppicing from ground-level stumps is apparent.

TABLE 2.—*Wildlife utilization of five major habitats in the intensive study area based on data from 79 10 by 10-foot-square plots. Mean canopy cover is shown for December 1970.*

Habitat	Sample size	No. species	Per cent of individuals utilized			Mean per cent canopy
			nil	moderate	heavy	
Riparian Forest Fringe	2	20	20	20	60	95.4
Riverine *Acacia* Tree Savanna	34	21	3	50	47	63.7
Dichrostachys Thicket	21	13	38	52	10	61.9
Regrowth *Combretum-Baphia* Scrub	11	16	0	45	55	46.8
Mixed Tree-Brush Ecotone Complex	8	15	0	75	25	38.9

larger, however, comparisons can be made to similar data presented by Child (1968), based on transects run in the same general area in 1965. *Baphia obovata* (Fig. 5) showed a trend toward heavier wildlife use in 1969-1970 than in 1965, as did *Combretum mossambicense* and *C. elaeagnoides* collectively (Fig. 6). *Dichrostachys cinerea* was recorded more heavily used in the earlier sampling; this may be because the plants were younger at that time and so more attractive to ungulates.

Animal use of vegetation in the sample quadrats was evaluated by habitat (Table 2) and shows an overall moderate use. The habitat with the heaviest use was the Riparian Forest Fringe, followed by the Regrowth *Combretum/Baphia* Scrub and then the Riverine *Acacia* Tree Savanna; this is in accord with Child's (1968) field observations on vegetation use by elephant. Elephant feed between the riparian strip and the regenerating woodland on the sand ridge during their annual concentrations at the river in the dry season. The relatively low number of plant species and few individuals recorded in the riparian quadrats reflect continued heavy browsing by elephant (see Simpson, 1975).

Analysis of the vegetation utilization plots established by Child (1968) show a marked change in the five years following their first survey. These changes can be evaluated as follows:

Eastern plots.—Over the five year period between counts, there was an increase in the number of plant species present and a shift in dominance (Table 3). Child (1968) found a total of 11 species on both these plots, whereas the 1970 assessment showed 19 present.

When the five numerically dominant species are examined in detail, considerable changes can be seen to have occurred between the two assessments. *Combretum elaeagnoides* was the most com-

TABLE 3.—*Change in vegetation of two sample plots (data pooled) on sand ridge above general census route Sector "B" (eastern plots), related to animal usage. Only the dominant species are reported. Use classes are a, virtually untouched by elephant; b, tops browsed off, but plant healthy; c, heavily damaged or dead.*

Species	1965* total plants	1970 total plants	Species composition total plants 1965 %	Species composition total plants 1970 %	Per cent use of plants in each category 1970 a	b	c
Baphia obovata	390	428	31.0	41.7	0	2.6	98.4
Combretum elaeagnoides	593	403	47.1	39.3	0	2.7	98.3
Bauhinia macrantha	194	91	15.4	8.9	1.1	12.1	86.8
Dichrostachys cinerea	38	30	3.0	2.9	13.3	6.7	80.0
Combretum mossambicense	21	17	1.6	1.7	41.2	47.1	11.7
Other species	22	51	1.9	5.5	9.6	17.6	62.8
Total plants (all species)	1,258	1,020			2.1	4.7	93.1

*Follows Child (1968).

mon plant in 1965, and *Baphia obovata* was second; by 1970, this had reversed. Of the remaining three common species, *Bauhinia macrantha* decreased to about 50 per cent of its 1965 numbers, but both *Dichrostachys cinerea* and *Combretum mossambicense* stayed approximately the same. The actual number of these later three species had fallen from a combined total of 253 plants in 1965 to 138 in 1970. All five species showed increased animal use between the 1965 and 1970 assessments.

Western plots.—Alterations in the western plots (Table 4) were similar in some respects but probably represented an earlier stage in habitat deterioration due to heavy utilization. Again, there was an increase in the number of species found, from nine in 1965 to 20 in 1970, with an 8.7 per cent increase in total individuals. Two species not recorded in 1965 ranked among the five most abundant plants in the 1970 evaluation.

Combretum elaeagnoides remained dominant in both plots, but the number of plants dropped from 558 to 370 in 1970, a loss of 26.1 per cent in total numbers. *C. zeyheri*, *Baphia obovata*, and *Dichrostachys cinerea*, increased, and two new species appeared, *Markhamia acuminata* and *C. mossambicense*. The appearance and spreading of *Markhamia acuminata* in these plots is significant because this species is known to be an invader in disturbed or damaged areas, especially in open aspects.

The results of these two vegetation assessments carried out five years apart give some indication of what is happening to the habitats

TABLE 4.—*Change in vegetation of two sample plots (data pooled) on sand ridge adjacent to intensive study area (western plots), related to animal usage. Only the major six species are considered. Use classes are a, virtually untouched by elephant; b, tops browsed off, but plant healthy; c, heavily damaged or dead.*

Species	1965* total plants	1970 total plants	Species composition total plants 1965 %	Species composition total plants 1970 %	Per cent use of plants in each category 1970 a	b	c
Combretum elaeagnoides	558	370	67.1	41.0	0	0.9	99.1
Combretum zeyheri	121	163	14.6	18.0	0.7	3.0	96.3
Markhamia acuminata	0	89	0	10.0	3.4	10.1	86.5
Baphia obovata	52	87	6.2	9.6	0	2.3	97.7
Dichrostachys cinerea	42	64	5.0	7.1	1.5	8.9	89.6
Bauhinia macrantha	42	42	5.0	4.7	1.4	1.4	97.2
Combretum mossambicense	0	40	0	4.4	42.5	25.0	32.5
Other species	16	48	1.9	5.3	0.3	0.9	4.1
Total plants (all species)	831	903			2.9	4.8	92.3

*Follows Child (1968).

along the Chobe sand ridge. Both sample areas were browsed heavily by buffalo and elephant. Although there can be little doubt that buffalo were responsible for some damage on these plots, elephant, due to their bulk and destructive feeding habits, were certainly the main factor influencing vegetation change.

The eastern plots were selected deliberately in an area heavily used by elephant in 1965, and regular observations over the duration of this study confirmed that elephant continued to utilize this ground in large numbers, especially during the dry months. For comparison, a locality of relatively light elephant use was selected as the site for the western plots. At no time in the course of this study period was elephant pressure here as great as that in the vicinity of the eastern plots, although habitat utilization by elephant in the western sample area was greater in 1970 than it was in the previous year.

Child (1968) calculated vegetation use in both sets of plots by computing the number of heavily browsed plants as a percentage of total individuals. He found that 93 per cent of plants in the eastern plots and 2 per cent in the western plots were subjected to severe defoliation and damage by elephant. In the 1970 assessment, these figures remained at 93 per cent for the eastern plots, but rose to 92 per cent for the western areas sampled. Thus, even though there was a clear difference in the degree of utilization between the two habitats and areas in 1965, by 1970, their use was almost identical. If the trend indicated by these date is correct, two factors emerge.

FIG. 7.—View along the high flood line of the river showing relict of what was probably a well-developed riparian fringe forest. Past elephant damage has removed all but a few large trees of the original habitat and continuing animal pressures are breaking down the subsequently developed replacement thicket.

In the first instance, it is very apparent that there has been a new, heavy animal pressure on the Riverine *Acacia* Tree Savanna, which up to 1965 had not been subjected to intensive elephant utilization. The two sample areas cannot be compared directly because of differences in vegetation type, but the degree of change exhibited in each over five years indicates their relative stability under utilization pressure. The Regrowth *Combretum/Baphia* Scrub appears able to maintain its *status quo* better than the Riverine *Acacia* Tree Savanna under the present utilization regime. However, the former habitat is only marginal cover for many localized wildlife species whereas the latter has been found to be of major importance, especially in conditions of diminishing riparian habitat. A very real threat therefore exists. With increased use of Riverine *Acacia* Tree Savanna by buffalo and elephant, the present reduction of desirable riverside habitats (Fig. 7) will be accelerated.

The second factor of importance in the ecology of the riverside habitats lies in the species changes due to habitat breakdown. The majority of plant species eaten by bushbuck and kudu (Simpson, 1974*b*) are those commonly associated with riparian fringe and the

riverine woodlands. Habitat selection in the Chobe bushbuck showed a high preference for riparian vegetation, despite its present state of deterioration (Simpson, 1974*c*). The degree of change in floral composition that can occur without adversely affecting riverside wildlife survival remains unknown, but the reluctance of these latter animals to spread far out from the river, even in seasonally optimal months, serves as evidence for the marginal nature of other habitats. With heavy use of the riverine woodland, invader plants like *Markhamia acuminata, Combretum mossambicense, C. zeyheri, Baphia obovata,* and *Dichrostachys cinerea* tend to replace the more sensitive riverine plants and produce a succession into an open xeric plant community similar to the regrowth vegetation type. This in turn could be of major importance to the survival of wildlife species closely associated and dependent on more mesic riparian habitats.

Conclusions

The census figures for 1970 clearly show a build-up of elephant along the Chobe River in the last five years. This is a continuation of the trend since the 1940's when elephant first appeared in the area. Census data indicate a marked seasonal fluctuation with animals moving into the river strip with the progressing dry season, and away from the river once emancipated by the rains.

Increases in elephant numbers over the last 30 years have undoubtedly brought a heavy pressure to bear on riverside vegetation. Due to the seasonality of elephant concentrations in the river strip, vegetation is subjected to a short-term, high-intensity utilization in the dry season when plant biomass is minimal and most species have dropped their leaves. As a result of this high-intensity use at a time when plant stress is maximum, the impact of elephant on the habitat becomes more devastating. The relatively rapid breakdown of vegetation between Child's 1965 evaluation and the 1970 survey show the effect of heavy elephant use on plant succession.

Prevention of habitat deterioration along the Chobe is not the only reason for controlling vegetative types subject to over-utilization by animals, especially by elephant. With vegetation damage comes a change in the quality of habitats available to other, more specialized, wildlife species. Riparian and riverine habitats in semiarid areas are generally the focal point of many smaller wildlife species. If these habitats are destroyed, the loss of these less spectacular, but equally fascinating animals is inevitable.

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