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part 1

Deloitte & Touche Management Consultants (Pty) Ltd.

CHOBE NATIONAL PARK

Management Plan
Volume 1

Background Information

September 1992

PREPARED ON BEHALF OF THE

DEPARTMENT OF WILDLIFE AND NATIONAL PARKS

BY

DELOITTE & TOUCHE MANAGEMENT CONSULTANTS (PTY) LTD

AND

COMMISSIONED BY THE KALAHARI CONSERVATION SOCIETY

WITH

FUNDING FROM

THE UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT

AS

PART OF THE

NATURAL RESOURCES MANAGEMENT PROJECT

(USAID PROJECT # 690-0251-33)

Deloitte &
Touche

CHAPTER TWO
RESOURCE DESCRIPTION

2.1 TOPOGRAPHY AND GEOMORPHOLOGY

The study area is generally flat with relief differences over the entire area in the order of 160 m. Landform development in the study area is the result of the effects on the Kalahari peneplain of a series of fluctuations between wet and dry conditions in the recent geological past (the Caenozoic - the last 65 million years), and tectonic flexure and faulting. Geomorphological features thus reflect both desert conditions (dune fields and deep aeolian sands) and the effects of rivers and lakes (old lake beds, fossil valleys, beach ridges). This history has had a profound effect on soil formation and current drainage development.

The geomorphological evolution of parts of the study area is described in Shaw (1985). Additional information comes from Hutchins *et al* (1976), Mallick, Habgood and Skinner (1981) and the reports accompanying the reconnaissance soils maps (FAO, various dates). In addition to this, a recent topographic survey (1:10000) of the Pandamatenga plains was consulted (Arup Atkins, 1988). The geomorphological divisions are incorporated in the Land Systems map (Map 6).

2.1.1 Detailed Description of the Area

In the north, a plateau of aeolian sands at an average altitude of about 1000m is bounded by the Chobe river scarp. The escarpment itself slopes down to the Chobe river floodplains, lying at an altitude of about 930m. Along this periphery, it is incised by numerous seasonal river courses draining north into the Chobe. Outside the CNP itself, the relics of old longitudinal sand dunes occur to the south east.

In the north east, an extensive lacustrine plain, the Kakulwane *seloko* (Setswana for black cotton soil), forms the upper catchment for the Ngwezumba seasonal river system draining south west. This plain is separated from the central and southern Pandamatenga plains by a ridge which rises to 1078 m above mean sea level (AMSL). These latter two drain out of the study area. This plain slopes to the north west with a gradient of about 0.2%. A major drainage way runs along the north western boundary of this plain (FAO, 1988) into the Ngwezumba.

The Ngwezumba is joined by a tributary, the Molapowadiphofu/Kashaba, incised into the sand plateau in the north.

The destination for these river courses is the Mababe depression, another large lacustrine plain lying in the south. Topographically, this is the lowest feature in the area, at an altitude of about 920 m AMSL. It also receives occasional flow from the Mogogelo/Khwai rivers (sporadic outflows from the Okavango system), and from the Savute (sporadic outflows from the Kwando/Linyanti system).

Associated with the Mababe depression are three well developed sand ridges; to the west, north and north east. These are barrier beach ridges and were formed by a combination of wave/fluvial action when the depression was a lake and wind deflation during the dry periods. In places they rise up to 60m above the lacustrine plain. Where the inflowing drainages penetrate this old shoreline, sandy alluvial fans have been deposited on the depression's edges. The most striking of these is the fan of the Savute Marsh. Back-barrier lagoons in wet periods resulted in a complex mosaic of sandy and clayey deposits in the areas outside the ridges. The depression is bounded in the south-east by a prominent fault striking north east - south west (Thamalakane/Kunyere fault extension).

Parallel faulting to the north west, the Linyanti/Chobe/Gumare and related faults, has resulted in the deposition of extensive alluvial deposits by the Kwando and possibly Okavango systems. These form a mosaic of sands and clays to the north west of the Chobe fault scarp, forming a distinct boundary between the sand plateau and this alluvium.

To the south east, an elongate, north east - south west striking ridge of rock related to the Chinamba hills rises under a thin layer of Kalahari cover.

Inselbergs protrude through the recent deposits in the Mababe depression (Gubatsaa, Qango and Kgiarotsha hills), just north of the northern sand ridge (Gcoha hills) and in the south east of the park at Chinamba. These are erosional relics surviving the Kalahari peneplanation. The peaks of the Gubatsaa hills rise to about 976 m AMSL.

2.1.2 Conclusions

These geomorphological features provide the physiographic basis for the land classification system described in Section 2.8. The geomorphology of the area is a major controlling influence on soil formation and drainage development. These in turn are determinants for plant ecology and distribution of animals, both resident and mobile.

2.2 GEOLOGY

The hard rock geology of the study area is characterised by very little outcrop and most of the area is covered by a layer of recent Kalahari sediments. Isolated outcrops form inselbergs protruding through this layer.

The largest scale geological mapping available for the study area is the Geological Map of Botswana, at 1:1 000 000 (Geological Survey Department, 1984). Structural information comes from the National Reconnaissance Aeromagnetic Survey Interpretation Sheets at 1:250 000 (Geological Survey Department, 1976), with additional interpretation from a series of Landsat FCC images. Hydrogeological data come from the DWA database (National Water Master Plan (NWMP), 1991) and the Hydrogeological Reconnaissance maps at 1:250 000 (Geological Survey Department, 1983). These maps are part of the CNP GIS. Small scale versions are presented in this report.

2.2.1 Stratigraphy

The oldest rocks represented are the metamorphosed sediments of the Ghanzi Formation; quartzites, shales and limestones. These were intruded by acid porphyries of the Kgwebe Formation. A few outliers of these two formations form the small rocky hills protruding through the Kalahari sands in the southern part of the study area. These older rocks are overlain by Karoo group rocks. These are essentially sandstones with a capping of Stormberg basalts, of which minor outcrops occur on the Ngwezumba valley in the east, along the Chobe river fault scarp and in the valleys feeding into the Chobe. Tuffs and cherts related to the basalts also occur as suboutcrop (e.g. Sedudu valley). The Kalahari Beds are a series of unconsolidated aeolian and alluvial sediments with associated calcretes and silcretes. (Map 1).

2.2.2 Structure

The CNP lies in an area which has been affected by large scale normal faulting and flexure. Two major directions of structural fabric can be distinguished :

- North east - south west; this parallels the normal faulting observable in the Okavango graben system. Faulting and flexure along this direction in the recent geologic past has had a profound effect on the geomorphological evolution of the study area. This is particularly true of drainage patterns.

- East south east - west north west; this parallels the trend of the dyke swarm found to the south of the study area.

Tectonic activity on these fault lines has broken the bedrock up into a number of independent blocks. The movements of each of these has affected the drainage development in the area. The Kwando-Linyanti system is ponded by the Linyanti fault scarp. A similar scarp forms the boundary between alluvium and sandveld in the north west of the CNP. Tilting from flexure and/or faulting has created watersheds between the Kakulwane plains (which drain north west) and the Pandamatenga central (draining east) and southern plains (draining south south west). A further important fault is that forming the south eastern margin of the Mababe depression.

There is some evidence to suggest that some of these faults are currently active. The Zimbabwean seismic network records show that a number of micro-events with epicentres in the area occurs each year (Scholz *et al*, 1976; Hutchins *et al*, 1976). There have been reports of an earthquake of sufficient magnitude to rattle cups and saucers (*pers comm.* Graham). The reduction in flow of the Savute channel has been ascribed by various authors to movements on the Linyanti fault.

2.2.3 Economic Geology

At present there are no known major economic mineral deposits in the CNP. There is some sedimentary copper/lead mineralisation in the Ghanzi Group rocks (Baldock, 1977). Some geochemical soil sampling was carried out by US Steel (1971) at Chinamba. Four reconnaissance boreholes were drilled, but the highest grade of mineralisation encountered was 0.9% copper. The Senior Economic Geologist (*pers comm*) at Geological Survey concludes that the potential of the Chinamba prospect appears low.

Deposits of weathered basalt and calcrete have been exploited for road construction. Several borrow pits for calcrete and gravel extraction have been established along the Kazungula-Ngoma road, on the Sedudu drainage, close to Gcoha hills, at Simwaza and Serondela. These were identified from 1987 aerial photography (except Gcoha). It is likely that alternative sites for gravel extraction exist outside of the CNP, as geological conditions are similar.

2.2.4 Hydrogeology

Groundwater potential is shown on Map 4. As can be seen there are no major constraints on groundwater availability in the study area. There are some areas in which the salinity is too great for human consumption (B/H 5297 and 5299 in the southern Mababe).

The existing boreholes in the CNP and their status are shown in Table 5.

Water Quality

From the table, it can be seen that groundwater quality in terms of Total Dissolved Solids (TDS) is generally good. Groundwater from aquifers in recent alluvium such as the Mababe depression, and fossil deltaic deposits has a higher level of TDS than that from the hard rock aquifers and river frontage areas. No groundwater encountered so far is too saline for consumption by any of the major wildlife species. The WHO limit for TDS for human consumption is 1500 parts per million (ppm). The water from two holes in the Mababe exceeds this, and the likelihood is that water from elsewhere in the fossil lake bed will be equally saline. These ancient landforms were essentially evaporating pans at various stages in their evolution.

Aquifers

The study area has four main aquifers :

- Ghanzi group metasediments, in the central part
- Ntane sandstone, an upper Karoo aeolian sandstone occurring in the west of the area
- Stormberg basalts, in the east
- Kalahari beds which overly the majority of the area.

Table 5 : Boreholes in Chobe National Park									
Registered Number	Site	Location		Date	Depth	Yield	TDS	Equipment	Reticulation
		Latitude	Longitude						
1346	Maikaelelo Road		25°04'30"					Solar	No
2010	Namuchira	18°26'30"	24°53'30"	1967	106.6	3.0	820	Solar	No
2024	Poha Pan	18°25'	24°55'	1967	46.3	10.3	<1500	Solar	No
2025	Sarigho	18°22'	24°54'30"	1967	53.6	11.4	592	Solar	No
2026	Tjinga	18°21'	24°59'30"	1967	31.1	10.0	440	Diesel	Yes
2031	Noghatsau	18°17'	24°53'30"	1967	22.9	11.4	548	Diesel	Yes
2032	Tambiko	18°17'44"	24°59'	1967	21.3	12.3	550	Solar	No
2038	Kabungu	18°17'	24°53'30"	1967	46.2	4.9	420		
2039	Ngwezumba	18°27'	24°38'30"	1967	30.5	8.2	408		
2057	Ngwezumba	18°41'	24°23'	1967	37.2	0.2	508		
2076	Zweizwe	18°38'30"	24°21'	1967	35.1	1.0	348		
4670	Savute	18°34'27"	24°3'24"	1983	30.0				-
4671	Savute	18°34'27"	24°3'24"	1983	24.0				
4672	Savute	18°34'27"	24°3'24"	1983	24.0	1.6			
4678	Savute	18°33'35"	24°4'19"	1984	45.0	9.0			
5295	Mababe	18°47'54"	24°9'56"	-		-			
5297	Mababe	18°47'54"	24°9'56"		27.0	3.4	>1500		
5299	Mababe	18°47'54"	24°9'56"		24.0	-	>1500		
5409	Mababe	18°47'54"	24°9'56"			-			
5470	Mababe	-	-		24.0				
-	Chinamba	18°46'57"	24°49'36"						
5882	Noghatsau	-	-	-	-	-	-	Solar	No
6489	Marabou Pan	-	-	-	-	-	-	Solar	No

Note : This information was collected in August 1992. There may have been some changes since then.

Source : Department of Water Affairs Field Observations, FGU Spinage Report and DWA Records.

These have varying properties and the most significant with respect to the CNP are the basalts and the recent Kalahari beds. Aquifers in the basalts occupy weathered interflow zones and recharge occurs where the rocks outcrop and suboutcrop in the east of the area. The Kalahari aquifers are generally unconsolidated aeolian and fluvial sands. Aquicludes of calcrete and in alluvial areas, silts and clays give rise to patchy groundwater in perched

and confined aquifers. Recharge occurs both by direct percolation from the surface and from the numerous water sources, seasonal and perennial, in the Kalahari sand sheet. (NWMP, 1991)

Recharge

Regional recharge estimates were made as part of the National Water Master Plan (NWMP, 1991). The estimates for the study area are shown in Map 2.

Recharge is highest where outcrop or suboutcrop of rock occurs such as the exposed basalts of the Kakulwane and Pandamatenga plains, and the Chinamba ridge. Values are lowest where soils are of low permeability, e.g. the vertisols (black cotton soils) of the Kakulwane plains. Intermediate values are estimated for the Kalahari sands.

These estimates are derived from four main parameters :

- rainfall intensity and distribution
- evapotranspiration
- soil properties and condition, and
- depth to the groundwater table.

It should be noted that the values estimated are averages for extended periods of time. Conditions for recharge may only be met very infrequently (when rainfall exceeds evapotranspiration plus soil moisture requirements), resulting in episodic recharge events. The mapped estimates must be viewed in this light. In addition, these estimates take no account of local variations of a scale smaller than regional. Topographic and geomorphological considerations will modify the estimates on a local scale.

2.2.5 Conclusions

Factors which are of particular relevance to the CNP include the economic viability of the copper deposits at Chinamba, and various aspects of the hydrogeology.

Implications of Chinamba Copper

The economic viability of copper deposits in the Ghanzi group rocks in the Chinamba area depends, among other factors like grade and size of deposit, on physical factors such as access and availability of water. With the construction of an eastern bypass road between Maun and Kasane, access will be much improved. As far as water is concerned, the

proximity of the Chinamba ridge to the Stormberg basalts means that groundwater will be the first option looked at. Mining of this type of deposit is only economic under open cast conditions.

If the deposit proves to be viable, the implications for the CNP management are serious. Developments in this regard must be carefully monitored. Prior to that, however, any further exploration itself has implications with regard to the potential for increased fire frequency, increased access and potential for poaching.

Hydrogeology

The estimates of recharge given in the NWMP are regional calculated estimates. The derivation takes no cognisance of local topography or local variations in soil type or vegetation. There are some features within the study area that would affect the derivation of these estimates on a local scale :

- The topography of the central part of the park, in particular the Ngwezumba valley, its upper catchment and tributary Kashaba. Although it runs through Kalahari sands for most of its course, bedrock is exposed in the valley in some places and various calcrete layers are exposed in the valley sides. It is considered that river flows in this system are important for recharge to these shallow aquifers. This groundwater is an important resource for elephant in the dry season. Similar riverine recharge to aquifers in recent sediments must occur along the length of the Savute and Khwai rivers when flow occurs. This is of some significance to the groundwater resource in the Mababe depression.

- No cognisance appears to have been taken in these estimates of the large areas of lacustrine clays in the Mababe depression itself. Recharge through these clays is likely to be considerably lower than Kalahari sand rates. Experience from Lake Ngami indicates that much of the depression probably consists of varying thicknesses of these clays overlying very deep massive sands (delta front sheet sands). Most of the groundwater in these sands is likely to be saline as the depression is a sump where evaporative concentration of salts would occur. The only places where freshwater recharge can occur are the alluvial fans of the present inflowing rivers and around the rocky hills (runoff). Hence relatively fresh groundwater is found in the Savute area, but at the Mababe gate the water is too saline for human consumption. In the absence of regular recharge an increase in salinity in the Savute groundwater might be encountered.

- As pointed out above, the estimates are averages. The episodic nature of rainfall events means that in addition to episodic recharge events, the runoff factor is very important in the distribution of rainfall-derived water.

2.3 CLIMATE

2.3.1 Introduction

The Study Area has a semi-arid climate, characterised by hot moist summers and mild dry winters. Rainfall decreases in quantity and reliability to the south and west. In the north, it is affected by the movement of the Zaire Air Boundary (ZAB), but is characteristically increasingly patchy moving south. Potential evapotranspiration (PET) exceeds rainfall in most months of the year. In particular, September, October and early November are usually periods of water stress for plants.

A compilation of available climatic data is presented in Appendix 3. These come from a variety of sources. Localities of recording stations are shown in Map 5, with rainfall isolines. These are derived from the NWMP Geographic Information System (DWA, 1991).

The bulk of the data come from the FAO Land Evaluation database (MOA, 1992). These include decadal (10 day) means of rainfall and monthly records of temperature, relative humidity (RH), potential evapotranspiration (PET), wind speed and frost. Some of these data are interpolated. Records of rainfall and temperature from the Savute research station were included in this compilation.

The data from Savute, although of short duration of record, are the only data for areas within the CNP. All other stations are either peripheral or at some distance from the CNP. This is not a major limitation, as the climate is broadly consistent. It does, however, have implications for future monitoring. The length and reliability of record from some of the peripheral stations is also a minor limitation.

2.3.2 Description

Data from Kasane (67 years record), Savute (10 years record) and Maun (68 years record) are summarised here to provide an overview of the general climatic variation within the study area. Data from these and other peripheral stations have been summarised as

monthly means and are tabulated in Appendix 3. Selected data are shown to illustrate regional characteristics.

Temperature

Mean monthly temperature data for Kasane and Savute are presented in Figure 2. For comparison, records from 1983 in Savute are also presented (Figure 3). This illustrates the extremes of temperature that can occur on a seasonal basis and which tend to be masked when presented as means. It should be noted that the range at Kasane is generally less extreme than that at Savute. The temperature variation is least in the months January, February and March, and greatest in July, August and September. Maximum temperatures are greatest in October and November, with minima in June and July.

Figure 2 : Mean Monthly Temperatures at Kasane and Savute

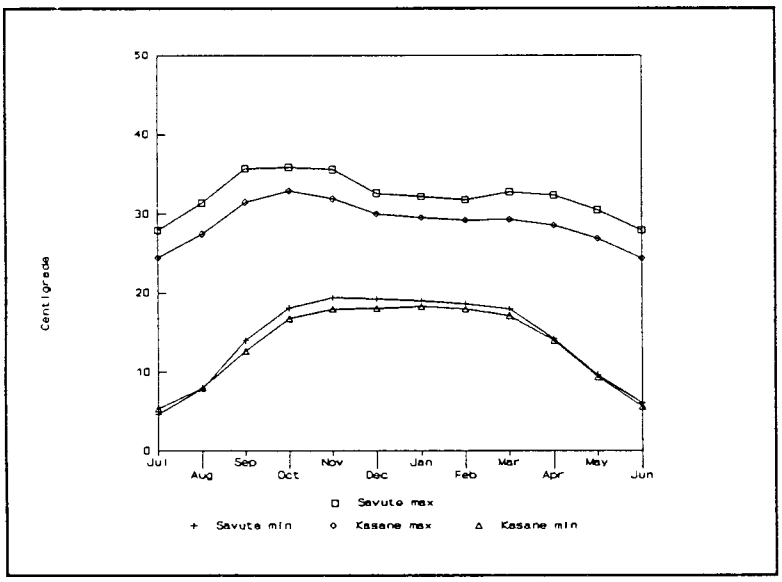
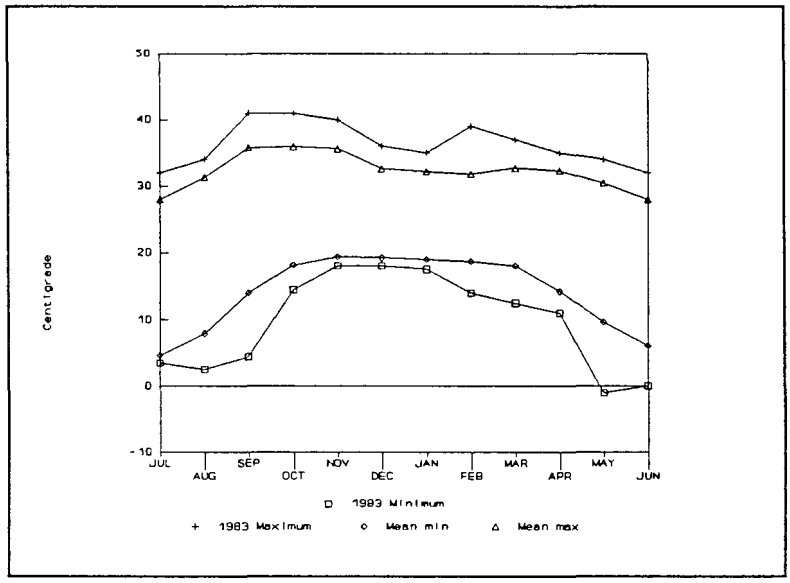


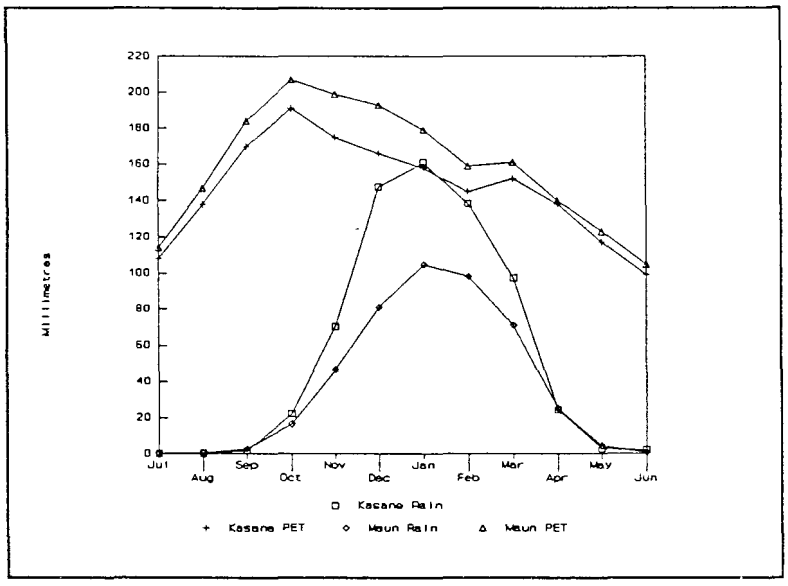
Figure 3 : Comparison of 1983 Temperatures with Monthly Means, Savute



Rainfall and Evapotranspiration

Mean monthly rainfall and calculated PET for Maun and Kasane are shown in Figure 4. Kasane receives more rainfall than Maun, and PET is lower. This is indicative of the regional gradient. The PET distribution shows a marked peak in October, consistent with high temperatures and low humidity. PET is always greater than rainfall, except for a very brief period in the peak of the rainy season in Kasane.

Figure 4 : Comparison of Maun and Kasane Rainfall and PET

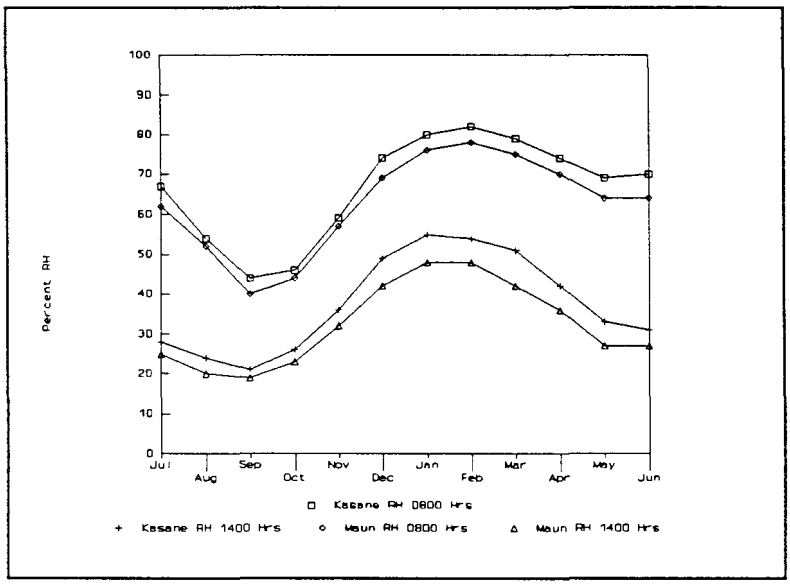


Relative Humidity

Variations in Relative Humidity (RH) for Kasane and Maun are shown in Figure 5. The Maun data illustrates the decrease in RH moving southward. This data may be slightly affected by the presence of floodwaters in Maun in winter, but does show a qualitative change. In general, RH in the study area may be expected to be lower than at either of these stations, except where there is perennial open water (Chobe and Linyanti river fronts).

There is a strong seasonal variation in RH, with minima in September and maxima in January and February.

Figure 5 : Comparison of Relative Humidity, Maun and Kasane



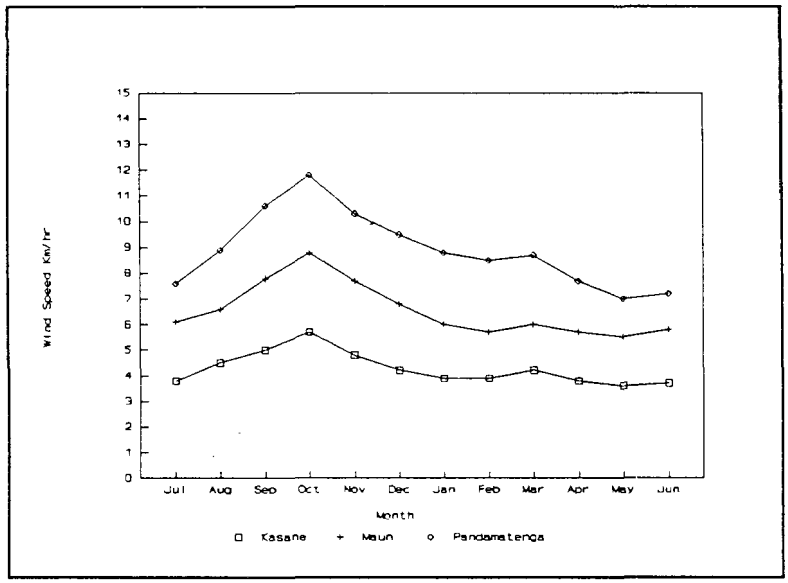
Frost

An average of 2.9 days of ground frost occur at Kasane and there are no recorded air frosts. Maun likewise experiences no air frosts, but an average of 9.8 days of ground frost. Kavimba may be more representative of conditions in the dry interior of the study area. Here an average of 12.3 days of ground frost and 1.7 days of air frost are recorded (length of record 20 years).

Wind

Monthly average wind speeds are available for Kasane, Maun and Pandamatenga and are presented in Figure 6. There is a pronounced peak in wind speed during the months of September and October. This is significant in relation to fire, being the end of the dry season.

Figure 6 : Mean Monthly Wind Speed



2.3.3 Conclusion

Climatic Variability

The most important feature of the climate of the study area is its variability in both the long and short term. This is particularly true of rainfall distribution, which varies widely with both time and geographically. The distribution of average annual rainfall shows a decrease in both quantity and reliability to the south and west. This does not truly represent the pattern of rainfall, however. In a given season, rainfall events may be very patchy in time (large quantities of rain in short periods, or long dry periods within a season) and in space (cloudbursts over some parts of the area, while others get below average for the month or season). The range of variability in annual rainfall at Kasane is 1274mm (max 1405, min 231), and in Maun, 1045mm (max 1187, min 142). Rainfall events may thus be considered episodic.

This climatic variation is of great importance ecologically. In the absence of any major topographical features, precipitation is convective, and unrelated to the earth's surface. Distribution is essentially random. From season to season there is an imposed random variation in range quality and water availability in the system. This ultimately determines the long term carrying capacity of the system. It has implications for fire frequency and

distribution as well. The relationship between pans, rainfall and dry season water availability is a critical factor in understanding the movements of mobile herbivores.

The implications are most profound away from the perennial water sources of the Linyanti and Chobe rivers, in water supply from pans and groundwater and in plant growth. Variations in range quality may be sufficient to trigger movements of herd animals such as zebra and wildebeest. Widely separated bimodal rainfall in some years can give rise to two complete grass seed sets in one season (*pers comm.* Vandewalle).

Frost

Air frosts, when severe, can affect vegetation in a similar manner to fire. The conductive tissue of woody plants may be destroyed, either killing the plant outright, or killing the aerial parts. They are most likely to affect topographically low areas like the valleys of the sporadic rivers (winters are not sufficiently severe for the occurrence of air frosts near open water). This has implications for monitoring.

Wind

Wind speed and direction are relevant to both the spread and intensity of fires and to damage to trees in woodland, in addition to evapotranspiration and relative humidity. Recent research (Coulson, 1991, Wackernagel, 1991) has shown that damage to riparian and other trees may be caused by wind. Wind direction also has important implications for fire break design.

2.4 SOILS

Soil formation in the study area has been influenced by the climatic fluctuations of the Quaternary period. Parent materials are mainly the unconsolidated sediments of the Kalahari system. Soils are therefore mostly sandy, with some accumulation of clay and silt sized particles where reworking by water has taken place. In the west of the study area, a complex mosaic of alluvial soils occurs where soil formation has been affected by fluvial action. Lacustrine clayey soils dominate the Mababe depression and the Kakulwane and Pandamatenga plains. The remainder of the study area is dominated by very sandy soils formed on Kalahari dune systems. In a small area to the east, the dune structure is preserved, but elsewhere inundation has deflated and reworked the dunes.

The soils of the study area provide the basis for the derivation of the vegetation and land systems mapping. The soils of the area have been mapped at reconnaissance scale by the FAO (various years). These maps have been digitised and appended for the GIS (Map 3). A detailed explanation and legend is given for this GIS coverage in Appendix 4. The level of detail, however, is considered too high to provide a useable regional view. This section attempts to describe the soils in terms of their relevance to the ecology of the area. Soil moisture is a primary determinant of plant ecology in arid systems (Tinley, in Huntley and Walker, 1982). Soils have been grouped in terms of their moisture characteristics. This approach provides a map which does not adhere strictly to the land systems divisions described in Section 2.8. It is intended as a comparative map to illustrate ecological constraints before the effects of topography, drainage and climatic variation are considered. It should be noted that this has involved broad generalisations within the soil associations mapped at 1:250 000. These associations are now mapped purely in terms of their major soil type. The relative contributions of major, associated and included soils to the 1:250 000 map units is explained in Appendix 4.

2.4.1 Arenosols

These soils represent the majority, about 27 000km^2, of the study area. They are generally deep free draining sands. There may be local accumulations of fines in places due to reworking forming patches of luvisols, which are important in facilitating the formation of pans. Where little reworking has occurred they are reddish in colour, with a low pH. Climatic fluctuations have given rise to the formation of duripan (hard, impermeable subsurface) layers in some places (calcrete, silcrete or ferricrete) which may impede drainage, or host perched groundwater.

Vegetation on these soils is generally adapted to high moisture availability for short periods of time, or to utilising perched groundwater at depth.

2.4.2 Luvisols

These soils occur where fluvial or lacustrine reworking of the mixed Kalahari sediments has taken place. They constitute 4 800km^2 of the study area. They are characteristically deep, imperfectly to moderately well drained loams with varying proportions of sand and clay. They have an increase in clay content with depth. There is some correspondence between the distribution of luvisols and that of small pans. There may be calcic, sodic or lithic layers in the profile.

The increase in clay with depth means that the water storing capacity of the essentially sandy soil is improved. Some waterlogging may occur depending on the topographic position of the soil. Vegetation thus is adapted to minor periods of anaerobic conditions in the lower root zone.

2.4.3 Gleysols

These clayey soils are associated with sedimentation in standing water. They constitute 910km^2 of the study area, and are typically deep, poorly drained sandy clays to clays. Again, there may be calcic, sodic or lithic layers.

Clays in arid environments are very xeric substrates (Tinley, in Huntley and Walker, 1982). Though their moisture storage capacity is high, so too is field capacity. The moisture which is available to plants is thus very limited. In addition to this, the duration of anaerobic conditions in the soil is too long for many species of plant to survive. Vegetation must be tolerant of extremes of moisture availability.

2.4.4 Vertisols

These soils are also formed in lacustrine environments, and constitute 1 037km^2 of the study area. They are similar to the gleysols in many respects, being generally deep and poorly drained dark clays. They may be sodic, saline or calcic. The difference is that vertisols contain a high proportion of swelling clays. These have a tight matrix that expands when it absorbs water. The expansion and contraction that occurs due to seasonal rainfall (which may even happen with single rainfall events) can form large cracks and bumpy micro-topography (gilgai).

Water relations are also similar to those of the gleysols. However, the vertisols take some time to swell to the point of impermeability - which may take as long as two days (*pers observation*, 1989). During this period the apparent permeability is deceptively high. Once this point is reached, they become almost impermeable. Because of their xeric behaviour and the swelling and shrinking characteristics, they are a very harsh environment for plants.

2.4.5 Chernozems

These are clayey soils related in genesis to the gleysols. They constitute 800km^2 of the study area. They are deep, generally imperfectly drained very dark sandy clays. They form

a transitional soil between heavy vertisols and gleysols, and arenosols. They may be calcic, but not often sodic.

In terms of moisture relations the chernozems behave in a way between gleysols and luvisols. Variations in clay content cause variations in field capacity and storage.

2.4.6 Other Minor but Significant Soils

Nitosols: Very deep, moderately drained, loamy sands to sandy clay loams. Young (1976) notes that these are some of the most productive soils of the tropics, combining good moisture retention with free drainage. They occur in the interdunal depressions to the east of CNP.

Planosols: Deep, poorly drained, sandy loams to clay loams

Cambisols: Deep, moderately drained, sandy clay loams to clays. These soils occur in the Mababe depression and have a calcic horizon.

Regosols: Shallow, well drained, sandy to clay loams. These soils occur on rock suboutcrop, for example along the escarpment of the Chobe river.

2.4.7 Pans

The following relationships between soil type and pans have been summarised from FAO (1988) :

- Pans occur in association with Calcic Luvisols and Eutric Gleysols
- Arenic Orthic Luvisols occur in pans in the sandveld
- Calcic Luvisols occur in pans in the sandveld
- Stagnic Luvic Chernozems occur in pan complex in north west part of Pandamatenga plain
- Eutric Planosols occur in pans towards the edge of the sandveld.

The following relationships between pans and land systems were noted by FAO (1988) in their unit "Almost flat sand plains with major pans systems" :

- Intermediate parts; Orthic or Arenic Orthic Luvisols
- Lower parts influenced by lacustrine Pandamatenga system; Orthic Luvisols and Vertic Calcic Gleysols and towards the edges sands on Eutric Planosols.

2.4.8 Conclusions

Ecological Significance

Under the specific climatic conditions operating in the study area at present, soil moisture status is a more significant parameter in determining plant ecology than nutrient status. Given the relatively narrow range of parent material, soil formational processes give rise to a closely related suite of soils in which water relations depend primarily on the content, position and type of clay in the soil, and the presence or absence of duripan layers. There is also a range of soil pH found, but this, like nutrient status, is felt to be more important in determining species composition than structure (Tinley, in Huntley and Walker, 1982).

Moisture relations in similar soils will vary with the amount of incoming water. This makes the topographical position of the soil, and hence the drainage, very important. An example of this is the difference in vegetation on the alluvial fans of the Ngwezumba and Gautumbi. Dominant soils in both sites are arenosols and luvisols. The Gautumbi is not known to carry water (see Section 2.5, Surface Water), while the Ngwezumba sporadically carries water as far as Zweizwe. The fan of the Ngwezumba supports a mixed mopane shrubland, open grassland and pans, while that of the Gautumbi has a mopane shrub/woodland.

Pans

The formation and maintenance of pans is poorly understood in this system. In general, the luvisols, and planosols constituting pans are characterised by sandy topsoils overlying very hard massive subsoils. Field observations indicate that on sandy soils, the pan itself is in the form of a luvisol "saucer" on the top of the otherwise sandy surroundings.

Observations in the field indicate that where deep sands underlie the pan structure itself, heavy and/or continuous use by wildlife inevitably results in the destruction of the pan layer and the loss of water retention. In the natural situation, this results in the pan becoming disused and eventual reformation of the pan seal. The cycling time *under natural conditions* for this phenomenon has been estimated to be in the order of a few years (*pers comm.* Vandewalle).

Preliminary indications from work currently being carried out in Zimbabwe are that there are very important causal relationships between pan formation, maintenance and demise and biotic factors including both termites (*Macrotermes* spp and *Odontotermes* spp) and large herbivores, particularly hippopotamus and elephant (Weir, in prep).

There is likely to be some difference between "luvisol" type pans occurring on the sandveld, and pans occurring on "mopane gleysols", where the surrounding soils are also clayey and deep. Here, it would seem likely that the pan structure would be less fragile and prone to destruction. Possibly pan profiles are different, and there may be a difference in duration of water retention (rainfall being equal).

2.5 SURFACE WATER

The study area has three major perennial surface water sources all of which arise outside Botswana :

- the Chobe river, fed primarily by the Zambezi system
- the Linyanti, fed by the Kwando
- the Khwai which is sporadic within the CNP itself.

The other water courses in the area carry water sporadically, in response to rainfall events or river floods from their source areas. There are a number of perennial seeps, or springs, in the bed of the Ngwezumba (*pers comm.* Slogrove, Wilmot), and numerous seasonal pans scattered in various parts of the area.

The behaviour of both perennial and sporadic water courses in the area is not well recorded or understood. This is due in part to their remoteness and in part to the lack of perceived necessity. What follows is an attempt to qualitatively classify the drainage systems to assist in the derivation of land systems. Drainage and zones of high pan density are shown in Map 4.

2.5.1 Surface Water Description

Perennial Rivers

Chobe

This system is primarily supplied by the Zambezi. This water comes as floodwater percolating through the alluvial flats of the eastern Caprivi. Two major channels are important conduits across these flats :

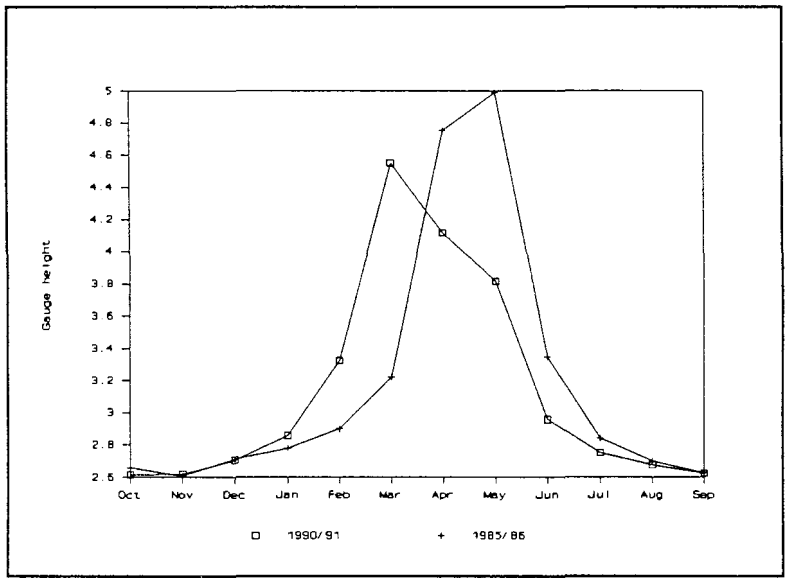
- The Bokala waterway, which conveys Zambezi floodwater into Lake Liambezi.

- The Kasai cut which conveys perennial water from the Zambezi into the Chobe upstream of the rapids. Water backs up the Chobe from this source.

Occasional inflows may occur from the Linyanti via Liambezi (although the possibility exists that flow may travel in the opposite direction too - from Liambezi towards Shaile (*pers comm.* Gibson).

The Chobe is a collector system for Zambezi waters and flow is consequently often relatively static. Seasonal flood characteristics measured in Kasane are shown in Figure 7.

Figure 7 : River Stage : Chobe at Kasane



The incoming flood peaks at the end of the rainy season, between March and May, with low flow around October-November. The total magnitude of the flood rise is in the order of 2.4 m. In years of high rainfall in the Angolan highlands, the Kwando-Linyanti system may contribute to the Chobe flows via Lake Liambezi, through the Chobe flats to Ngoma. Indications from less complete seasons of record are that in some years flow may be bimodal (*pers comm.* Seisa). The earlier peak is possibly a response to rainfall over the Eastern Caprivi swamplands.

Linyanti (including Sibadianja)

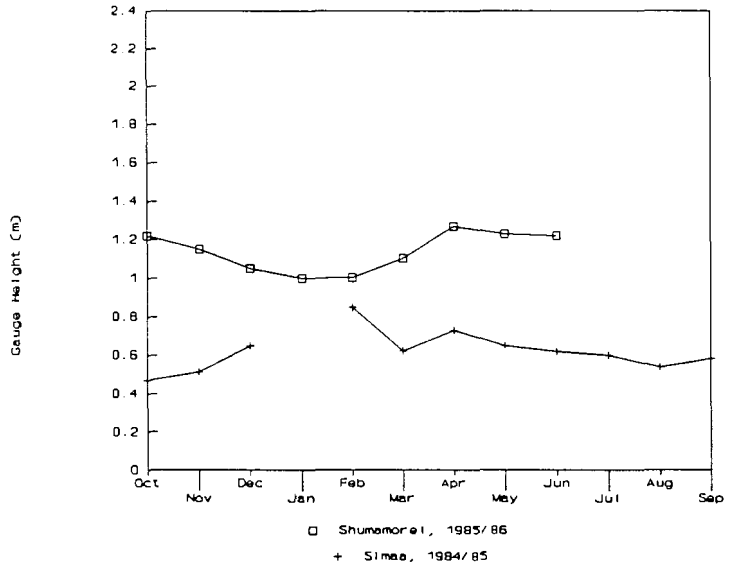
This system is supplied from two sources :

- Kwando river flow, by both main channel flow and through an extensive swamp system of anastomosing channels and floodplains. Most of this swamp lies in the Caprivi strip

- In high flood years, the Okavango via the Selinda spillway.

The Linyanti is a collector system for Kwando water. Outflows, when they occur, are through Lake Liambezi to the Chobe, and through the Savute to the Mababe depression. Due to their remoteness, neither the Linyanti nor the Kwando have been consistently regularly monitored. Gauging stations locations are shown in Map 5. It is, however, difficult to select representative hydrograph readings or even stage readings for either system due to the lack of continuity in the record. In Figure 8 below, the longest continuous record of stage for each system is presented. The vertical scale is approximately the same as that for the Chobe hydrograph, to illustrate the difference in magnitude of fluctuation which is 0.6m as compared to 2.4m on the Chobe.

Figure 8 : River Stage Kwando at Shumamorei; Linyanti at Simaa



Note that the records shown are from different hydrological seasons. In general it can be said that water level fluctuations on both systems are small, in response to either local rainfall or to flood water from rainfall in the Kwando catchment. There appears to be a

significant buffering capacity in the system. It is also worth noting here that Kwando flows in October 1992 are the lowest on record for this time of year (*pers comm.* Heyns).

The distribution and flow of water within the Linyanti swamp is controlled by a sediment/vegetation equilibrium system which has been well documented in the Okavango (McCarthy *et al*, 1986, 1988). Currently, the lower Kwando main channel is the site of channel aggradation and blockage, approximately 12,5 km north west of the Linyanti fault line, close to Hamokata island. Some spot discharge measurements made by DWA (1991) showed that flow immediately below this blockage was less than 10% of that measured upstream of the blockage (approximately 200 m upstream of a side channel to the east). Flow in the Linyanti at Sajawa (King's Pool) was back up to 60 % of the Kwando flow. The losses in the main stream appear to be due to an increase of flow through the eastern floodplains. This can be attributed to the effects of the aggrading main channel and its associated blockage (*pers comm.* Seisa).

Sporadic Rivers with perennial sources.

Savute

Source : The Sibadianja/Madiba complex.
(It should be noted that this complex is supplied primarily by the Kwando, but outflows from the Okavango in high floods may reach Sibadianja via the Selinda spillway).

The Savute system is characterised by long periods of inactivity, interspersed with sporadic periods of flow. At present, water in the system does not reach much farther than 10 km from the Sibadianja offtake. This dry period started around 1982, after a flow period which started in the 1950's, with dry spells between 1964 and 1967 and in 1973 (FGU,1988). Prior to that, the channel had been dry since the late 1800's. When they do occur, river flows are likely to have low magnitude seasonal flood and ebb characteristics related to the fluctuations in the source complex. Gradients are low and the system is not highly erosive.

Khwai/Kudumane

Source : Outflow from the Okavango system via the Khwai river and the Mogogelo.

The Khwai drainage carries water in most years for some distance towards the Mababe depression. This is a seasonal flow related to a combination of Okavango inflows and rainfall on the swamp areas of the lower Moanatshira/Khwai. The Mogogelo only carries

water in very high flood conditions. The Mogagelo system is currently subject to a severe reduction in flow due to blockage induced changes upstream.

In the very high flood conditions of the late 1970's, water from both systems was sufficient to reach the Mababe depression. Again, river gradients and consequently erosive capacity are low.

Sporadic Rivers with seasonal sources

Chobe contributories : Sedudu, Simwanza, Kaswabenga, and others.

Source : Runoff from the sand plateau and escarpment.

A series of short, incised valleys draining the northern escarpment of the CNP into the Chobe river. Flows are in response to intense rainfall events and are therefore likely to be high volume short duration floods. In places, valley floors may be eroded to bedrock (because of the lower overburden, the valleys are used for borrow pits). They are a characteristic landform of the escarpment and are used as access routes by animals moving down from the sandveld to water, and for road routes.

The Sedudu valley has a number of man-made structures in it. There are borrow pits excavated for road fill, and also a weir wall.

Ngwezumba/Kashaba

Source : Rainfall runoff from the area of clayey soils around the western perimeter and the northern drainage way of the Kakulwane plains. The Molapowadiphofu/Kashaba catchment is in the central sandveld but is unlikely to be a major contributor to Ngwezumba flows due to high infiltration rates.

The Ngwezumba river flows in a long and fairly straight well-incised valley. Some exposures of bedrock occur. There was a dam on the valley at the site of the old bridge (built in 1976). It was constructed to improve water availability for wildlife (*pers comm.* Slogrove), but has since been washed away.

Rainfall events in the catchment area for the Ngwezumba headwaters are, like those in the rest of Botswana, characteristically extreme. (Pandamatenga has the highest rainfall recorded in a ten day period of the stations analysed for this study, namely 343 mm in the

first decad of March, 1976). Large rapid floods can and do occur, as for example the 1988 flood which destroyed the dam wall. However, due to the geographical characteristics of the catchment some modification of the typical seasonal river flash flood can be expected.

There are a number of springs or seeps in the valley floor. These are supplied by shallow groundwater, and are frequently excavated by elephant during the dry season. There has been no formalised monitoring of this resource, but by most accounts these seeps have not failed in living memory. They were the water source for an old cattle trek route, and probably, prior to that, a water source for pastoralists when tsetse fly densities were low (Section 2.6.5, Vegetation history). River flows are important for recharge to the aquifers supplying these seeps. In addition to the seeps, there are many pans on the floodplains which hold water for extended periods into the dry season.

When they occur, large river flows discharge into the Mababe depression at Zweizwe, itself the site of numerous large deep pans. The sandy alluvial fan formed by this inflow supports a grassland similar to that of the Savute marsh, although it appears to be subject to encroachment by shrub mopane.

Gautumbi/Potopoto

This system is fed by runoff from the clay soils around the base of the Chinamba hills and to the east of the CNP boundary.

There are no records of flows in this system. Slogrove (*pers comm*) records minor channel flow in the portion close to Chinamba Hills. Localised waterlogging due to runoff collection probably maintains grasslands on some of the valley floor clays. Pans on the same clays probably retain water for some months into the dry season. There was a distinct band of green vegetation following the course of the system visible from the Chinamba hills in August, 1992.

Nunga

The system is fed by runoff from the southern Pandamatenga plain.

This system is included here only because of its similarity to the Ngwezumba. It falls on the boundary of the study area and is of limited relevance to CNP ecology.

Pans

Pans are an important and often overlooked feature of the surface hydrology of the study area. Areas of high pan density are shown in Map 4. This was used as a criterion in deriving the land systems map.

Pans are generally filled by localised runoff. Some may receive water from flash floods in the seasonal river beds.

They are small depressions on clay soils and collect water during the rainy season. Depending on size, substrate, evaporation and usage, they may hold water for varying lengths of time into or through the dry season.

2.5.2 Water Use

Botswana

Water rights for the following total amounts of river draw-off have been granted by the Water Apportionment Board :

- Kasane/Kazungula 3109,2 m^3
- Chobe National Park 9,2 m^3
- Ngoma/Kachikau 200,5 m^3

These represent nine separate river draw-off rights and come to an annual total of 1.23 million cubic metres (mcm). No water rights were located regarding boreholes. Details of the existing rights are given in Appendix 5. It must be noted that these are registered water rights, which entitle the holder to that amount of water. As has been pointed out (*pers comm.* Gibson), a number of water right holders probably no longer use their full entitlement. Equally, there are probably some users who do not have a draw-off right. The total draw-off figure can only be used to give a rough indication of the magnitude of water abstraction.

Upstream

Kwando/Linyanti

There are two offtakes for water supply to the villages of Chinchiname and Linyandi, and an offtake for stock watering from the Kongola bridge. These constitute an estimated total

of 0.43 million cubic metres (mcm) per annum. This may have increased to 0.6 mcm/annum by the year 2000 (*pers comm.* Child, Heynes). At present the Chinchiname offtake point is dry, the Kwando flow being at a record low for this time of year (*pers comm.* Heyns).

Zambezi

There is a small agricultural project at Katimo Mulilo of which approximately 100 Ha is currently under irrigation. This uses an estimated 2 mcm/annum (*pers comm.* Heyns). There is a proposal from the private sector to develop a cane sugar project near Lake Liambezi, using Zambezi water. The maximum planned development may be 10 000 Ha which would require an estimated project of 140 Ha, downstream of Katima Mulilo on the Zambezi (*pers comm.* Child). This is unlikely to require more than for the Liambezi scheme is to channel water down the Bokala waterway by deepening and widening this (*pers comm.* Gibson). This would have tangible effects on Liambezi and the Ngoma/Chobe enclave area.

There has also been some preliminary discussion on a ministerial level concerning the possibility of a joint study for a control structure at Ngoma. This is still at an early stage (*pers comm.* Child).

2.5.3 Discussion

Chobe

The seasonal water level fluctuation has great importance in the maintenance of the floodplain system of the Chobe river itself. This comprises 43km^2 of edaphic grassland which supports a variety of water-dependent grazers at various times of the year. The variation in depth, duration and extent of floods is critical in maintaining the floodplain grazing resource. This is the only portion of this habitat in the CNP. Backwater flooding from the Chobe is also important in the maintenance of the flood recession farming in the Chobe flats, where organic rich soils have been formed from floodplain peats.

The Linyanti : Sensitivity of supply

The Linyanti, being supplied by a system which runs through three different countries, is very susceptible to changing land use patterns in the Kwando catchment and course.

Agriculture and river draw-off can affect Linyanti hydrology. It is also sensitive to changes in the swamp through which much of the water passes. Significant processes here include fire frequency changes and floodplain agriculture. The Botswana Government has opened lines of communication with the Governments of Namibia and Angola to establish a tripartite agreement on the future use and development of these systems (*pers comm.* Muzila).

Relationships between the Kwando/Linyanti system and the Savute

The Savute and its sporadic flow behaviour have been the cause of much disturbance to CNP management in recent years. Much infrastructural development was allowed to take place while the channel was flowing, due to the concentration of large game along the water. No account was taken of the history of flow in the Savute channel in the planning of this development. The channel is now dry for most of its length in the CNP.

There are two possible causes for this sporadic behaviour :

- Sedimentation/vegetation dynamics in the Linyanti swamps
- Gradient changes related to tectonic movements.

The first is a continual process operating in alluvial system with low gradients and high sediment loads. (McCarthy, 1988) The lower Kwando is currently undergoing aggradation and blockage as outlined in Section 2.5. It appears likely from both the DWA discharge measurements outlined in Section 2.5 and from satellite imagery (Landsat FCC's, 1973 and 1983) that most of the redistributed water spilling above this blockage is being diverted to the east of the Kwando mainstream. This has the effect of reducing spill to Sibadianja, and thus potential Savute flow.

The second is a conjectural possibility based on the fact that there is ongoing seismic activity in the region. The Zimbabwean seismic network has recorded a series of minor events with epicentres in northern Botswana (Scholz *et al*, 1976). Without very accurate absolute levels as baseline data, it is impossible to establish this as a definite cause.

Though no major perennial seeps occur along the dry Savute river bed, it is probably an important source of recharge to aquifers in the recent alluvial deposits during flow periods.

The Ngwezumba

The Kakulwane plains have a high proportion of vertisols. These clay soils (*seloko* in Setswana) are characterised by high expansion and contraction with variation in water content. They are also typically almost impermeable when wet. As outlined in the topography/geomorphology section, the plain slopes from the south east to the north west (see Section 2.8, Land Systems). The gradient is low (0.2%), however, and little runoff will occur until the vertisol lattices have expanded with water. Once this stage is reached, however, infiltration drops to an insignificant level and any further rainfall is ponded. Runoff from the plains themselves will therefore be buffered and slow, particularly with a dense sward of grass present.

This system is sensitive to changes in physiography outside the CNP. With such low gradients, any impediment to flow can have large consequences to the hydrology of the system. Examples of this may be the construction of roads, disturbance of the surface for agriculture (ploughing), or even grading of firebreaks across gradient.

Pans

The most striking thing about pans in this system is the lack of knowledge concerning their origin, water-holding ability, and maintenance. This has major implications for any proposed development of artificial watering points. From field observations of pans into which water has been pumped for wildlife, it can be concluded that continuous use of pans by wildlife results in the destruction of the pan structure itself. Pans have been observed on the sandy soils of the periphery of the Mababe which have lost their clay seal due to excessive animal usage. These fail to hold water for an appreciable period in the dry season, and wildlife learns to ignore them as a potential water source. In time sufficient fines accumulate to reform the seal, and the pan again holds water. This process, in this situation, appears to have a relatively short cycling time and is in the order of a few years. Pans were observed in the Savute area in which the underlying sands were visible, and apparently have a similar topography to the surface. In addition, the steepening of the pan sides due to export of material by wallowing animals effectively restricts access to elephant alone. Some variability in usage is necessary for the long-term viability of the pan itself. This variability is usually imposed by climate.

It may be possible to distinguish different types of pan. Field observations and soils data indicate that pans found in the sandveld tend to have larger catchment aprons and fewer

large trees associated with them. Pan shape is important in determining how long water is held. Deeper pans will hold water longer due to the lower evaporative loss.

Pans are a very important part of the system. In general, more knowledge is required regarding the structure and functioning of pans, the relationship between rainfall and duration of holding water, and the role of animals in their formation and maintenance.

Water Use

It is considered that the river draw-off quantities indicated by the water-rights records are not representative of the amount of river draw-off actually occurring. At present, however, there would appear to be no serious constraints on availability. The lowest flow rate on record in the Zambezi, 220 cubic metres per second (cusecs) October 1992, produces an annual flow of approximately 7000 mcm/annum. Current offtake levels from this system amount to less than 0.1% of this flow. The possible proposed Bokala-Liambezi scheme may use almost 3% of this low flow figure. More significant than the draw-off, however, are the potential effects on the upper Chobe hydrology. A thorough Environmental Impact Assessment should be carried out for this scheme before it proceeds beyond feasibility study level. This should include a complete assessment of potential sociological impact on the Liambezi/Enclave populations and an assessment of the potential changes to the Chobe floodplain regime. Any major changes to the flooding regime may alter the edaphic status of this vital resource. Similarly, an assessment should be made of the possible proposed control structure at Ngoma.

The Kwando draw-off rates seem likely to increase slowly, being used primarily for domestic and stock water supply. There are relatively large numbers of people living on the eastern side of the system and these will increase. Such quantities do not, however, represent large proportions of river flows.

TOPOGRAPHY AND GEOMORPHOLOGY, GEOLOGY, CLIMATE, SOILS AND SURFACE WATER

MAIN ISSUES

- Climatic random variation in range quality and water availability determines the long term carrying capacity of the ecological system.
- The relationships between pans, rainfall and dry season water is one of the major determinants in herbivore mobility.
- Soil moisture is the most significant determinant of plant ecology. Soil type and catenary position are critical.
- The sporadic behaviour of the Savute channel may be due to a sedimentation/vegetation dynamics in the Kwando/Linyanti system or to tectonic movements in northern Botswana, or a combination of both.
- The Linyanti itself is highly susceptible to variations and changes in the Kwando catchment area.
- The origins of pans, their water holding ability and maintenance have implications for any proposed development of artificial water points.

2.6 FLORA

2.6.1 Introduction

The Chobe National Park falls between the 700 and 450mm rainfall isohyets. Most of the area lies within the arid savanna biome although the Linyanti and north eastern Chobe are part of the moist savanna biome. The area has therefore been classified by Vandewalle (1989) as a tropical semi-arid savanna ecosystem.

The complex hydrological history, variations in kalahari sand depths, perennial and seasonal rivers, floodplains and variation in average annual rainfall so that the CNP spans the arid-moist biomes divide, all contribute to a complex plant distribution.

Major changes in hydrology and climate have resulted in three distinctly different soil types dominating the area. These soils are those of aeolian, lacustrine and alluvial origin. The type and structure of vegetation within the CNP are therefore dictated by these three soil types and the following determinants, which are, in general order of importance :

- hydrology and soil moisture availability (in areas where flooding occurs)
- soil structure and nutrient status (affected by past hydrological and climatic events)
- annual rainfall
- fire (intensity, frequency and time of year)
- herbivory (past and present).

2.6.2 Approach to the Study

A literature survey was undertaken which identified three country wide descriptions of vegetation, three descriptions specifically describing the CNP, three detailed descriptions of limited areas within the park and six vegetation descriptions in areas adjacent to the CNP. The descriptions in the literature were considered sufficient to provide most of the necessary descriptions for associations mapped at a scale of 1:250 000. The base reference is that of Vandewalle (1989).

Because of the importance of soil in determining plant associations, it is used as the basis for division of the plant associations into groupings. The FAO/UNDP/GOB soils maps, at a scale of 1:250 000 were used.

The initial plant associations were mapped onto the soils map using a combination of literature and landsat photography. Key landsat sheets used were; 28th August 1983, bands 4,5 & 7; 27th August 1983, bands 4,5 & 7 and 6th July 1987, bands 4,5 & 7. A field trip from the 22nd June to 1st of August 1992 served to fill in gaps in information and correct initial mapping.

The occurrence of fire was recorded from three sources :

- Landsat imagery (coverage was far from satisfactory).
- Interviews.
- Observations during the field trip.

2.6.3 Plant Associations

A total of 34 plant associations were identified and are outlined in four groupings, namely wetlands, fluvial soils, lacustrine soils, aeolian soils, with two associations being placed within a miscellaneous group. Vegetation has been mapped at a scale of 1:250 000 (Map 8). A maximum of three plant associations have been described for each of the map units with plant associations being placed in order of importance. The associations are outlined below and described in detail in Appendix 6.

- Wetland Plant associations (mapped as W + No.)
- Dryland associations on fluvial soils (mapped as F + No.)
- Dryland associations on lacustrine soils (mapped as L + No.)
- Dryland associations on aeolian and partially reworked Kalahari sands (mapped as A + No.)
- Miscellaneous dryland associations

2.6.4 Community Area Relationships

Community area relationships have been calculated using the dominant plant association within each mapping unit. Tables 6 and 7 represents the area and percentage of plant associations within the CNP (based on the principal communities).

Mopane is probably the most important plant in the CNP, dominating the vegetation in 38% of the park. Mopane is dynamic, invading open grasslands and occurring in different forms from stunted mature plants on pans, through rapidly developing shrublands, to woodlands of varying height and density.

The teak areas (*Baikiaea plurijuga*) cover 30% of the park. Only 35% of the teak can be considered woodland, the rest being savanna of varying degrees of openness. Within the sands of the teak areas, there are patches of grassland which often contain watering holes during the wet season. These areas are important for the grazer species and make up 2.2% of the teak areas.

Another sand association, the burkea savannas, cover a total area of 13% of the park. These are usually open savannas made up of burkea on aeolian and lacustrine sands.

The total area of grassland dominated vegetation, including the patches of grassland in the teak areas and the grassy shrublands of the Mababe, is 10.46% of the park. The edaphic grasslands of the Kakulwane, the Savute and the Gcoha hills, which are open grasslands free of shrub encroachment, makes up 4.5% of the parks area. In the past, if assumptions are correct that many of the pans with mopane shrub on were open grasslands, the CNP would have had 16.5% grassy areas. The capacity for grazer species was, therefore, much greater.

Acacia savannas, predominantly *Acacia erioloba* are important in the lacustrine and alluvial systems, making up 2.4% of the area of CNP.

Of the smaller associations, the *Lonchocarpus nelsii/Terminalia sericea* on old river bed sediments make up only 0.11% of the area, but are important for elephant browse and movement down to water in the Linyanti area. The hills, making up only 0.6% of the CNP, are unique habitat for both wildlife and vegetation. Flooded grasslands cover 0.24% of the park (Chobe river) and are highly productive areas used by all the water dependent ungulate species during the dry season. Because of the scale of vegetation mapping, the ribbon like structure of riparian woodlands was difficult to plot. The area provided is only useful in indicating the limited extent of this important plant community.

Table 6 : Area and percentage of plant associations within the CNP. (Based on the principal communities)			
Plant Community	**Map Code**	**Area (KM²)**	**% of CNP**
Aeolian sands			
Baikiaoa woodlands	Aia	1080	10.28
Baikiaea dense-open savanna	Aib	1649	15.69
Baikiaea/Guibourtia woodland	Aic	384	3.65
Burkea dense-open savanna	Aii	679	6.46
Mopane dense-open savanna	Aiii	1076	10.24
Savanna on basalt outcrops	B	20	0.19
Fluvial soils			
Riparian woodlands	Fi	118	1.12
Acacia savanna/shrublands	Fii	20	0.19
Acacia erioloba, A luederitzii	Fiii	33	0.31
A erioloba savanna	Fiv	93	0.89
Mixed savanna	Fv	93	0.89
Mopane woodland	Fvia	5	0.05
Mopane dense-open savanna	Fvib	491	4.67
L nelsii/T sericea	Fvii	12	0.11
Rocky hill communities	H	6	0.06
Lacustrine soils			
Ephaneral marsh/grassland	Li	43	0.41
Ephadic grasses (hydromorphic)	Liia	151	1.44
Edaphic grasses (basaltic)	Liib	281	2.67
Edaphic Acacia habeclada	Liiia	527	5.02
Edaphic Acacia tortilis	Liiic	27	0.26
Mopane shrub encroached pans	Liva	637	6.06
Mopane shrub (hydromorphic)	Livb	225	2.14
Mopane woodlands (hudromorphic)	Livc	459	4.37
Mopane woodland/shrubland	Livd	1053	10.02
Magwikwa sand ridge	Lv	102	0.97
Burkea savanna (deep sands)	Lvi	730	6.95
A eriloba/ T sericea	Lvii	104	0.99
L nelaii/C hereroense	Lviii	280	2.66
C hereroense shrubland/grass	Lix	83	0.79
Wetland associations			
Perennial swamp	Wi	21	0.20
Flooded grasslands	Wiii	25	0.24
	Total area	10507	

Table 7 : Area of CNP covered by groupings of similar plant communities	
Grouping of similar communities	**% of CNP**
Teak woodlands	10.28%
All Teak areas including woodlands	29.63%
Burkea savanna	6.46%
All Burkea dominated areas	13.41%
Basalt outcrops	0.19%
Hills	0.06%
Historic river channels	0.11%
All edaphic grasslands	4.52%
All grasslands and shrublands	10.64%
Grasslands within Teak areas	0.79%
All mopane dominated areas	37.56%
All Acacia savannas	2.38%

2.6.5 History and past land use affecting vegetation.

The 19th Century

Prior to the 1890's, the presence of tsetse fly limited the presence of cattle in most of the area which had perennial water. Humans' influence was mainly traditional hunting by Basarwa, and the main impact was a slightly higher fire frequency due to the use of fire as a hunting tool. Towards the end of the 19th century elephant hunters had driven elephant, rhino and buffalo out of the Mababe and away from the Chobe river. The presence of tsetse fly kept pastoralists out of most of the present day CNP. The rinderpest pandemic of 1894-1896 not only decimated the wildlife populations, but also caused tsetse fly to become locally extinct within the CNP area. The increase of pastoralists along the permanent water areas and the associated increase in fire frequency is what probably opened up much of the dense riverine forests which Selous (1881, prior to the rinderpest) described as a dense continuous jungle, interspersed with large forest trees which went down in most parts to the water, and which, in places, was nearly impossible to creep through.

When Selous visited the Mababe in May 1879 (Selous, 1881) there were tsetse fly near the Savute swamp which during that period was receiving annual water down the Savute channel. The structure of the eastern Mababe was similar to that of today with dense wooded areas of mopane adjacent to the open grasslands/shrublands of the Mababe flats. There were reed beds within the Mababe marsh that were burning when he visited the area. Selous wrote of Basubia towns on the Mababe river. It is certain that there were people living in and using the Mababe area near the swamp, although livestock numbers must have been low due to the presence of tsetse fly. Areas of dense *Dichrostachys* thicket near the Savute channel are considered by Vandewalle (1989) to be sites of old arable lands.

The depletion of elephant to insignificant densities from the 1890's until 1935 (Child, 1968) allowed for the development of a riparian strip with a species composition containing many trees palatable to elephant.

Expansion of Livestock

After the tsetse fly died off, cattle posts extended along the Linyanti, Chobe, lower Kwando, the Magweqana spillway and some along the Ngwezumba as far as the Kakulwane (Child, 1968). In 1912 cattle owning Batawana from Ngamiland moved into the Enclave, many of whom emigrated again in 1920.

The first of the cattle trek routes between Ngamiland and the Chobe was pioneered by Kays in 1922. As the cattle market to the Zambian copper belt developed, large numbers of cattle were trekked up to Kazungula, initially via the Mababe. But as tsetse fly spread east, they pushed the trek route onto the Ngwezumba and then from 1949 onwards pushed the route even further east to the Boteti/Nxai pan/Pandamatenga trek route (Appendix 7). Child describes the change in vegetation caused by the heavy livestock grazing as a change from open grasslands to that of dense shrub as fire was excluded due to grazing. The shrub encroachment on the pans of the northern Mababe (Zweizwe) pans area, the northern Gcoha pan, and between the upper Ngwezumba and Kazungula, is probably a direct result of past livestock use and annual early burns. This indicates a change of "stable" state from grasslands to shrublands.

Logging and Other Commercial Developments

Other developments that would have had an effect on the species composition of the area (FGU, 1988) were the development of irrigable areas and a rice paddy by Chobe

Concessions Ltd. in 1950-51. In 1934 Susman Brothers were given a logging concession over 390 km² in the north east, and during 1935 to 1938 cut over some 140 km², removing *Baikiaea plurijuga, Pterocarpus angolensis, Entandrophragma caudatum, Afzelia quanzensis, Guibortia coleosperma* and *Ricinodendron rautenenii* with a girth of 97 cm and above. In 1944 Chobe Concessions Ltd. were granted a concession over some 1,400 km² and set up a sawmill at Serondela in 1945. From 1944 to 1949 they logged some 57 km² between Serondela and Kabulabula, removing *B. plurijuga, P. angolensis, E. caudatum, G. coleosperma, R. rautenenii, A. Quanzensis, Burkea africana, Kirkia acuminata, Amblygonocarpus obtustangulus* and *Erythriphleum africanum*, taking trees with a girth of 112 cm and above. Between 1949 to 1954 they logged 280 km² in the Chobe Main Concession area between Kabulabula and Moana. Logs continued to be removed from the area until 1956 when operations within the area ceased. The estimated totals of wood taken over the whole period were *B. Plurijuga* 130,350 m³; *P. angolensis* 42,500 m³; *E caudatum* 7,084 m³ and other species 14,170 m³.

Tsetse Fly Control

Tsetse fly control operations aimed at stopping the eastward spread of fly to the east has also modified vegetation. Along the escarpment edge of the Chobe Enclave, most of the large dark barked species of tree were felled. There was also a four kilometre wide strip of trees cleared along the Ngwezumba to prevent fly spreading further to the east.

2.6.6 Terrestrial and Aquatic Weeds

Terrestrial weeds were not observed to be a problem within the CNP. *Cynodon dactylon* grass is thought to have increased its distribution as a result of colonisation of old human settlements. The grass was observed by Child (1968) to be spreading within the Chobe floodplain grasslands and it is now widespread within the Savute grasslands.

The potential for spreading terrestrial weeds is relatively high along the perennial rivers, the Savute Channel and the Ngwezumba channel.

Aquatic weeds were observed in the Linyanti and Chobe rivers. In all cases, the weed *Salvinia molesta* (Common names are Motshimbama in Setswana, or Kariba weed in English) contained the biological control insect *Cytobagous salviniae* which has proven to be a successful control agent within Botswana. The weed was not observed to colonise large areas and now takes its "natural" place within the ecosystem.

Salvinia was first collected from the Zambezi river system at Kazungula Island in 1948 (Mitchell, 1967). By 1967 Salvinia was found throughout the Chobe river system from the Zambezi river almost to Lake Liambezi (Mitchell, 1967).

Within a river system, once salvinia has been introduced, spreading usually occurs due to passive water flow. Spreading by large herbivores also occurs. Kariba weed spreading between river systems is primarily due to human factors such as discarded aquarium plants or inadvertently on boats.

There is one patch of the water lettuce *Pistia stratiotes* on the Linyanti system at Sibadianja which may inadvertently be spread further through boating activities.

On a wider scale, in October 1986, the Department of Water Affairs passed legislation which controls the import and movement of boats in the country. The legislation limits boats to specific zones unless movement permits are obtained (GOB, 1986). However, whilst DWA has passed legislation for the control of boat movements, Botswana's neighbours have not. Thus the effects of these controls on the Chobe, Linyanti and Kwanolo rivers, as well as on Lake Liambezi if it had water, are negated.

2.6.7 Fire

Selous' description of fire and people in the Mababe in 1879 indicates a history of man made fire in the area.

Effects of Fire on Plant Communities

Fire is an essential component of savannas, being important in the breaking of seed dormancy and recycling of nutrients. It affects the structure and composition of vegetation by causing a reduction in woody plants, both in size and number, and can in wetter climates result in savanna replacing forest. It also leads to selection in favour of fire resistant species, and the development of the xylopodium, or "underground tree". (Huntley and Walker, 1982).

Field observations indicate that the high fire frequency within the teak woodlands is changing the woodlands to savanna and seriously disrupting the recruitment of *Baikiaea*. In areas which had been protected from fire for a number of years have dense stands of young teak trees have been developing into a closed woodland. In the Chobe Forest Reserve fire, is keeping teak seedlings in the shrub stage resulting in reduction in

recruitment. An estimated 55% of rootstocks were burnt, 11% browsed and 30% of the tree crowns had significant fire damage (Norwegian Forestry Society, 1992). The effect on the long term structure of the woodland is obvious.

The economically important species of *Pterocarpus angolensis* (Mukwa) is being affected by a combination of elephant damage and subsequent destruction by fire. Recruitment of mukwa is low and although there are indications that episodic events such as fire or disturbance is important to mukwa recruitment, it is considered unlikely that natural regeneration will be able to maintain mukwa populations unless fire and other damage is minimized (Norwegian Forestry Association, 1992).

The "mukwa die-back", a wilt disease in which *Fusariun oxisporum* clogs up conductive tissue, is thought to develop when the plant is stressed. Fire could be one of the agents of stress.

Fire can have a marked effect on riparian woodlands if the protective fringe of fire resistant shrubs along the outer edge is removed (Simpson, 1975).

Frequency and Location of Fires

The absence of any formal monitoring of fires within the CNP made it necessary for a fire frequency map to be developed based on field observations and Landsat images. Fire frequency of one every 2 years on average is considered to be high (Appendix 8). Fire frequency in the Maikaelelo and Sibuyu forest reserves is so high that the woodlands have lost their commercial value (Norwegian Forestry Society, 1992). The calculated natural fire frequency for the Hwange National Park, (an area of similar rainfall to the CNP) is that an area is on average burnt every 6.6 years (Frost, 1990).

Wind and Sources of Ignition

The windy months (September and October) are during the dry season with the prevailing wind from the east. During 1981 when at least half of the CNP was burnt, the sources of ignition appear to be the Kakulwane plains, starting on the Zimbabwean border and the Lesomo area. The fires spread as far as the Linyanti, burning through the Chobe forest and into the Enclave. Zimbabwe and Pandamatenga are considered to be the sources of ignition for fires burning the Sibuyu, Maikaelelo and Kazuma forest reserves (*pers comm*).

The author of this report was personally told by a member of National Parks and Wildlife Management, Zimbabwe, that they annually set fire to the Botswana side of the Kazuma National Park to prevent fires from Botswana. Although this practice may now have stopped, it occurred in the late 70s and 80s.

There are, according to our information, numerous fires being started deliberately in Botswana (the hunting companies to the west of CNP and the people of the Enclave). But these fires are of less direct influence on the vegetation within the CNP than the fires started in the east.

In addition the landsat imagery indicate that fires burn parallel to the Gcoha hills - Linyanti boundary, making it easy to use as an effective fire break.

Although vast areas of Caprivi burn each year there is no indication that the CNP fires are started from Namibia as both the wind direction and the riparian woodlands protect the CNP.

Plant Communities with Low Fuel Loads

A number of plant communities act as natural firebreaks. The effect is due to a combination of soil type and vegetation structure. In mopane woodlands the understorey is sparse and fuel loads low. There are also dense stands of mopane shrub which effectively exclude fire. The riparian strip, if in prime condition, acts as an effective firebreak.

On sandy soils, yearly burning of fuelbreaks could deplete fuel loads so that fuelbreaks cannot clean burn. A double system, in which either side of the access track is burnt on alternative years, is needed for firebreaks.

State of Present Fire Breaks

An examination of the CNP boundaries indicated :

- The eastern boundary is well graded but not effective as a firebreak unless a second trace is graded and the area between burnt to form a fuel break.

- The Kakulwane plains, the source of most fires, has a fire break track overgrown with grass which renders it ineffective.

- The track along the boundary between the CNP and the Enclave is in good condition, but the absence of a double trace on the Molapowadiphofu - Ngoma section limits its effectiveness in preventing fires exiting the CNP.

- The western cutline as far as the Tsatsarra is in good condition.

2.6.8 Elephants and Herbivory

History

Elephant densities change throughout their northern Botswana range on a seasonal basis. Densities also vary considerably from year to year as elephant respond to local rainfall and changes in hunting pressure. On a longer time scale elephant densities have changed during the last century. During Selous's second trip to the Linyanti in 1879, he found a big drop in elephant numbers. Ivory hunters had, in 5 years, pushed most elephant away from the Chobe, Savute and Linyanti river systems. Shortly after, at the end of the century, the rinderpest decimated the remaining wildlife population resulting in a die-off of tsetse fly. Basubia and Batawana peoples spread along the Chobe, Linyanti, Kwando and the Magweqana water systems. Elephant densities in Botswana have therefore varied from low densities of less than 1000 in the late 1890's to the present estimate of 60000 (Child, 1968; FGU 1992; Booth, 1990).

There has been a period of at least 70 years in which elephant populations in northern Botswana were less than 10 000. Tree growth and woodland understorey during that period would have been unaffected by elephant. Changes to the vegetation would therefore be expected where elephant densities are now high. The change would be expected to be high initially and then tail off to a new composition and structure that is more tolerant of elephant. The period of low elephant densities could be viewed as an episodic event, unlikely to be repeated unless elephant populations are drastically reduced or excluded from areas for long periods.

Elephant impact on vegetation

The Chobe river front has had a significant reduction in riparian tree canopy cover from 54.5% in 1962 to 33.4% in 1973 and a further small reduction to 31.9% in 1985. In the riverine acacia the canopy cover changed significantly from 30.9% in 1962 to 14.4% in 1973 and 8.82% in 1985 (Parry and Blyther, 1990).

The total loss of tree canopy cover in the riparian strip of Chobe study sites is 41%. The rate of canopy loss was 3.5% per annum from 1962-1973 and reduced to 0.4% per annum from 1973-1985. In the acacia riverine woodlands there was a 71% decrease over 23 years, averaging 3.1% per annum. The rate of canopy loss from 1962-1973 was 4.8% per annum, reduced to 3.2% per annum from 1973-1985 (Parry and Blyther, 1990).

Trees within the *Acacia* and *Mopane* areas were used by elephant significantly more than those in the *Baikiaea* and *Burkea/Terminalia* areas (Sommerlatte, 1976; Moroka, 1984). The Chobe had the highest percentage of elephant-used stems, with 71.4% of all acacia areas being effected. Sommerlatte also found that elephant damage to be the most important cause of tree mortality in all species except *Baikiaea plurijuga* and *Burkea africana*. These findings have recently been challenged as it is difficult to prove that elephant are the cause of tree death as wind, fire and flooding play a major role. (Coulson, 1991; Wackernagel, 1991).

Moroka (1984) found that both acacia and mopane trees to be heavily used by elephant, with the mopane being better adapted to withstand the use. There was a decline in acacia species in the Savute from 55.2% in 1973 (Sommerlatte, 1976) to 41.2% in 1983 (Moroka, 1984). Part of the decline in the Savute was attributed to flooding. A similar decline was found for the Chobe river front from 37% in 1973 to 22.4% in 1983. The *Baikiaea* woodlands were the least affected areas of the CNP.

From the above data and field observations, there is a clear indication that elephant are affecting the structure of riverine vegetation and vegetation in areas where elephants concentrate, particularly the acacia woodlands of the Savute and the hedging of mopane within the Noghatsau area.

Elephant are also affecting the relative species composition of woody plants in high concentration areas by selecting for certain species (Coulson, 1992) and probably being instrumental in reducing the recruitment of certain species in the Linyanti (Wackernagel, 1992). Certain shrub species were recorded by Simpson (1975) to be increasing due to elephant activity along the Chobe river front. Theses were *Dicrostachys cinerea, Combretum zeyheri, Markhami · acuminata, Baphia obovata, Combretum mossambicense*. The increase in woody shrub species and the loss of open grasslands on the Chobe river front may be due to elephant, but changes in herbivore numbers and fire frequency could also have caused these changes. Field observations indicate a reversal of the woody shrub encroachment trend along the Chobe river front.

2.6.9 Artificial Watering Points

Artificial watering points were observed in two different systems.

- In the area which abuts the Kakulwane plains, where Noghatsau, Kwikamba and Tjinga pans occur, the clay soils are deep and a number of large pans occur which contain water most of the year. This is similar to the pan complex near the Ngwezumba delta. In both areas elephant densities were high and the entire area around the pan complexes were heavily used by elephant. Mopane shrub was cropped to a browse height, but generally trees were undamaged. In areas which under normal circumstances contain water most of the year, the effect of permanent water on vegetation seems marginal. But this could be an artefact of the long term exposure of the vegetation to elephant. Child (1968) examined 300 *Acacia nigrescens* south east of the Ngwezumba delta and found 90% of them dead. This he attributed to elephant, and today very few of these trees exist in the same area.

- In the Savute area the effect of artificial water on vegetation is obscured due to past flooding and the huge herbivore population in the area between 1957 and 1983. There are few natural pans and those that do occur tend to be made up of a thin clay layer on a deep bed of sand. Excessive use of the pans through artificial water supply and hence elephant activity has resulted in the destruction of the clay layer in Pump pan and hence the loss of the pan to wildlife even as a natural pan. Similarly the loss of the seep at Savute, through human manipulation needs to be questioned from a management of natural resources viewpoint.

2.6.10 Roads

The present road structure directly affects edaphic grasslands. In the Kakulawane grassland there are two graded tracks crossing the plain, although they are not a problem to drainage at present, persistent grading could deepen the track and affect drainage.

The main road which crosses the edaphic grassland to the west of the Gcoha hills is affecting both drainage and soil composition. In a system with so few open grasslands, manipulation of the primary determinant of a grassland should be considered as a major problem.

The main dry season track which enters the CNP from the south would effect plant communities and drainage if it is developed into the main road and is gravelled. Tracks across the open grasslands effect drainage and hence species composition of edaphic grassland in a system which is sporadically flooded.

Pits for gravel extraction not only detract from the wilderness appeal of the area but permanently change drainage and soil structure. It is possible, because of the specific gravel requirements for roads, that extraction of gravel could impact specific plant communities.

2.6.11 Utilisation by People

The history section of this report indicates the extent that the natural resources within the present CNP were used. At present there is very little use of the park's vegetation resources by the surrounding communities.

Visitors to the CNP, permanent tourist camps, DWNP staff and members of the BDF all use locally collected fire wood. Depletion of dead wood within and surrounding camp areas is noticeable. Removal of firewood in a nutrient poor system directly affects nutrient cycling. The change to solar water heating introduced by the DWNP has a much lower effect on the nutrient cycling.

In the areas surrounding the CNP people are heavily dependent on natural resources. In every aspect of the communities' lives, resources are used :

- Medicines
- Food (Moss and Taylor, Unexploited food plants of Botswana)
- Building (thatch roofing, reed walls, bark rope, wood supports and roof structure, kraal structures)
- Transport. *Baikiaea plurijuga*, *Pterocarpus angolensis*, and *Afzelia quanzensis* in the northern Enclave and Kasane/Kazungula areas are used to produce Mekoro. (ECOSURV, 1988)
- Energy (most cooking and water heating requirements, with exceptions in Kasane and Savute, are met through fire wood)

- Crop production

- Livestock grazing.

2.6.12 Determinants of Plant Communities

There has been no significant research carried out on the major processes in the CNP to date. During this study, however, an attempt was made to identify the major determinants which affect the key processes. The three main processes that determine the functioning of ecosystems are primary production, herbivory (and secondary production) and decomposition (Huntley and Walker, 1982).

Conclusions

The type and structure of vegetation within CNP is dictated by three distinct soil types dominating the area (viz. soils of aeolian, lacustrine and alluvial origin) and, in the opinion of the author, the following determinants in descending order of importance :

i) hydrology and soil moisture availability
ii) soil structure and nutrient status
iii) annual rainfall
iv) fire
v) herbivory.

Of these determinants, fire and herbivory are most easily managed and therefore should be given special consideration in the management planning of CNP. In terms of the desired objective of preserving the functioning of natural processes, fire intensity and frequency has already been modified and increased substantially by mans activities. Herbivory, particularly the influence of elephant, has also been modified by man's activities. For example, hunting pressure and other disturbances outside park boundaries, together with the introduction of artificial water points, are undoubtably affecting the dispersion and seasonal movement patterns of the major herbivores.

Consequently, the control of fire or use of fire as a management tool and the factors influencing the natural movement patterns of herbivores (particularly artificial waterpoints) pose major challenges in the management planning process.

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MAIN ISSUES

- The CNP is on the ecotone between the moist and the arid savanna biomes. As a result it contains a diverse range of plant communities.

- Important plant communities, due to their limited areas and the diversity they create are : rocky outcrops, wetland, riparian, open grasslands, irregularly flowing river channels and historic river channels.

- Communities of commercial value are the teak woodlands, and the grasslands of the Kaklwane plains (thatch and agriculture).

- Past use of the area by people has resulted in modifications to vegetation which are still observed today, i.e. bush encroachment due to livestock activities and changes in fire intensity, logging of teak woodlands, the near eradication of elephant at the beginning of the century.

- Limited control of fire, high fire frequency and lack of records. Some plant communities/soil types could act as useful fire breaks.

- Elephant numbers are high enough to have a significant effect on the vegetation.

- Artificial watering points will increase the problems of veld management, spread the effects of water dependent species and interfere with the basic processes which control plant population dynamics.

- Roads affect both soil structure and drainage, and can have a major impact of edaphic plant communities.

- The vegetation in the CNP has been considerably disturbed by human activity in the past which have ramifications through to today, and is still heavily impacted by man-made fires.

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- Fire frequency is a major determinant in the density of plant species.

- The principal sources of fire ignition are located east of the CNP (Zimbabwe, Pandamatenga, Kakulwane) and spread by the easterly winds of the dry season. The firebreaks in this sector of the park are not effective.

    - Elephants have caused a major reduction in riparian tree canopies (71% reduction in acacia over 23 years) and in the Savute acacia and Noghatsau mopane around the artificial watering points.

    - Roads affect both plant communities and drainage, particularly in the areas of open grasslands.

2.7 FAUNA

2.7.1 Introduction

Northern Botswana has remarkably rich fauna, on account of the mixture of wetlands and semi-arid savannas that are found in close proximity to each other. In the CNP, these are characterised by the permanent wetlands of the Linyanti swamp, the Chobe river alluvial flats and the occasionally inundated Savute marsh, situated within dry woodlands bordering the northern edge of the Kalahari. The fauna is dominated by elephants and northern Botswana and neighbouring areas of adjacent countries have what is probably the largest remaining elephant population in Africa. As far as large mammals are concerned CNP is not a complete ecological unit but part of a far larger ecosystem.

2.7.2 Large Mammals

There are 27 protected mammal species listed in the 6th schedule of the Wildlife Conservation and National Parks Bill (1992). Nineteen occur in the CNP, making it an important area for the preservation of protected species. Most of the protected species that do not occur in the CNP are found in the drier areas to the south.

The most comprehensive description of the large mammal fauna found in the CNP is given by Child (1968) who discussed the status of 36 species at that time. FGU (1988) listed a total of 50 species of monkey size and larger. A more complete list of species thought to be present at this time is shown in Appendix 9.

Estimates of numbers of animals in the CNP have been made from aerial counts done over a number of years, the first being a partial count covering a small area, in 1965 (Hepburn and Child, 1965, in FGU, 1988) followed by aerial counts of elephants between 1973 and 1975 (Sommerlatte, 1976). The earlier surveys (before 1980) used methods which make the comparison of results with recent surveys invalid because the strip widths used were very wide and would have yielded gross underestimates.

Melton (1985) carried out aerial surveys over the CNP and Enclave in 1981, the Kalahari Conservation Society carried out a series of surveys in 1984 and 1985 and DWNP did surveys in 1987 (FGU, 1988). In 1989, an aerial survey co-ordinator was appointed in the DWNP and a programme of country wide aerial surveys was started. CNP and the surrounding areas were counted in September 1989, April 1990, September 1990 and March 1991 (Bonifica, 1992). The same areas were also covered in September 1991 and April

1992 (DWNP, 1991; DWNP, 1992). Tables 8 and 9 show dry season and wet season population estimates respectively for the CNP from these surveys. There are great differences between population estimates for the same species in different years e.g sable, tsessebe, impala and zebra in the dry season and wildebeest in the wet season and the estimate for buffalo is certainly low. The confidence limits for all species are too wide to draw any conclusions about trends in numbers. Tables 10 and 11, while not accurate, do serve to show that for many species, numbers are higher outside than inside the CNP.

It must be stressed that the numbers provided within these tables are the only population estimates that exist. The consultants believe that for this reason they should be included within the report, acknowledging the fact that much better estimates are required and this requirement will form part of the Volume 2 Management Plan recommendations.

Some species that do occur are not recorded because of their size and cryptic habits and the estimates of numbers from aerial surveys are certain to be underestimates (except for elephants), particularly for the smaller species.

Table 8 : Estimated numbers of the larger wildlife species in Chobe National Park from aerial surveys during the dry season. The 95% confidence limits are expressed as a % of the population estimate (Bonifica, 1992).

	Sept. 1989		Sept. 1990		Sept. 1991	
Species	Est.	95% CL	Est.	95% CL	Est.	95% CL
Elephant	16212	70	11592	78	16654	79
Zebra	4120	178	1217	191	2325	191
White rhino	0	-	0	-	0	-
Hippo	41	202	0	-	27	204
Warthog	82	204	53	215	54	148
Giraffe	968	71	847	101	703	77
Eland	0	-	0	-	297	183
Kudu	41	140	291	188	0	-
Gemsbok	0	-	26	204	81	205
Roan	41	138	0	-	54	217
Sable	144	138	53	157	1000	125
Waterbuck	0	-	26	204	0	-
Lechwe	0	-	397	215	0	-
Reedbuck	0	-	0	-	0	-
Tsessebe	82	163	953	144	5461	206
Wildebeest	0	-	0	-	0	-
Impala	989	170	2885	139	1595	171
Puku	0	-	53	214	0	-
Steenbok	206	96	79	211	27	210
Buffalo	124	151	26	219	595	136
Ostrich	165	152	53	133	189	184

Table 9 : Estimated numbers of the larger wildlife species in Chobe National Park from aerial surveys during the wet season. The 95% confidence limits are expressed as a % of the population estimate.

	April 1990		March 1991		April 1992	
Species	Est.	95% CL	Est.	95% CL	Est.	95% CL
Elephant	3212	70	5397	42	6811	52
Zebra	2871	142	2265	183	1095	168
White rhino	0	-	56	209	0	-
Hippo	41	202	0	-	0	-
Warthog	227	205	56	218	0	-
Giraffe	1052	99	1454	74	851	67
Eland	0	-	0	-	0	-
Kudu	284	168	84	204	170	118
Gemsbok	0	-	0	-	0	-
Roan	114	210	168	205	50	142
Sable	824	169	391	175	0	-
Waterbuck	0	-	0	-	0	-
Lechwe	0	-	0	-	0	-
Reedbuck	28	207	0	-	0	-
Tsessebe	256	208	336	173	0	-
Wildebeest	2075	204	28	206	0	-
Impala	5486	135	3747	137	0	-
Puku	0	-	28	218	0	-
Steenbok	341	106	280	61	125	120
Buffalo	3695	159	2461	186	4558	217
Ostrich	284	144	419	149	50	194

Table 10 : Population estimates in areas around Chobe National Park from aerial surveys in September 1990 (Bonifica, 1992). For location of the areas see Fig. 1.

Species	CH1 2934 sq km	CH12 7683 sq km	NG14 4996 sq km	NG18 3601 sq km	Total
Elephant	3868	3014	19319	4618	30,819
Zebra	1219	582	9234	199	11,234
Hippo	159	0	875	0	1,034
Warthog	0	0	292	0	292
Giraffe	26	185	753	323	1,287
Eland	26	185	122	0	333
Kudu	0	211	24	0	235
Roan	0	0	49	0	49
Sable	477	793	49	0	1,319
Lechwe	0	0	2965	50	3,015
Tsessebe	0	26	729	50	805
Wildebeest	0	0	729	0	729
Impala	0	423	2916	323	3,662
Buffalo	0	0	1337	0	1,337
Baboon	0	0	24	0	24
Lion	0	0	24	0	24
Cattle	12849	0	0	0	12,849
Sheep+goat	980	317	0	0	1,297
Donkey	450	0	0	0	450
Ostrich	53	0	74	0	127

CH1 includes CH1+CH2
CH12 includes CH4+5+6+7+8+9+10+11+12+13
NG14 includes NG14+15+16
NG18 includes NG18+19+20

Table 11 : Population estimates in areas around Chobe National Park from aerial surveys in March 1991 (Bonifica, 1992). For location of the areas see Fig. 1.					
Species	CH1 3088 sq km	CH12 7898 sq km	NG14 5093 sq km	NG18 3367 sq km	Total
Elephant	1910	9714	5761	10133	27,518
Zebra	337	56	843	330	1,566
Hippo	0	0	1096	55	1,151
Warthog	0	0	422	165	587
Giraffe	28	195	787	413	1,423
Eland	0	28	0	0	28
Kudu	28	307	112	83	530
Roan	84	56	703	0	843
Sable	0	1284	0	83	1,367
Waterbuck	0	0	112	0	112
Lechwe	0	0	1855	1514	3,369
Reedbuck	84	0	28	193	305
Tsessebe	0	56	815	330	1,201
Wildebeest	0	0	281	0	281
Impala	0	0	3400	2726	6,126
Duiker	0	56	56	0	112
Steenbok	56	195	112	165	528
Buffalo	1405	56	2248	138	3,847
Cattle	8062	56	0	0	8,118
Sheep+goat	1405	0	0	0	1,405
Donkey	253	56	0	0	309

CH1 includes CH1+CH2
CH12 includes CH4+5+6+7+8+9+10+11+12+13

NG14 includes NG14+15+16

- *Elephants*

  In 1991, Botswana's elephant population was estimated to be 60,902 +/- 8081, comprising 40% of the wildlife biomass in the country (Bonifica, 1992). Of these about 400 were in the Tuli Block and the rest occupied a range of approximately 80,000 sq km in the north of the country (Figure 9). There are indications that the population increased significantly in size between 1987 and 1991, but the significance is marginal, and more surveys are required to confirm this (Bonifica, 1992). Approximately 8% of the total population can be found in the CNP during the wet season and 24% in the dry season.

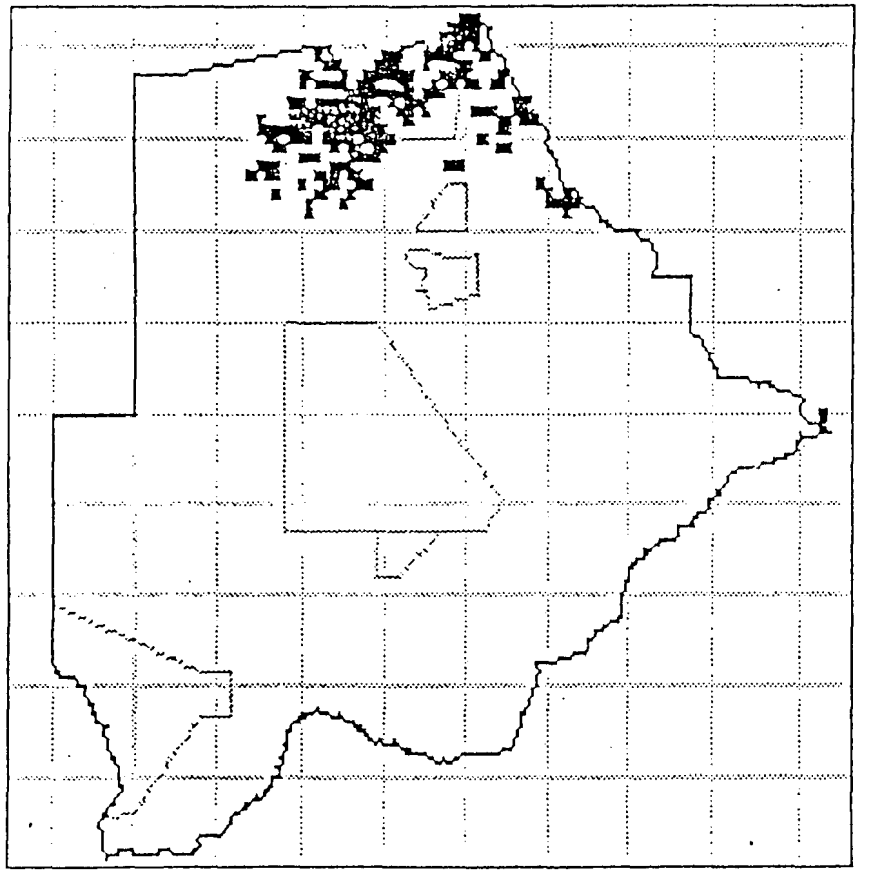
  The official DWNP estimate was 54 600 (±14,8%) in 1989/90 (DWNPa, 1991) and is now 55 000 (±13%) calculated as a mean of all wet season and dry season counts since 1989 (*pers comm.* R Masago, DWNP). The elephants are part of a larger contiguous population that extends from north west Zimbabwe through Botswana, western Caprivi and into southern Angola and south west Zambia.

- *Black rhino*

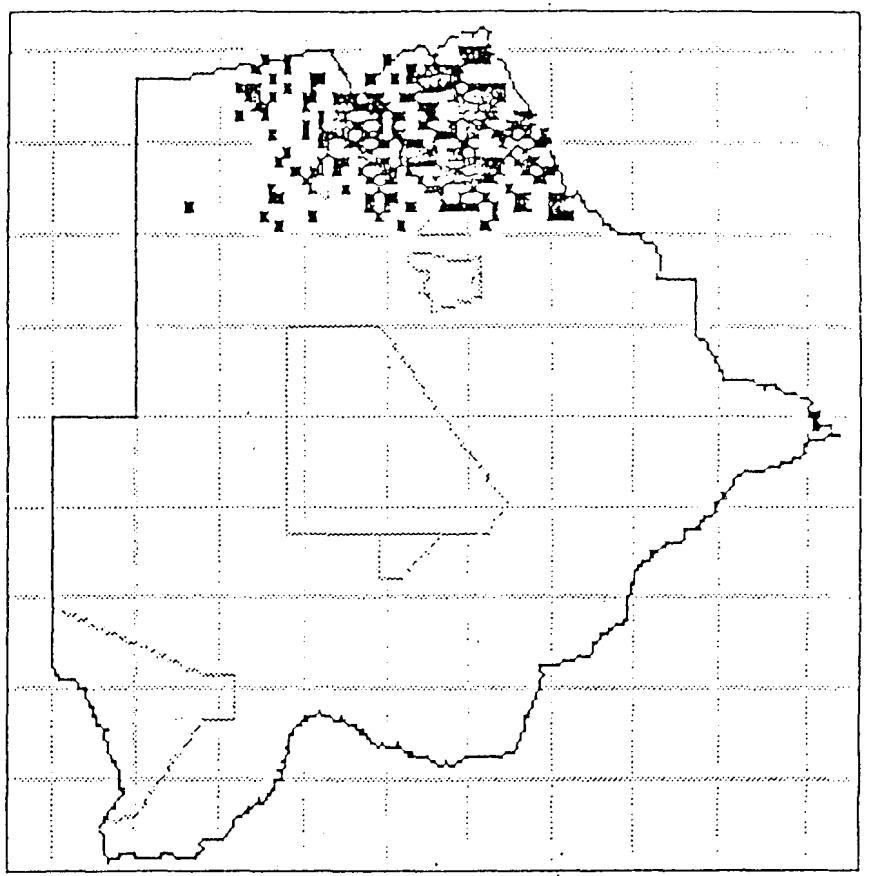
  Child (1968) recorded recent sightings of animals and spoor and noted that although the actual number present in the area was unknown it was clear that they had declined in the previous 20-30 years. There are still isolated reports of black rhino but there are probably not more than 10 in the CNP and surrounding areas. Two were killed by poachers on the western boundary in 1991.

- *White rhino*

  White rhino became extinct in the CNP between 1880 and 1890 (Smithers, 1971). In 1967 five were introduced into the CNP from Natal and between 1974 and 1976, 37 were introduced, with 14 also going to Moremi Game Reserve. Subsequently 92 more were introduced into Chobe and Moremi but the exact number to each is uncertain (FGU, 1988). In 1981, Melton estimated the total number in the CNP to be about 100 (in FGU, 1988). They have apparently declined in number as a result of poaching and in the 1980s they were commonly seen in the Serondela area in the dry season (*pers comm*). They are no longer seen in this area. Some did remain in the Ngwezumba dam area as they were recorded in the aerial survey in March 1991 (Table 11). Seven rhino were also seen from the air on a different occasion in 1991 and spoor was seen on the eastern edge of the Mababe depression (*pers comm*). They have been a target for poachers in 1992. Up to 1985 they were seen at Savute but are no longer present. Their disappearance may be associated with the drying up of the Savute channel rather than poaching but it is most likely that poaching is the greatest reason for their decline in the CNP.



(a) dry season



(b) wet season

Fig. 9 : Seasonal distribution of elephants in northern Botswana (Bonifica, 1992)

- *Eland*

  There are estimated to be 20 000 eland in Botswana, with the main concentration in the Central Kalahari Game Reserve. Eland are not seen regularly in Chobe during aerial surveys and there seem to more outside the CNP than within.

- *Kudu*

  Kudu are common in Chobe but easily overlooked in aerial surveys and the estimates for the CNP are certainly too low.

- *Waterbuck*

  Waterbuck are not common in CNP or in the areas immediately surrounding the Park, although they do occur along the Chobe river (*pers comm.* M Slogrove).

- *Puku*

  Puku are limited to a short section of the eastern flood plain of the Chobe. Apparently much more common in the late 1800s according to Selous, (Child, 1968), numbers have been much reduced and there are now thought to be about 100-150 compared to Child's (1968) estimate of less than 100. There is therefore no evidence that they are declining further, but they are now an isolated population as puku seem to have been eliminated in Caprivi.

- *Lechwe*

  Lechwe are the third most numerous wildlife species in Botswana according to the aerial surveys with the total estimate being 70 000. They are mainly concentrated in the Okavango Delta and along the Kwando/Linyanti with a few in Chobe. Within the CNP they are confined to the Chobe floodplain and the Linyanti but occur over a larger area than puku. They are said to be declining and are a major target for cross-border poaching. Numbers in the CNP are low.

  The CNP population was formerly part of a larger population that included Eastern Caprivi in its range (Child, 1968). If the Chobe floodplain is completely inundated, the lechwe may be forced to cross to higher ground in Caprivi where they will be vulnerable to poaching.

- *Sitatunga*

  There are very few in the CNP, probably about 10 on Sedudu Island. There are higher numbers in the Linyanti swamp in CHA 6 where they are afforded some protection in a WMA.

- *Bushbuck*

  They occur in the riverine vegetation of the Chobe and their numbers have been much reduced as a result of modification to the vegetation by elephants. A study of bushbuck on the Chobe river was done by Simpson (1974) and a more recent study in the same area by Joanna Addy has not yet been completed. Preliminary results indicate that although not often seen, they still occur in fair numbers.

- *Roan*

  The population estimate for the country is about 1 000 animals found mainly in Ngamiland and Chobe Districts. They are recorded regularly in aerial surveys of the CNP but the results indicate less than 100 animals, which is almost certainly an underestimate.

- *Sable*

  Sable are more common than roan and the country wide population estimate is about 3 500. In the CNP the aerial surveys indicate about 500 animals and there are also large numbers outside the CNP.

- *Oribi*

  Oribi have not been recorded in aerial surveys and occur only on the Kakulwane plain where numbers are unknown. Their distribution also extends outside the CNP in this habitat and more oribi undoubtedly occur outside than inside the CNP. They also occur in Caprivi in the area opposite the Enclave (*pers comm.* M Slogrove).

- *Grysbok*

  Child (1968) stated that they occurred only in the extreme east of the CNP near Kasane for a distance of about 2 km along the Chobe river. There is no further information and they must be considered to be extremely rare. Sightings are reported to be much less frequent than formerly.

- *Reedbuck*

  Child (1968) reported them to be rare in the CNP with the greatest numbers found in the Savute marsh. Following the drying of the Channel in 1983 all the reedbuck have disappeared from this area. Their numbers are reported to have declined on the Linyanti/Kwando and along the Chobe river (*pers comm.* M Slogrove).

- *Klipspringer*

  The specialized habitat requirements of this antelope limit its potential distribution to the few rocky areas present. Klipspringer formerly occurred along the Chobe "escarpment" from Simwaza to Ngoma, but numbers are said to have declined. It occurs on some, if not all, the hills in the Savute area and possibly on the Gcoha hills in what appears to be a recent range extension. It is thought that klipspringer do not occur in the Chinamba hills. Total numbers are undoubtedly low.

- *Red hartebeest*

  They are not normally considered to be present in the CNP but were recorded in the extreme south on the Mababe depression in an aerial survey in April 1992 (DWNP, 1992). It is possible that these animals were tsessebe that were incorrectly identified.

- *Gemsbok*

  Gemsbok are typically animals of the drier areas to the south of the CNP but do occur on the Kakulwane plain and are occasionally seen in the park.

- *Tssessebe*

  They were formerly more common and were resident along the Chobe river and the Kakulwane plain (*pers comm.* Slogrove). They are thought to have declined in number but some occur in the dry season at Savute marsh without access to surface water.

- *Bushpig*

  Apparently never numerous, they are now not seen, although they still remain on the mammal list for the CNP.

- *Buffalo*

  There are estimated to be around 40 000 buffalo in northern Botswana, comprising 10% of the total (wildlife) herbivore biomass. The total number has declined

significantly since 1987 possibly from overhunting. Buffalo are very mobile and undoubtedly move in and out of the CNP seasonally. Although some local residents claim that numbers in the CNP have increased, Mike Slogrove (*pers comm*), former game warden, stated that there are fewer than there were twenty years ago.

- *Wild dogs*

  Recognized as the most endangered large carnivore in Africa (Ginsberg and Macdonald, 1990) this species occurs from western Zimbabwe across northern Botswana in one contiguous population, which probably represents the largest population on the continent. They appear to be at higher density in Moremi Game Reserve than in CNP, probably because of higher prey densities. There are occasional sightings in the Savute area, where there are thought to be 2 or 3 packs, with probably 2 more in the Noghatsau area (*pers comm*). They may be more common outside the CNP to the east, as they are seen on the Nata-Kazungula road, where it is not uncommon for dogs to be killed by vehicles.

Seasonal Movements

Most species of water dependent animals undergo some seasonal change in home range associated with widespread surface water in the wet season and relatively few sources of water by the end of the dry season (e.g. buffalo). Three species in particular show very marked seasonal movement patterns in the Chobe area.

- Elephants

  The aerial survey results clearly demonstrate the seasonal changes in elephant distribution in northern Botswana (Fig. 9) During the wet season elephants are spread over an area of about 80 000 sq km north of latitude 20° and are only absent from the extreme west of the country. During the dry season most of the population moves to permanent water sources in the Okavango delta, the Chobe and Linyanti rivers and the artificial water points at Noghatsau and Tjinga within the CNP. Around 200 elephant bulls remain around Savute. The timing of this seasonal shift depends on the patterns of rainfall in the previous wet season and the persistence of water in seasonal pans. In an average year, most seasonal pans will have dried by the end of July with the largest pans likely to last longer.

This pattern is somewhat different to what existed before elephant hunting ceased in Botswana. When hunting was permitted there was heavy pressure on elephants along the Linyanti and relatively few animals were found there. They were forced to remain within the CNP and dry season densities were higher at that time than at present. The change of distribution pattern is clearly demonstrated by the distribution maps of Melton (1985) and Bonifica (1992).

- Zebra and wildebeest

The movement patterns of these species have been studied by Vanderwalle (1988). At the start of the rains up to 20 000 zebra move from their dry season range on the Linyanti past Gcoha hills to Savute marsh and to the southern end of the Mababe depression. At the end of the rains, and before seasonal pans dry up the zebra move north again.

A wildebeest population of about 500 animals show the same pattern but follow behind the zebra and remain in the wet season range until the pans dry up.

There are also other zebra in the CNP that are not part of this migration and remain in the Noghatsau/Kwikampa area. Before artificial water points were established they moved to the Chobe river when seasonal pans dried (Child, 1968).

Poaching

Since 1988 the anti-poaching unit based near Kasane has been responsible for combating illegal hunting in the CNP and surroundings. Most poaching within the CNP and along the Kwando is done by people from the Caprivi strip who regularly penetrate up to 10 km from the border. Animals are killed for meat using firearms. Species affected include lechwe, kudu, impala and probably buffalo. Some of this poaching takes place on an opportunistic basis by people using dugout canoes posing as fisherman on the Chobe river and is very difficult to control, as even if the poacher is seen, once the poacher returns to the other side of the river he cannot be arrested.

Formerly, puku were snared in the long grass on the flood plain and it is not known whether this practice continues. Generally however, snaring is not a problem in the CNP, although it does take place outside the CNP, in particular around Lesoma and various cattle posts and the Pandamatenga farms. More commercial poaching for rhino and elephants does take place than previously. Rhino, both black and white, have virtually been

eliminated and the exact number of elephants killed is uncertain. There does not seem to be a high level of poaching by Botswana residents in the rest of the CNP.

Problem Animals

These fall into 3 categories, mainly animals that damage crops, carnivores that kill stock and animals that cause problems in the CNP, usually for tourists or tour operators in campsites. Around Chobe the main problem areas are in the Enclave, in the Kazungula/Lesoma area and the Pandamatenga farms. Animals killed in these areas since 1990 according to DWNP records are shown in Table 12. Information shown in this table may be incomplete. It is difficult to justify the number of valuable and protected animals killed on the Pandamatenga farms under the cover of crop protection.

Elephants have not been a problem around Kasane, where only about 6 elephants have been killed in the last 5 - 6 years (*pers comm.* Slogrove and Van Eyssen). The Chobe banana farm has an electric fence which undoubtedly reduces conflict there.

Animals, and elephants in particular, have traditionally moved between the woodlands of the Kasane Forest Reserve and the river between Kasane and Kazungula to go to water and use a large salt spring close to the river, north of the road. If ribbon development along the road that block this access is allowed to continue, problems of conflict between the animals and people are certain to arise.

Within the CNP, problems are experienced with baboons and monkeys at Serondela and Chobe Game Lodge and elephants at Savute. When they become too much of a nuisance or a danger to visitors these animals are usually shot.

Cross-border movement of animals

Cross-border movement is possible into the Caprivi strip and into Zimbabwe. The extent to which it occurs is unknown but the only significant movement is likely to be by elephants and buffalo. There have been reports recently of elephants crossing the Linyanti into Caprivi (*pers comm.* D Joubert) and there is certainly some movement of elephants between Botswana and Zimbabwe (*pers comm.* Calef).

There is very little movement of animals from the CNP across the Chobe river into Caprivi because of the hunting that takes place. Elephants are known to cross occasionally and lion sometimes kill cattle in Caprivi. The biggest problem appears to be the incursion of large

numbers of cattle across the Chobe to the west of lechwe flats when the river is shallow. They remain on the riverine grasslands and may have significant impact on grazing available to wild herbivores.

2.7.3 Small Mammals

For the smaller mammals, there are no checklists and little information on status and distribution. Some rodent collection was done in the early 1970s (*pers comm.* Carr-Hartley), but the whereabouts of the records, if any exist, is unknown. For this report a provisional list has been extracted from Smithers (1971) and is listed in Appendix 10).

Table 12 : Problem animals killed in the Chobe area, 1990 - 1992 (DWNP records, Kasane). Data for 1992 are from January to July. CE - Chobe Enclave K/L - Kazungula/Lesoma PMT - Pandamatenga farms

Species	1990			1991			1992		
Species	CE[1]	K/L[1]	PMT	CE	K/L	PMT	CE	K/L	PMT[2]
Elephant	-	-	3	2	1	1	4	0	-
Hippo	-	1	0	0	0	0	0	0	-
Buffalo	0	0	14	0	0	6	0	0	-
Eland	0	0	14	0	0	6	0	0	-
Kudu	0	0	4	0	0	4	0	1	-
Sable	0	0	11	0	0	4	0	0	-
Roan	0	0	1	0	0	6	0	0	-
Tsessebe	0	0	5	0	0	2	0	0	-
Waterbuck	0	0	6	0	1	2	0	0	-
Reedbuck	0	0	6	0	0	0	0	0	-
Impala	0	0	0	0	0	0	0	1	-
Duiker	0	0	1	0	0	0	0	0	-
Lion	0	0	2	6	2	3	0	2	-
Leopard	0	0	0	2	1	6	3	0	-
Genet	0	0	0	0	0	1	0	0	-
Crocodile	0	0	0	0	0	0	0	1	-
Ostrich	0	0	2	0	0	1	0	0	-

[1] Data appear to be incomplete
[2] No data available

2.7.4 Birds

Child (1968) listed 309 species and FGU (1987) listed 409 species. A Bird atlas project under the auspices of the Bird Club of Botswana has been underway since 1980 and maps showing bird distributions should be published in 1992 (*pers comm.* D Bishop). In this project 460 species have been recorded in the Park and it is considered likely that up to 20 more are likely to be recorded (*pers comm.* Carr-Hartley). A full list is given in Appendix 11. Fifty of these species have very restricted distributions in Botswana, being confined largely to the Okavango Delta and the Chobe river (Newman, 1989). Two species, the slaty egret and the corncrake are considered to be threatened species (IUCN, 1990).

Anecdotal reports from Slogrove (*pers comm*) are that there have been declines in most species of migratory waterfowl, e.g. Yellow-billed duck, Spurwing geese, Egyptian geese and Red-billed teal. Although there are still large numbers of White-faced ducks, there are fewer than existed formerly. A Pink-backed pelican breeding colony in the Linyanti was abandoned by the birds in 1992. The reasons for these changes are unknown.

The Wildlife Conservation and National Parks Bill, 1992, does not list individual species of protected birds, but includes a number of taxonomic groups, most of which are represented in the CNP.

2.7.5 Amphibians and Reptiles

There is no checklist of amphibians and reptiles specifically for CNP. Auerbach (1987) gives species and localities from which they have been recorded for the entire country and those from the CNP and immediate surroundings have been extracted to make a provisional checklist for this report (Appendix 12).

Crocodiles occur in the Chobe river and are thought to be increasing in spite of suffering mortality in fish nets (*pers comm.* Carr-Hartley). Prior to 1970 crocodiles were hunted and there were few in the river. Pythons are the only protected reptile in Botswana and certainly occur in the CNP.

2.7.6 Fish

There is no checklist of fish that occur in the CNP. The fish fauna is however, likely to be similar to that of the Upper Zambezi and a provisional checklist (Appendix 13) has been drawn up for this report from Bell-Cross and Minshull (1988).

2.7.7 Hydrobiology

There is no information on hydrobiology in the CNP.

2.7.8 Invertebrates

Little work has been done on invertebrates generally in Chobe and there are no checklists specifically for the CNP. A checklist of butterflies of Botswana has been published in four parts (Pinhey, 1968, 1971, 1974, 1976) and Pinhey (1967, 1976) has also published information on dragonflies.

Tsetse fly occur along the Linyanti and as recently as 1962 were present throughout the Enclave and along the Ngwezumba river. The Linyanti and Kwando were last sprayed aerially for tsetse control in 1987 and ground spraying was carried out annually up until 1991. A history of tsetse fly control in Botswana is given by Davies (1981).

2.7.9 Evaluation

Mammals

The gross differences in estimates of population size for most species between different surveys and the high confidence limits to the estimates demonstrate that these surveys are not satisfactory for estimating numbers other than for elephants, particularly if estimates are required for sub-units within the total survey area. They also provide data at too crude a level to show anything but gross seasonal distribution patterns of elephants within CNP and the neighbouring areas. The problem is that the sample intensity is very low, generally around 3.5% to 4.0%. Transects are flown approximately 10 km apart so that 12 north-south transects cover the entire east-west width of the CNP, and the distance between the Chobe river and the southern boundary is divided into only 10 blocks. With the low density of animals it is likely that species could be missed in any single block. The number of animals of all species other than perhaps elephants is likely to be greater than the survey results indicate.

Although the results do not definitely show that elephants are increasing in number it is highly probable that they are increasing. This raises the question of population control i.e. culling, which has been a controversial issue in Botswana for some years. The subject of culling is discussed in more detail in the Volume 2 report.

Poaching

At this stage illegal hunting is perceived by DWNP to pose an insignificant threat to most species (*pers comm.* M Buser). Exceptions are black and white rhino that have already been reduced to low numbers and possibly eliminated, and lechwe along the Chobe river. There is also a threat of more organised, more intense elephant poaching, mainly from Namibia.

An important factor may also be overhunting by licensed hunters in CHAs outside the CNP and while it seems to be accepted that this occurs the actual magnitude of the problem is unknown. It may be the most important factor in the decline in numbers of buffalo and zebra in particular. The appointment of a new officer in charge of the Anti-poaching Unit (APU) and liaison with the BDF should help in curbing these irregularities as well as more effectively combating the expected upsurge in cross-border poaching.

Problem animals

The number of animals reported killed in protection of crops and livestock is not at present a threat to the survival of any species. The official figures do not however, reflect the magnitude of the problem, as put forward by local people, since many complaints receive no reaction from the DWNP, and some local residents feel that more animals have been killed than are shown in the official figures. There is, however, no hard data.

On the Pandamatenga farms, the number of animals killed is excessive, and again the official figures are thought to underestimate the scale of the problem. Landholders were supposed to have fenced their properties to prevent animals entering but they have not done so and the laws give farmers great leeway in where they can kill animals that are a potential threat to their crops. The system is open to abuse but probably does not directly affect animal populations in CNP.

Other groups

Except for birds there is very little known about the other groups of fauna in the CNP and there is a clear requirement for basic inventory work.

Importance of contiguous areas

The Linyanti River, from Zibadianja north is a very important source of dry season water of food for elephants, buffalo, zebra and wildebeest. It is necessary that this area continues to receive protection and not become settled or farmed. The Chobe Forest Reserve is also important as it separates the CNP from this area and acts as a corridor for access to the Linyanti. The CNP also joins the Moremi Game Reserve and it is important that movement of wildlife between the two protected areas is not hindered by any future development.

Contiguous protected areas in Zimbabwe and Namibia

The north western area of Zimbabwe adjacent to the Botswana border is under wildlife utilization in the form of National Parks, Forest Reserves or Safari Areas as far south as the Nata river. Between the CNP and border, considerable development has taken place and is likely to expand and this will have a negative impact on movement between Zimbabwe and the CNP.

The area of Namibia adjacent to the CNP is heavily settled and virtually denied to wildlife. At present there is a link between the CNP and the western Caprivi Game Reserve and north to Cuito-Cabango Reserve in Angola. This corridor could be cut by settlement along the Kwando River.

FAUNA

MAIN ISSUES

- For a number of species, in particular elephants, zebra, wildebeest and probably buffalo, the CNP does not cover the complete range and these species spend a large part of the year outside the CNP. The Linyanti river is a particularly important dry season source of water and grazing for a number of species, without which the CNP would not retain its diversity of wildlife.

- The very large, probably expanding elephant population, of northern Botswana, has caused major changes to the vegetation, especially along the Chobe river and is now affecting vegetation along the Linyanti.

- The numbers of black and white rhino have declined as a result of poaching to a level where the populations are no longer viable.

- There is an apparent decline in the lechwe population. This species is perhaps the most characteristic species of the Chobe river front. The isolated puku population is in a precarious position.

- There is a decline of a number of other species, such as bushbuck and grysbok, for reasons that are not entirely clear but are probably associated with habitat changes.

- The poor quality of data on numbers and distributions of most species of large mammals within the CNP and the lack of information for all other groups of animals.

- Excessive killing of animals at the Pandamatanga farms.

2.8 LAND SYSTEMS

The distinction of land systems is used to identify areas of relative stability, of particular sensitivity or of other significance to ecological processes, and therefore to planning. It provides a regional overview of physical resources and system functioning.

The land systems map (Map 8) is derived from the 1:250 000 soils maps for the district, the land systems and physiographic maps which accompany the soils maps, and from the broad geomorphologic history of the area. The approach used by CSIRO is followed (FAO, 1990) in which a hierarchy of land regions contains smaller land systems grouped on the basis of geomorphological and topographical similarity. Due to the extensive Kalahari cover, the regions themselves are also distinguished on broad geomorphological characteristics, rather than hardrock geology. Some grouping of units within systems has been done for the sake of clarity. Over the basic criteria of soils and geomorphology, a tertiary level has been used, namely surface hydrology.

Four major regions and one minor region are distinguished :

- Sand plateaux
- Lacustrine depressions
- Perennial rivers and associated scarp, tributaries and floodplains
- Seasonal/irregular rivers, and associated features
- Rocky Hills

These regions are discussed in the following sections :

2.8.1 Sand Plateaux

Longitudinal dune systems

This system mostly occurs outside of the CNP itself, to the east. The dunes are arid phase relics, consisting of deep ferralic sands, and may be subdivided on the occurrence of interdunal depressions. In well developed interdunal depressions more clayey soils occur.

Sand plains with high pan density

These occur where lacustrine reworking of aeolian sands has taken place. Lacustrine action has increased the clay content of the sands, forming patches of luvisols.

Sand plains with low pan density

These represent deflated or reworked aeolian sands. They are generally comprised of deep ferralic sands.

2.8.2 Lacustrine depressions

Lacustrine depression with beach ridges and alluvial fans

The Mababe depression is a flat lake bed, bounded to the west, north and north east by pronounced beach ridges. Inflowing rivers have deposited sandy alluvial fans on the otherwise clayey old lake bed. Topographically it is a sump for most of the internal drainage in the study area.

Back-beach alluvial flats. These are peripheral to the lake bed itself. They consist of a complex mosaic of clay and sand alluvial deposits, laid down by ponding of the feeder rivers behind the barrier beach ridges.

Lake Liambezi is a currently dry lake bed that is subject to irregular flooding from the Linyanti and also the Zambezi.

Lacustrine plains

The Pandamatenga plains are lobes of a large old lacustrine system. They are poorly drained flat clays, on basalt bedrock. To the east, the basalt is exposed and being eroded. The Kakulwane, or northern plain is an important part of the catchment for the Ngwezumba river.

2.8.3 Perennial rivers

Channel and floodplains

The Chobe river and its floodplains is primarily a collector system for overflow from the Zambezi to the north, and irregularly the Linyanti to the west.

The Linyanti river flows along a fault scarp and consequently relatively little seasonal floodplain is developed. In years of high flow, discharge to Lake Liambezi and the Chobe system can occur.

Old alluvial deposits

The area between the Chobe fault line and the Linyanti is largely an area of fluvially reworked sands with some more clayey soils occurring to the north, around Parakurungu and Satau.

Scarp and seasonal tributaries

A narrow zone along the perennial river frontages where topography causes some erosion, and locally high groundwater supports riverine vegetation. Old river terraces along the Chobe have exposures of calcrete/silcretes. In some of the seasonal tributaries, the bedrock is exposed or sub-outcrops. The area is prone to erosion.

2.8.4 Sporadic rivers

Incised channels and associated floodplains.

The Ngwezumba/Molapowadiphofu and Potopoto/Gautumbi systems are strictly seasonal/sporadic flow systems. Valley floors are well incised in places. Floodplains often have a high density of pans. These systems are important for water supply from seeps. Some parts of the terraces are erosion prone.

The Savute channel is an outflow from the Kwando/Linyanti system. Its flow is highly variable and dependent on hydrological conditions on the Kwando (see Section 2.5, Surface Water).

The Khwai/Mogogelo (Kudumane) system is a similar outflow, from the Okavango system. Flows are more seasonal and less sporadic than the Savute, but rarely under present conditions actually reach the Mababe depression.

2.8.5 Rocky Hills

These are isolated inselbergs that form island systems in the otherwise flat plateaux and lake beds.

2.8.6 Discussion

This division provides a useful system for ranking land units according to their ecological sensitivity. This parameter may be related directly to the water relations within a given system, and also highlights the relationships between the systems.

For example, the Kakulwane (northern Pandamatenga) plains are comprised of lacustrine clays. Edaphic conditions in these clays, which are very prone to waterlogging, preclude the establishment of woody species on the plains. In addition to this, the low permeability of the clays means a low infiltration rate, and consequent high runoff potential, modified by the flat topography. The plains drain from the south east (FAO, 1988), and act as the catchment for the Ngwezumba river, a separate land system, but one in which ecological processes are entirely dependent on the water inputs from the plains. These include recharge to the shallow aquifers (seep supplies) along the valley, and also the potential for short high volume flow events which may reach as far as the alluvial fan in the Mababe depression, a third system. Similarly, sporadic flows in the Savute channel help to maintain the edaphic grassland of the Marsh. These flows are dependent on changes occurring in the Kwando/Linyanti system.

These factors have been used to identify sensitive areas and areas prone to change in which careful planning and management are needed in order to maintain natural processes and variability, such as :

- Savute channel and alluvial fan (the "marsh") with water availability/flooding dependent on Kwando hydrology
- Kakulwane plains, Ngwezumba valley and Zweizwe alluvial fan
- Perennial river frontages
- Khwai river and floodplains

LAND SYSTEMS

MAIN ISSUES

- Water availability, the primary determinant for both plants and wildlife depends on natural processes inside and outside the CNP. Land use in the areas outside the park is a major determinant in the functioning of the natural system.

- Any imposed change which reduces natural variability or affects the peripheral system will fundamentally affect the natural processes in the CNP. Examples might be manipulation (if possible) of the Savute offtake at Sibadianji or provision of artificial water to control animal densities.

JF8
Part II

CHAPTER 3

RESOURCE MANAGEMENT PROGRAMMES

3.1 MANAGEMENT ZONES

Based on the information described in Management Plan : Volume 1, Chapter 3, and a fundamental value system, zoning proposals were developed to protect the integrity of the bio-diversity of CNP. These are contained in Appendix 15 supported by maps titled "Management Proposals" (Annexure A) and "Zoning and Planning Proposals" (Annexure B) which forms part of Appendix 15. These zoning proposals should be referred to when considering the long term conservation of CNP.

In view of some practical considerations pertaining to specific management requirements of DWNP, these zoning proposals have been adapted to the proposals contained in this chapter. The naming of the zones have also been changed to more accurately describe the use of the zone.

3.1.1 Analysis

The following guidelines were used in developing the zoning proposals (see Appendix 1):

- The land systems in the Chobe region, as identified in Section 2.8 and Map 6 of Management Plan : Volume 1. The zoning is primarily based on protecting the ephemeral drainages flowing into the Mababe Depression and associated pans. Collectively they provide much of the surface water within the Park that drives the movements and distribution patterns of water dependent wildlife species. This watershed is also one of the few unaltered examples of a closed natural drainage system within southern Africa. As such, it has great value for environmental education and scientific research purposes.

- Current and proposed tourist development was applied to these land systems and areas less sensitive to disturbance designated for varying intensities of public use to accommodate the developments. Popular use areas with existing infrastructures are zoned to maintain tourism within prescribed limits. Carrying capacities (refer Appendix 13) of respective zones have been calculated to assist management with

Appendix 13) of respective zones have been calculated to assist management with regulating visitor numbers to CNP. [3] It is intended that carrying capacities proposed will eventually be replaced with Limits of Acceptable Change (LAC) for environmental and social conditions [4].

- The baseline information required for developing LAC's will be provided by the proposed inventories and monitoring projects. (Also see Chapter 4 and Appendix 10.) Park managers will then use this information to draft measurable conditions desired by management. These conditions will be reviewed by management and used to refine pilot LAC's as appropriate.

- For practical rather than scientific reasons, boundaries of the zones follow natural features and the roads/firebreaks network that can be readily identified on the ground.

A total of six management zones have been described for the area of the CNP:

- Protection Zone
- Low Use Tourism Zone
- Medium Use Tourism Zone
- High Use Tourism Zone
- Special Protection Zone
- Transition Zone.

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[3]Carrying capacity as used in this plan is the maximum measurement of bednights and vehicles/kilometre allowed in each zone.

[4]LACs are explicit statements of management objectives. The objectives are defined by acceptable ranges of resource and social conditions. The intent is to define the conditions desired for management rather than on how much use the environment can tolerate. Each objective has a range of specific conditions that are measurable. These conditions are the "standards of naturalness" for maintaining vegetation mosaics and associated wildlife compatible with each of the management zones. Similarly, standards for human activities are prescribed to maintain the appropriate level of "wilderness experience". Routine monitoring is required to assess management success in maintaining these conditions. When conditions do not conform to the prescribed values, management action is taken to return them to the permissible range. This action includes the rewriting or abolishing of LACs that prove to be impractical or not possible. LACs are reviewed periodically to reflect changes in management priorities and updated information from monitoring programmes.

It is recognised that the zone classifications were prepared with limited information about environmental and social conditions within the park. The proposed zone boundaries are subject to change in response to new information. It is intended that the results of baseline inventories will be used to prepare LACs for each zone. Boundary readjustments may be required to implement the LACs and improve management efficiency.

The distinguishing feature of these zones is the variation in their intensity of use, which reflects the view that park management is primarily managing the human impact on the natural environment. Unique sites (cultural, ecological, etc) are recognised as special protection zones requiring site specific management. These unique sites should be identified by park management and appropriately designated. (Refer Section 3.6)

The effect of changes in land use outside the CNP can seriously impact on the park itself. It is therefore important to establish which of the important ecological features determining the well-being of the CNP lie outside the park boundaries. An option is to expand the CNP boundaries but that may be politically imprudent at this stage. It is also important that some of the benefits of the CNP be transferred to the people in surrounding areas in a more direct and tangible manner. Certain community areas should be established where a combination of activities relating to tourism or resource utilisation can be developed. Recommendations must be compatible with the district land use plans. This management plan, therefore, recognises an additional zone with no definable boundaries or prescribed management activities. This Transition Zone encompasses the adjoining communities areas and Forest Reserves.

3.1.2 Description of the Management Zones

This section should be read in conjunction with Appendix 1 except for the transition zones, which are not shown since they occur outside the park, and the special protection zones which are too small for representation at this scale.

Protection Zone

No development or management intervention will be allowed in this zone. This zone contains unique ecological features which are most critical to the CNP ecosystem. (For a more in-depth argument to the importance of this area, please refer to Appendix 15, para 3, "Ecological Protection Zone".) The priority for management is complete protection of the natural environment.

Objectives

The specific management objectives for the Protection Zone are :

- **To maintain and preserve biological diversity and essential life support systems.**
- **To provide facilities and opportunities for research and monitoring to further understand the physical and biological processes within the CNP.**

This zone comprises approximately 25% of the CNP and encompasses the Linyanti wildlife migration corridor to the Mababe Depression and the natural pans to the South.

In line with the specific management objectives, no tourist or administrative facilities are planned for this zone, which currently includes the Mababe entry/exit point with gate-house, staff accommodation, domestic use boreholes and graded transit roads to other zones. Access into this zone should be for normal management purposes and research.

Low Use Tourism Zone

This zone is designated for low impact visitor use. Management aims to retain the pristine wilderness quality of the natural environment, while accommodating limited and infrequent visitor use.

Objectives

The specific management objectives for the Low Use Tourism Zone are :

- **To maintain and preserve biological diversity and essential life support systems.**
- **To facilitate opportunities for research and monitoring to further understand the physical and biological processes within the CNP.**

This zone comprises approximately 63% of the CNP and includes a portion of the Kakulwane flood plain, the drainage systems of the Ngwezumba, Molapowadiphofu, Potopoto, Ghautumbi and the Savute Channel that all flow into the Mababe Depression.

Developments planned for this zone are restricted to activities and facilities with the least impact on the natural environment that also offer small numbers of visitors a feeling of remoteness and solitude. Accordingly, visitor use of this zone will be limited to guided hiking trails and access routes linking other tourism zones. Mobile tour operators should be allowed to establish wilderness campsites in this zone. (Refer Section 5.1.5(d)). These campsites should be established after consultation with the CNP management. Facilities for this zone include graded 4x4 through-roads, hiking trails, fixed campsites for mobile tour operators and wilderness campsites. Professional guides authorised to lead hiking groups will be allowed to camp randomly along hiking trails to minimise impact on any one site. Administrative facilities, in particular entry/exit gates and related staff accommodation will be developed on the periphery of the CNP.

The zone hiking carrying capacity is suggested to be 2 guided hiking groups per designated trail per week (maximum 10 visitors and guides per group). The vehicle carrying capacity of the Low Use Tourism Zone is 10km per vehicle. (Refer Appendix 13)

Medium Use Tourism Zone

This zone is designated for medium density visitor and management use. The principal management aim is to provide additional game viewing opportunities in the park with minimum interference to its wilderness quality. Detailed development plans for certain areas within this zone are discussed in Chapter 5.

Objectives

The specific management objectives for the Medium Use Tourism Zone are :

- **To maintain and preserve biological diversity and essential life support systems.**
- **To provide facilities and opportunities for research and monitoring.**
- **To develop and manage unobtrusive facilities to enhance visitor enjoyment and appreciation of the wilderness.**
- **To generate economic benefits from the CNP, while safe-guarding its ecological integrity.**

This area comprises approximately 8% of the CNP including the Noghatsau area, which has one of the largest concentrations of natural pans in Botswana, the Zweizwe pan area, the Savute marsh and the Linyanti river front, which has the last remaining riverine forest in the CNP. This forest is designated as a special protection zone.

Tourism facilities and activities proposed for this zone include graded 4x4 tracks, temporary tourist lodging, guided hiking trails, public campsites, exclusive campsites for mobile tour operators and school groups and night game viewing activities. Administrative facilities include entry/exit points with gate-house, staff accommodation, domestic boreholes, artificial water points and game viewing hides, airstrips for fly-in safaris and administrative and information offices for public campsites.

The zone carrying capacity is set at 192 beds of which 128 are in tented campsites and 64 in temporary tourist lodging. The vehicle carrying capacity is 75 vehicles or 4 km per vehicle. Facilities for school groups account for an additional 64 beds. (Refer Appendix 13).

High Use Tourism Zone

This zone is designated for high density visitor use and tourism related infrastructure. A development plan for this zone is discussed in Chapter 5.

Objectives

The specific management objectives for the High Use Tourism Zone are as for the medium use tourism zone and in addition :

- **To provide educational and interpretative programmes for visitors aimed at promoting an awareness and better understanding of the natural environment.**

- **To mitigate the less desirable impacts of existing or potential land use conflicts.**

This zone comprises approximately 4% of the CNP and includes the Chobe River Front bordered by the Kasane-Ngoma transit road. The scenic nature and wildlife species diversity of this area due to the perennial river system, is the major tourist attraction of the CNP. Although this zone is recognised primarily as a recreation area, CNP management will regulate visitor usage of the area through the number, distribution and size of tourist facilities. The carrying capacities (refer Appendix 13) will provide the necessary guidelines for visitor numbers.

Facilities and activities proposed for this zone include gravelled 2x4 and graded 4x4 vehicle roads, public campsites, mobile tour operator exclusive campsites, permanent lodging for organised educational groups, permanent tourist lodges, river cruises, guided hiking trails, picnic sites, game viewing hides, night game viewing activities and artificial water points. Administrative facilities comprise CNP headquarters with an entry/exit gate-house, workshop, garage, storerooms, accommodation for staff and a visitor centre complex which includes an environmental education facility.

The zone carrying capacity is set at 194 beds which include 96 camp beds. Maximum carrying capacities for vehicles will be 1km per vehicle. Facilities for school groups account for an additional 60 beds. (Refer Appendix 13)

Transition Zone

This area is needed to safe-guard the ecological integrity of the CNP and reconcile its conservation needs with the development activities of surrounding communities.

Objectives

The specific management objectives for the Transition Zone are as for the high use tourism zone and in addition :

- **To integrate conservation needs of the CNP with development activities of its surroundings and thus mitigate the less desirable impacts of existing or potential land-use conflicts through participation in management and sharing of benefits with communities neighbouring the CNP.**

The area of the Transition Zone overlaps the boundaries of different land-use practices and are therefore impractical to define. Two crucial components of the Transition Zone are:

Community Areas

The community areas include:

- The western section of the Enclave (area 5). Controlled Hunting Area (CHA) CH122, zoned for community use.
- The area between the Savute channel, the Linyanti River and the western boundary of the CNP (area 4). CHA NG41 zoned for commercial leasehold. Community involvement from area 5 should be investigated.
- The small southern triangle of the Mababe Depression and related landscapes which lie outside the CNP (area 3). CHA NG41 zoned for community use within a Wildlife Management Area (WMA).
- The area south of the Maikaelelo Forest Reserve along the eastern boundary of CNP (area 2) CHA CH11 zoned for photographic use with no settlements in it. However, some benefits from this area could be transferred to the communities in area 1.
- The Kakulwane flood plain which falls within the catchment of the Ngwezumba River. This plain is important as an example of a rare landscape type in Botswana, a rare ecosystem and a wildlife corridor which links to Zimbabwe. It should be protected from agricultural development and should be promoted as a community area (area 1). CHA CH8 zoned for community use.

It is proposed that this zone include a range of tourist activities to be developed by local communities, including the construction of permanent tourist lodgings of the High Use Tourism Zone (refer Section 5.1.4), but developments should be done in consultation with CNP management to ensure against any undesirable impacts on the functioning of the eco-system.

Forest Reserves

The Chobe Forests Inventory and Management Plan, Volume II Final Draft of 1992, has zoned areas of the Forest Reserves contiguous with the CNP for eco-tourism[5] development. The recreational uses of the Forest Reserves resources should be compatible with those of the CNP, and generate economic benefits for the nearby communities. These Forest Reserves include the Chobe, Maikaelelo and Kasane Forest Reserves.

In addition, it is recognised that cooperation with the Forestry Department of the Ministry of Agriculture is a pre-requisite for the implementation of the CNP Management Plan.

3.1.3 Summary of Management Objectives

For ease of reference, the management objectives for the CNP by zone are summarised below in Table 1.

[5]The Eco-tourism Society defined eco-tourism to include purposeful travel to natural areas; to understand the cultural and natural history of the environment, taking care not to alter the integrity of the ecosystem, while creating economic opportunities that make the conservation of natural sources beneficial to local people.

An important aspect in the planning and construction of eco-tourism facilities is the use of locally available building materials, traditional technology and the blending of architectural shapes with the natural environment.

Table 1 : Summary of Management Objectives by Zone					
Protection Zone	**Low Use Tourism Zone**	**Medium Use Tourism Zone**	**High Use Tourism Zone**	**Transition Zone**	**Special Protection Zone**
• Preservation of bio-diversity • Research and monitoring	• Preservation of bio-diversity • Research and monitoring • Generation of economic benefits	• Preservation of bio-diversity • Research and monitoring • Generation of economic benefits • Unobtrusive facilities	• Preservation of bio-diversity • Research and monitoring • Generation of economic benefits • Unobtrusive facilities • Education and inter-pretation • Mitigation of land use conflicts	• Generation of economic benefits • Unobtrusive facilities • Mitigation of land use conflicts • Integration of CNP conservation needs with surrounding development	• To be determined by designation

3.1.4 International and Internal Linkages

The region in the vicinity of the CNP probably contains the largest population of free ranging elephants in Africa today. It also lies at the junction of four countries where many other conservation areas exist, namely Angola, Zambia, Zimbabwe and Namibia. To date these areas have generally remained undeveloped and has a profound affect on the CNP eco-systems. It is obvious that the zoning proposals for the CNP should recognize the opportunities for better links with neighbouring countries with regard to wildlife conservation efforts and related tourism. The land between these protected areas is vital to the migratory movements of elephants and other wildlife. Six possible linkages, four of which cross the international boundaries are identified and are proposed for compatible land use planning. These are illustrated in Appendix 2 "Regional Linkages" and discussed below:

CNP - Caprivi Wetland (Linkage 1)

The first link is between CNP, bridging the Chobe river, and the wetland situated in the triangle at the Zambezi/Chobe confluence. This wetland has international value and while it is unlikely that the Namibian authorities will be motivated, because of the settlements in

the area, to establish an additional national park to protect this sensitive asset. Botswana should however work closely with Namibia to achieve compatible land use planning.

CNP - Kazuma Pan National Park (Linkage 2)

The second link stretches from the CNP across the Kakulwane plains and Kazuma Forest Reserve to the Kazuma Pan National Park in Zimbabwe. It is a significant migration corridor for elephants and other herbivores moving between CNP and Hwange National Park. There is also potential for a transfrontier National Park.

CNP - Hwange National Park (Linkage 3)

A third important link should be established between CNP and the Hwange National Park in Zimbabwe. This migration corridor has been disturbed by the development of the commercial farms in the vicinity of Pandamatenga. A possible migration corridor to the south of these farms via the Sibuyu forest reserve still exists.

CNP - Nxai Pan National Park (Linkage 4)

Although evidence suggests that game movement between the two parks is limited, it is physically possible to establish such a link. This could incorporate the Makgadikgadi Pans National Park and the removal of the now defunct veterinary fence which exists between the Makalamabedi quarantine camp and Nxai Pan.

CNP - Moremi Game Reserve (Linkage 5)

This link currently exists and serves as an important migratory link for elephant herds.

CNP - Caprivi/Angola/Zambia (Linkage 6)

One of the most important migration corridors potentially exists between the Chobe/Moremi complex and the national park system of Namibia, Angola and Zambia in the vicinity of the upper Kwando river. With the cessation of hostilities, wildlife movement to the west of the Kwando, sidestepping the densely populated Caprivi areas, towards the Caprivi Game Park (Namibia), Coutada Publica Do Mucusso (Angola) and the Sioma Ngwezi National Park (Zambia) is likely to develop.

It is recommended that international discussions should take place to create a framework that would allow international conservation projects to co-exist and function as a greater national park system. It is suggested that Botswana take a leading role in discussing proposals for these projects through the SADCC National Resources Management Programme.

3.2 SOILS, ROCKS AND MINERALS

Introduction

For more background information to this section, please refer to Chapter 2, Management Plan : Volume 1. Geological influences in northern Botswana are beyond the control of management with the exception of soil erosion, consumptive use of rocks and mineral deposits. Natural erosion does not present a problem. Soil management is largely passive, and like the management of rocks and minerals, focuses on preventative measures rather than conservation.

Objective

- **To preserve the pristine nature of the geological environment.**

Policies

- Soil erosion should be minimised.
- Removal of rocks and minerals by tourists should be prohibited.
- Roads should be located on structurally stable soils and not cut across areas of heavy clays or pan surfaces.
- Gravel sites within the park must be limited and controlled.

MANAGEMENT ACTIONS

Soils, Rocks and Minerals

1. Establish an erosion plan of the CNP and keep records of critical areas requiring maintenance, including borrow pits. Construct storm drains on problem roads.

2. Establish, where appropriate, a programme to rehabilitate barrow/gravel pits and existing excavations in the park.

3. The Ministry of Commerce and Industry and the Ministry of Mineral Resources and Water Affairs should develop guidelines for exploration and mining within protected areas. The DWNP should assist in development of these guidelines.

3.3 VEGETATION

Analysis

For more background information to this section please refer to Section 2.6 of Management Plan : Volume 1.

It is recognised that the management of fire, artificial water points and elephant populations within the CNP will be predominantly based on managing zones for specific vegetation conditions. The desired vegetation conditions will be stated as LACs once baseline inventories have been conducted. Research priority will be given to establishing vegetation baselines with emphasis on species of high interest like riparian, acacia and teak woodlands. After baselines are obtained, research will define how fire, artificial water points and elephant populations act as change agents for existing vegetation communities.

Fire, elephants and vegetation are dealt with in this section. Artificial water points are covered in Section 3.5.2.

Management intervention will be related to the LAC prescriptions for each zone. The objective with regard to vegetation is:

Objective

- **To maintain and preserve the biological diversity of plants and their habitat.**

3.3.1 Plant Species of Special Concern

Policies

- Plant species of special concern should be identified and afforded special protection.

- A comprehensive inventory for rare, sensitive and endangered plants should be maintained.

- The following specific areas should receive priority inventory attention:

  - The grasslands of Savute and the Kakulwane plains.

  - The rocky hills represent unique, isolated habitats which contain species different from the surrounding areas. Detailed plant collecting in the hills during the early wet season will probably identify a number of plant species new to Botswana.

  - The riverine woodlands along the Chobe and Linyanti rivers.

  - The present poor state of recruitment of the predominant tree species within the *Baikiaea plurijuga* woodlands and savanna and the long periods needed for recovery make improved management of the teak areas essential.

  - The species composition of the grasslands along the Chobe floodplain. These could be affected by heavy use of grazing animals.

  - The acacia savannas are changing rapidly - some areas have already changed from acacia to mopane dominated (Ngwezumba delta) or to shrublands.

- The grassy *comberetum hereroense* areas within the teak woodlands. These may be important to animal species diversity.

MANAGEMENT ACTIONS

Plant Species of Special Concern

1. Carry out baseline research to establish vegetation patterns for use in establishing LACs for plant species of special concern. Priority species are dealt with in Appendix 10.

2. Draw up a register of plant species of special concern indicating type and geographical location. Monitor on regular basis and, if necessary, take appropriate corrective action.

3.3.2 Vegetation and Elephants

Analysis

The Elephant Management Plan (DWNP, 1991) outlines the DWNP's aims concerning vegetation within the elephant home range. In the introduction it is stated that "..active management of elephants is necessary if woodlands are to be preserved". The two policy objectives with reference to vegetation are :

- Policy No 1.2 "Maintain elephant occupied woodland in an acceptable state, subject to climatic influence."
- Policy No 2.4 "Reduce elephant populations if research and monitoring indicate unacceptable changes to elephant habitat."

In addition, Strategy No 3.6 indicates the acceptable state of woodland to be that of the 1990 woodlands.

To maintain the plant communities in their 1990 state would not only require a complete coverage of 1990 aerial photographs at 1:50 000 or larger scale (which do not exist) but also radical manipulation of the elephant population, of which the numbers are uncertain.

Policy

- No decisions regarding the management of elephant populations will be made until LACs are established for vegetation conditions.

MANAGEMENT ACTIONS

Vegetation and Elephants

1. Conduct baseline vegetation inventory on a regional basis in conjunction with other authorities. Conduct inventory within the CNP as a priority.

2. Consider the development of artificial waterpoints in the high use tourism zone to disperse elephants and contain damage to the waterfront vegetation.

3. Identify and protect the habitats of rare and sensitive plants.

4. Establish pilot LACs and monitor and modify as appropriate.

3.3.3 Fire

Analysis

Before any planned fire management programme can be put into effect, some element of control must be established. Fire management in the CNP will involve active intervention by park management through the use of natural and man-made firebreaks aimed at establishing control, particularly in the fire prone areas and taking steps to suppress all fires. (See Appendix 3)

Policies

- All fires within the park should be attacked with available resources for at least the next three years. This, however, should be an interim measure until LACs are

prescribed for vegetation conditions. Thereafter fire should be used as a management tool to maintain vegetation conditions within the prescribed LACs.

- Fire management should emphasize reducing fire hazards before the burning season to minimise the need for fire attack. This will be done by:

  - Early fire detection through constructing unobtrusive fire lookouts and CNP overflights during the burning season.

  - Annual removal of vegetation by mowing, slashing and backburning to fire-proof structures and property and to maintain firebreaks. Lease holders should be encouraged to fireproof their properties.

  - A network of firebreaks should be created to reduce the risk of fire spread.

  - An infrastructure should be developed to promote fire attack readiness.

- Heavy equipment should only be used to create new firebreaks. Minimal grading will be used to maintain roads that are used as firebreaks.

- The fire management programme for CNP should be coordinated with the Forestry Department and Chobe District fire officers. It should be compatible with the Chobe Forests Inventory and Management Plan when approved.

MANAGEMENT ACTIONS

Fire

1. Liaise with District and forestry fire representatives to formulate a fire management plan. This will include transport logistics, training needs, fire fighting personnel, communication equipment, first aid, etc.

2. Develop a fire occurrence map, recording date, source, cause, wind strength, and level of damage to identify fire prone areas. Monitor effects of fire on vegetation and identify the natural fire regime. This should be the first step in an adaptive management approach towards determining the desired frequency and timing of management burning.

3. Promote fire attack readiness by establishing a 24-hour fire despatching centre for reporting of fires in the Chobe District.

4. Purchase VHF repeater base station (refer Section 7.7) for complete park radio coverage and radios for fire lookouts. Purchase equipment needed to improve fire fighting readiness and maintain firebreaks.

5. Designate a fire officer for the CNP and provide appropriate training.

6. Prepare a map of the man-made firebreaks, identify their type and integrate with the pattern of plant communities which act as natural firebreaks.

7. Double trace firebreaks will be constructed and maintained along park boundaries where wild fires have historically been concentrated (see Appendix 3). Newly constructed double trace firebreaks will be built approximately 30 metres apart as prescribed by the Forest Reserves Management Plan. Fuel accumulation between the firebreaks will be burnt once at the end of the growing season (approximately the second week in May).

MANAGEMENT ACTIONS (continued)

Fire

8. Appoint contractor to establish and maintain the firebreak system if the CNP is not in a position to perform this function.

9. Establish a firebreak monitoring and maintenance programme.

3.3.4 Control of Exotic Plants

Species classified as alien or exotic are not considered part of the biological diversity of the CNP.

Objective

- **To control exotic terrestrial and aquatic plants throughout the CNP.**

Policies

- The planting of fruit and vegetable plants should not be allowed in CNP. Exemptions should be confirmed in writing.

- Existing exotic plants at lodges should be registered and their status reviewed with experts. Where these are considered invasive, they should be phased out over a period of time.

- In the development of lawns at tourist lodges, only grasses indigenous to the Reserve should be used *(Cynodon dactylion)*.

- As the Department of Water Affairs (DWA) has an active and effective control programme, it is important that they are given assistance with their programme within the CNP and adjacent areas. Increased cooperation between the DWA and

the CNP management could be achieved by a member of the CNP staff accompanying the DWA officials during field operations and surveys of Salvinia in the CNP.

- Control the access of boats into and through the CNP. It is essential that boats do not travel out of the Chobe/Linyanti river systems. This would present the greatest possible risk of infestation and spread of Salvinia.

MANAGEMENT ACTIONS

Control of Exotic Plants

1. Routinely inspect vehicles entering the park for introduction of undesirable plants.

2. Register all exotic plants at lodges and elsewhere, and develop a phased plan to eradicate exotic plants from CNP.

3. Train CNP staff in the recognition of exotic plants and assist in developing an understanding of the risks of these plants.

4. Exhibit clear photographs of *Salvinia* at gates and interpretation centres to assist in recognition and reporting of this weed.

5. Map location and date of first occurrence of species of all listed exotic plants.

6. Develop a biannual campaign to clear undesirable exotic plants, concentrating on the high and medium use tourism zones.

7. Increase cooperation with the DWA and enforce boat access control.

3.3.5 Consumptive use of Vegetation

Policy

- To meet the stated goal of vegetation management, consumptive use of vegetation

within the CNP will be limited to campfires and controlled supply of firewood to local communities.

MANAGEMENT ACTIONS **Consumptive use of Vegetation**
1. Support proposed management actions in the Forest Reserves Management Plan regarding collecting of thatching grass and firewood.
2. Replace, in the medium term, all wood fired boilers in the CNP, including those of safari operators, with alternative heating systems. In the longer term, solar and photovoltaic systems should be considered by safari operators and the DWNP.

3.4 FAUNA

Analysis

For more background information to this section please refer to Section 2.7 of Management Plan : Volume 1.

The region has a remarkably rich fauna on account of the unique mixture of wetlands and semi-arid savanna in close proximity to each other. The fauna is dominated by elephants and the broader region, including Zimbabwe, Namibia and Angola, has what is probably the largest remaining elephant population in Africa. While the population estimates for other herbivores are not certain, there appears to be a significant reduction in numbers of most species. (Pers. comm. M Slogrove, D Joubert)

The primary function of management with regard to fauna is to determine species occurrence, population numbers and the habitats that they occupy. The research proposed in Chapter 4 will provide the base information for establishing related LACs.

In addition, management needs to resolve species - specific issues such as problem animal control and elephant management. These issues are dealt with in this section.

Objective

- **To maintain and preserve the faunal diversity within the CNP.**

3.4.1 Elephant Management

Policy

- Until LACs are established for vegetation conditions and the role of elephants in influencing these conditions is determined, no decisions regarding the management of elephant population should be made in the short term. (See also Section 3.3.2).

MANAGEMENT ACTIONS

Elephant Management

1. Carry out specific surveys to determine a more accurate population estimate and distribution of elephants in the wet and dry seasons. Improve monitoring of distribution pattern to determine influencing factors.

2. Establish the role of elephants as a change agent for vegetation and other environmental factors.

3.4.2 Problem Animals

For background information, refer to Management Plan : Volume 1, Section 2.7.2.

Analysis

Problem animals in and around CNP fall into three categories:

- Animals that damage crop.
- Carnivores that kill stock.
- Animals that intrude into tourist areas.

In areas peripheral to the CNP, there is a great need to control animals that destroy community property. The level of loss to the surrounding communities as a result of problem animals should be assessed objectively to determine fair and equitable compensation for such losses. (Refer Chapter 8)

Within the CNP baboons and monkeys at public campsites and other tourist areas are the major problem animals. Other species such as elephants and hyaenas can become over familiar around permanent camps.

Objective

- **To minimise damage by wild animals to life and property.**

Policy

- A protocol should be followed in each case where a wild animal has been reported as causing problems. Proposed actions to be taken are:

  - The animals are to be scared away or excluded from the area with barriers.

  - Where this fails, the animal should be captured or relocated to an area where it will not do damage.

  - If both these steps fail or are not practical, the problem animal will have to be destroyed.

  Overriding this protocol is an instance where human life is threatened. In these cases, the problem animal will be removed by the quickest method possible.

- Educate visitors and communities (see also Section 6.4) on precautions to be taken when faced with problem animals. Erection of warning signs, particularly at Savute where the problem is severe, should forewarn visitors of possible dangers.

- Delegate the problem animal control (PAC) function to select units in the organisation structure of the CNP.

MANAGEMENT ACTIONS

Problem Animals

1. Collect technical information on fencing, traps for animal removal and suitable aversion tactics. These preventative measures will be passed on to the communities through the DWNP extension service.

2. Select and train Parks officers in specialised problem animal control skills, including marksmanship and hunting techniques.

3. Establish an adequate recording mechanism for the control of problem animals and the damage that they cause.

4. Prepare warnings for visitors to the CNP explaining precautions to be followed when confronting problem animals. If elephants continue to damage facilities at the Savute public camp ground, concentrate ablutions into one large block protected by an elephant proof barrier.

3.4.3 Anti-Poaching Operations

Analysis

Poaching in and around CNP can be categorised as follows:

- Illegal hunting of all species in the CNP.
- Overhunting by licensed hunters in the surrounding areas.
- Use of a "resource" by local communities.
- Cross border and commercial poaching.

Although this section deals with poaching inside the CNP, the problem should be addressed as a district problem through the Advisory Committee. (Refer Sections 7.1.4 and 8.2)

Objective

- **Control commercial and subsistence poaching within the CNP.**

Policy

- The Anti-Poaching Unit will be responsible for conducting anti-poaching operations in the CNP. Assistance in detection will be provided by the law enforcement section of the Parks Division.

- National Park regulations related to poaching will be enforced. Politically sensitive issues, however, will be referred to the Director, DWNP for guidance and appropriate action.

- Commercial poaching will be treated as a low key military insurgency and emphasis given to offensive tactics rather than reacting to poacher movements. Counter poaching operations will be based on foot patrols with aircraft support.

- Educate the surrounding communities and gain their support for anti-poaching measures within their specific areas. Establish an intelligence gathering network within these communities.

MANAGEMENT ACTIONS

Anti-Poaching

1. Continue removing any existing rhino from the CNP region for as long as they are significantly threatened.

2. Establish a repeater based VHF radio communication network and discuss operation with relevant members of the network.

3. The DWNP should liaise with the BDF to promote routine standby of patrol units to assist the anti-poaching unit outside the park. This contribution should be limited to the international border areas where poachers enter Botswana.

4. Employ 15 additional trackers with a minimum of five years tracking experience and two more suitably qualified personnel to train staff in the anti-poaching unit.

5. Obtain a helicopter for park management operations (population counts, monitoring, etc) and anti-poaching operations. Employ a pilot with suitable flying experience.

6. Establish an anti-poaching unit base and field training camp outside the south east section of the park where commercial poaching has been concentrated. Housing for 40 officers should be provided.

7. Develop an anti-poaching attitude within the communities through public relations and education. Institute a reward system for anti-poaching information.

8. Examine the possibility of using community-based game scouts.

3.4.4 Disease

Analysis

Refer to Management Plan : Volume 1, Section 2.7 for background information.

Animal disease is always a danger in National Parks where epidemics can wipe out large

numbers of animals. Also through cross border movements contagious diseases can be brought into the park.

Disease needs to be monitored and, where deemed necessary, controlled.

Objective

- **To control wildlife diseases in the CNP.**

Policy

- Only intervene with active management if diagnosed diseased animals risk triggering off epidemic proportion either with park populations or external cattle and wildlife populations.
- Treat all possible cases of disease as serious and be continuously aware of the dangers of animal disease.

MANAGEMENT ACTIONS

Disease

1. All relevant DWNP staff should be trained in disease recognition.
2. Monitor and report all disease occurrences, type and locality.
3. Where an animal is suspected of dying of a disease a veterinary officer should be contacted. CNP officers should be trained to take blood smears on finding a carcase and carry a kit at all times.
4. Develop an action programme for dealing with outbreaks of animal disease.

3.4.5 Livestock Movements into the Park

Analysis

Cattle incursions from Namibia have become a problem. In addition, livestock movements from the Enclave occur.

Policy

- No exotic animal species should be allowed in the CNP.

MANAGEMENT ACTIONS **Livestock Movements into the Park**
1. Enforce the park regulation prohibiting the introduction of exotic animals into the park. Liaise with local authorities on possible solutions.
2. Cattle incursions should be recorded and a corrective course of action established with the Namibian authorities. It will be necessary to promote dialogue with Namibia to deal with the international aspects of the problem.

3.5 WATER

Analysis

The CNP is characterised by perennial rivers on or outside the boundaries of the park and sporadic rivers and pans which dry up in winter within the park. This pattern of water supply availability for the fauna of northern Botswana leading to wet and dry ranges for most species is well established and underpins the ecology of the region.

Overlying this foundation pattern is the variability in rainfall, with occasional periods of above average rainfall and drought. The latter impacts on the vegetation cover (and therefore indirectly on the fauna) and on the animal population, which during these periods becomes more heavily focused on the perennial rivers. (Also refer Section 7.8)

Objective

- **To safeguard the ecological integrity of the CNP by preserving the natural system of drainage and water distribution**

3.5.1 Surface Water

Policies

- Water supplies for domestic/camp site use should be located as far as possible from any potential pollution sources. Ideally, the well point should be situated on the upstream side and soakaways on the downstream side of river camp sites. The Department of Water Affairs should be contacted in connection with an appropriate distance for the siting of septic tanks in relation to surface water.

- Any management activities that may interfere with the flow of drainage channels and rivers should be avoided.

- Natural pans should not be developed for artificial water points as this leads to the destruction of the pan.

- Promote the maintenance of water quality and existing in-stream flows of the Chobe and Linyanti river systems.

MANAGEMENT ACTIONS

Surface Water

1. Seek representation on the Tripartite committee on the Okavango and Kwando systems. Liaise with Department of Water Affairs (DWA).

2. Monitor and record water flow in the perennial rivers.

3. DWNP should notify the Ministry of Agriculture, the Land Board and other relevant bodies of the importance of the Kakulwane Plains to the CNP. It is essential that these plains are protected as far as possible.

4. Remove dams in river valleys.

3.5.2 Artificial Water Points

Analysis

The provision of artificial water represents a potential conflict in the primary purpose of the park, being the preservation of life support systems with minimal human intervention. Developing artificial water for wildlife is motivated by:

- Human desire to alleviate wildlife suffering during drought periods.
- A perception that artificial water points can be used to attract elephants away from settlement areas to reduce crop and property damage.
- A need to provide concentrations of animals for tourist viewing during the dry season and/or redistribute animals away from high concentration points such as rivers.

Drought is a natural phenomenon and its effects on wildlife, including potentially massive mortalities must be accepted if the park environment is to reflect the balance of nature.

The second motive reflects a concern of many rural residents in Chobe District. CNP

from agricultural areas and villages where they raid crops and break water systems. Artificial water points are perceived as an effective means to discourage incursions into human settlements. The efficacy of this idea however, remains to be tested (see Priority Research - Fauna, Appendix 10). Even if successful, DWNP would have to determine if the practice was compatible with environmental LACs and CNP management objectives.

The third motive is mandated by government policy. Parks will be developed to provide sustainable tourism compatible with eco-system maintenance.

Objective

- **To develop and manage artificial water points to enhance visitor enjoyment of the park.**

Policies

- Artificial water points should only be constructed in the high and medium use tourism zones in conjunction with game viewing hides. A full time maintenance infrastructure will be in place before water is reticulated.

- A strategic plan for the design, construction, and management of artificial water points within CNP should be prepared before new artificial water points are constructed. This will include standardising baseline inventory and monitoring programmes to measure environmental changes from artificial water point development. Pilot LACs for environmental and social conditions in the vicinity of artificial water points should also be prepared.

- The construction of artificial water points in CNP to control elephant movements into nearby villages may be considered as a future park management objective if research shows this technique to be successful and compatible with park LACs.

- Artificial water points for the Zwiezwe medium use tourism area should only be considered after it is demonstrated that the LACs at Savute and Noghatsau areas can be successfully maintained.

- No additional artificial water points for the Savute area should be considered until it is demonstrated that LACs for the waterholes in the Savute grassland (Maribou Pan and Rhino Vlei Pan) can be successfully maintained.

- No artificial water points should be constructed closer than 10 kilometres to public campsites and safari camps in the medium use tourism zone. None should be constructed within flood plains.

- Artificial water points and associated game viewing hides should be constructed to blend in with their surroundings. Tour operators will be given the opportunity to review and comment on pilot artificial water point designs, LACs and the siting of each proposed artificial water point.

- Boreholes with saline water that exceeds maximum standards for wildlife use will not be reticulated for artificial water points.

MANAGEMENT ACTIONS

Artificial Water Points

1. Develop a strategic plan for artificial water point development in CNP. Develop construction designs using the guidelines shown in Appendix 8. Standardise inventory and monitoring methodologies to measure changes in environmental conditions resulting from artificial water points. Prepare pilot LACs for environmental and social conditions.

2. Establish baseline profiles for environmental conditions before constructing new artificial water points.

3. Reclaim the partially completed artificial water point north of the Savute campground and the temporary 1992 artificial water point at Savute on completion of the artificial water points at Maribou Pan and Rhino Vlei Pan. Terminate pumping water into the pan at the former Noghotsau campground. Construct a replacement artificial water point.

4. Initially construct several artificial water points as pilot designs and evaluate their success before proceeding with additional water points.

5. Where appropriate, negotiate an annual service contract with the private sector to ensure full time maintenance and operation of artificial water points.

6. Consider the siting of artificial water points within the park if research shows that they are successful in controlling elephant incursions into villages.

7. Consider siting artificial water points in the high use tourist zone to disperse elephants (see Section 3.3.2).

3.6 SITES OF SPECIAL INTEREST

Analysis

The value of sites of archaeological and historical interest to the tourism community lie in their potential to extend the range of activities that can be marketed to visitors, and as such greatly enhance the visitor experience to the region. However, experience has shown that uncontrolled

visitor access to such sites has invariably lead to gross acts of vandalism, damage, and ultimately the irretrievable loss of such site's historical integrity.

While the perennial rivers in the Chobe district have been the focal point of human activity in the past, a number of limited monument sites exist in the area. Other sites or areas for special interest include more recent human activities such as logging camps at Serondela and the trek routes and cattle posts of the late 1800s and early 1900s.

Objective

- **To ensure that archaeological and cultural resources are kept intact as part of the heritage of Botswana. Where acceptable, manage them to enhance visitor appreciation and knowledge of the CNP.**

Policy

- All sites of special interest will be designated special protection zones. Where it is determined that visitors may visit the site without damage to the cultural resources, a strategy that allows for tourism use should be developed.

MANAGEMENT ACTIONS

Sites of Special Interest

1. Record and document specific cultural sites within the CNP and its surroundings.

2. Determine which sites are "safe" for visitor viewing.

3. Collate information relating to the historical processes and publish the data/information for tourists and use in the education/extension programmes.

4. Ensure that any development actions are preceded by an archaeological impact assessment.

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Part III

APPENDIX 3.1

VEGETATION TYPE: RECONCILIATION OF UNITS BETWEEN CD PLANNING STUDY, TIMBERLAKE AND ECOSURV

Appendix 3.1 Vegetation Types - Reconciliation of units between Central District Planning Study, Timberlake and Ecosurv

The following table is a reconciliation of vegetation units between the mapping for the Central District Planning Study, Timberlake's mapping of South Eastern Botswana and Ecosurv's mapping of the Nata Statelands.

CD PLANNING STUDY	TIMBERLAKE	ECOSURV
Bare Pan Surface		
Edaphic grassland		
Halophytic grassland		Halophytic grassland
Hyphaene savannah		
Burkea/Ochna savannah	A2	Burkea woodland on deep sands
Acacia erioloba savannah sericea	A1, B5, A5	Acacia erioloba, Terminalia and sands on broken calcrete
Baikiaea woodland		Baikiaea woodland on deep sands
Kirkia/Commiphora woodland		
Rocky hill woodland	C1, C2 .	
Acacia savannah	D1, D2, D3	Compact grey soils
Acacia nigrescens/Acacia nilotica savannah woodland	B3	
Colophospermum mopane/ Acacia woodland		Mopane on fine compact soils
Colophospermum mopane on shallow soils	B2	
Colophospermum mopane on sandy soils	A4	Shallow sands/C. mopane trees
Colophospermum mopane woodland/ shrubland		
Riverine woodland	E1, E2	

APPENDIX 3.2

SPECIES LISTS AND RELATIVE ABUNDANCIES

Appendix 3.2 Species Lists and Relative Abundance

The following appendix consists of lists of the woody sp· cies and grasses that were found at each stand and observation point visited whilst carrying out the field investigation for the Vegetation Ecology map. Relative abundance was only estimated for the woody species found in the stands.

Site no.	Stand/ Obs pt	Woody species and Relative Abundance
2	o	Colophospermum mopane
		Acacia nigrescens
		Combretum apiculatum
		Dichrostachys cinerea
3	o	Combretum hereroense
		Grewia flava
		Rhus tenuinervis
		Acacia erioloba
		Dichrostachys cinerea
		Euclea crispa
		Acacia tortilis
		Acacia nigrescens
		Commiphora angolensis
		Acacia erubescens
		Albizia harveyi
		Maytenus senegalensis
		Terminalia prunioides
		Ozoroa paniculosa
4	o	Colophospermum mopane
		Combretum apiculatum
		Combretum hereroense
		Acacia nigrescens
		Terminalia prunioides
5	o	Combretum apiculatum
		Combretum hereroense
		Terminalia sericea
		Acacia fleckii
		Ozoroa paniculosa
		Grewia Flava
		Dichrostachys cinerea
		Bauhinia petersiana
6	o	Terminalia sericea
		Combretum apiculatum
		Dichrostachys cinerea
		Acacia fleckii
7	o	Ochna pulchra
		Rhigozum brevispinosum
		Strychnos cocculoides
		Acacia erioloba
		Bauhinia petersiana
9	o	Strychnos pungens
		Burkea africana
		Acacia fleckii
		Strychnos cocculoides
		Ochna pulchra

Site no.	Stand/ Obs pt	Woody species and Relative Abundance
		Ricinodendon rautanenii
10	o	Combretum psidioides
		Acacia nilotica
		Grewia flava
		Grewia bicolor
11	o	Acacia erioloba
		Tarchonanthus camphoratus
		Ricinodendron rautanenii
		Acacia fleckii
		Dichrostachys cinerea
		Acacia nilotica
		Acacia hebeclada
		Acacia tortilis
		Maytenus senegalensis
		Acacia erioloba
13	o	Burkea africana
		Ochna pulchra
		Bauhinia petersiana
		Rhus tenuinervis
		Dichrostachys cinerea
		Terminalia sericea
		Acacia nilotica
		Grewia flavescens
		Boscia albitrunca
		Maytenus senegalensis
		Grewia retinervis
		Acacia fleckii
		Croton gratissimus
		Rhigozum brevispinosum
		Diospyros lycioides
14	o	Ricinodendron rautanenii
		Commiphora glandulosa
		Cephalocroton mollis
		Grewia monticola
		Rhigozum brevispinosum
		Euclea divinorum
		Euclea crispa
		Grewia bicolor
		Tarchonanthus camphoratus
		Kirkia acuminata
		Combretum apiculatum
		Combretum hereroense
		Euphorbia neochinzii (ingens ?)
		Commiphora mollis

Site no.	Stand/ Obs pt	Woody species and Relative Abundance
		Acacia nigrescens
		Terminalia brachystemma
		Euphorbia neochinzii
15	o	Terminalia prunioides
		Sclerocarya birrea
		Combretum hereroense
		Colophospermum mopane
16	o	Kirkia acuminata
		Sclerocarya birrea
		Combretum apiculatum
		Commiphora glandulosa
		Commiphora mollis
		Commiphora angolensis
		Terminalia prunioides
		Acacia nigrescens
		Grewia monticola
17	o	Catophractes alexandri
		Colophospermum mopane
		Acacia nigrescens
		Sesamothamnus lugardii
		Terminalia prunioides
		Lannea stuhlmannii
		Acacia tortilis
		Commiphora angolensis
		Sclerocarya birrea
		Dichrostachys ciinerea
18	o	Acacia nilotica
		Acacia mellifera
		Acacia tortilis
		Colophospermum mopane
19	o	Grewia bicolor
		Grewia monticola
		Combretum apiculatum
		Dichrostachys cinerea
		Combretum hereroense
		Grewia flava
		Acacia nigrescens
		Maytenus senegalensis
		Sclerocarya birrea
20	o	Combretum apiculatum
		Acacia nigrescens

Site no.	Stand/ Obs pt	Woody species and Relative Abundance
		Colophospermum mopane
		Terminalia prunioides
21	o	Acacia tortilis
		Grewia flava
		Rhus tenuinervis
		Acacia mellifera
		Ximenia americana
		Commiphora glandulosa
		Acacia arenaria
		Acacia nigrescens
22	o	Catophractes alexandri
		Grewia flava
		Combretum hereroense
		Acacia mellifera
		Acacia tortilis
		Acacia nigrescens
		Acacia erioloba
23	o	Acacia mellifera
		Acacia erioloba
		Acacia tortilis
		Tarchonanthus camphoratus
		Grewia flava
24	o	Colophospermum mopane
		Acacia mellifera
		Acacia tortilis
		Combretum hereroense
		Acacia nilotica
25	o	Combretum apiculatum
		Acacia nigrescens
		Combretum imberbe
		Dichrostachys cinerea
		Colophospermum mopane
		Grewia flava
		Grewia bicolor
		Rhigozum brevispinosum
26	o	Ricinodendron rautanenii
		Acacia nigrescens
		Colophospermum mopane
		Burkea africana
		Acacia ataxacantha
		Sclerocarya birrea
		Grewia flava

Site no.	Stand/ Obs pt	Woody species and Relative Abundance
		Bauhinia petersiana
		Acacia fleckii
		Combretum apiculatum
		Terminalia sericea
		Ochna pulchra
		Combretum hereroense
		Croton gratissimus
	27 o	
		Acacia fleckii
		Ochna pulchra
		Grewia retinervis
		Bauhinia petersiana
		Burkea africana
		Strychnos pungens
	28 o	
		Colophospermum mopane
		Acacia nigrescens
		Combretum apiculatum
		Combretum hereroense
		Combretum imberbe
		Acacia nilotica
		Acacia erioloba
		Dichrostachys cinerea
		Grewia flava
		Grewia bicolor
		Rhigozum brevispinosum
		Terminalia sericea
		Ximenia americana
		Cissus cornifolia
		Acacia fleckii
	29 o	Colophospermum mopane
		Acacia nigrescens
		Acacia tortilis
		Acacia erubescens
		Kirkia acuminata
		Sclerocarya birrea
		Terminalia sericea
		Dichrostachys cinerea
		Lonchocarpus capassa
		Acacia senegal
	30 o	Ricinodendron rautanenii
		Terminalia sericea

Site no.	Stand/ Obs pt	Woody species and Relative Abundance
		Colophospermum mopane
31	o	Colophospermum mopane Terminalia prunioides Acacia nigrescens Acacia erioloba
32	o	Colophospermum mopane Grewia flava Dichrostachys cinerea Boscia rehmanniana ssp foetida Rhigozum brevispinosum
33	o	Acacia mellifera Acacia tortilis Acacia erioloba Terminalia sericea Colophospermum mopane
34	o	Acacia mellifera Acacia tortilis Acacia arenarea Colophospermum mopane Combretum imberbe Rhigozum brevispinosum
35	o	Combretum apiculatum Colophospermum mopane Sclerocarya birrea Commiphora glandulosa Commiphora mollis Acacia fleckii Commiphora mossambicensis Kirkia acuminata Grewia flavescens
36	o	Colophospermum mopane Acacia mellifera Acacia erubescens
37	o	Colophospermum mopane Combretum imberbe Lonchocarpus capassa Sclerocarya birrea
39	o	Kirkia acuminata

Site no.	Stand/ Obs pt	Woody species and Relative Abundance
		Colophospermum mopane
		Combretum apiculatum
		Terminalia Sericea
		Sclerocarya birrea
		Commiphora glandulosa
41	o	Colophospermum mopane
		Kirkia acuminata
		Combretum apiculatum
		Dichrostachys cinerea
		Commiphora mossambicensis
		Commiphora mollis
		Albizia harveyi
		Lannea stuhlmannii
42	o	Flueggea virosa
		Combretum apiculatum
		Ximenia americana
		Dichrostachys cinerea
		Colophospermum mopane
		Grewia flavescens
		Grewia bicolor
		Kirkia acuminata
		Lonchocarpus capassa
		Albizia harveyi
		Cissus cornifolia
		Lannea stuhlmannii
		Boscia foetida ssp rehmanniana
		Dalbergia melanoxylon
44	o	Flueggea virosa
		Colophospermum mopane
		Terminalia sericea
		Acacia fleckii
		Terminalia prunioides
		Ricinodendron rautanenii
		Acacia erioloba
		Bauhinia petersiana
		Commiphora angolensis
45	o	Combretum apiculatum
		Combretum imberbe
		Terminalia sericea
		Sclerocarya birrea
49	o	Colophospermum mopane
		Terminalia sericea
		Combretum apiculatum

Site no.	Stand/ Obs pt	Woody species and Relative Abundance
		Sclerocarya birrea
		Ricinodendron rautanenii
		Commiphora glandulosa
		Acacia nigrescens
		Grewia flava
		Grewia flavescens
		Grewia subspathulata
		Bauhinia petersiana
		Maytenus senegalensis
50	o	Terminalia prunioides
		Colophospermum mopane
		Acacia erioloba
		Acacia nigrescens
51	o	Colophospermum mopane
		Acacia erioloba
		Croton gratissimus
		Terminalia prunioides
52	o	
		Colophospermum mopane
		Acacia grandicornuta
		Ximenia americana
		Acacia erubescens
		Mondulia sericea
		Croton gratissimus
		Acacia ataxacantha
		Boscia foetida ssp rehmanniana
53	o	
		Colophospermum mopane
		Commiphora glandulosa
		Acacia grandicornuta
		Acacia erubescens
		Boscia foetida ssp rehmanniana
		Croton gratissimus
		Combretum apiculatum
		Rhigozum brevispinosum
		Grewia bicolor
		Dichrostachys cinerea
		Ximenia americana
54	o	Combretum apiculatum
		Terminalia sericea
		Colophospermum mopane

Site no.	Stand/ Obs pt	Woody species and Relative Abundance
55	o	Colophospermum mopane Commiphora mollis Commiphora glandulosa Acacia nigrescens Combretum apiculatum Grewia bicolor Albizia harveyi Terminalia prunioides
57	o	Colophospermum mopane Acacia grandicornuta Cephalocroton mollis Grewia flava Grewia flavescens Flueggea virosa Croton gratissimus Grewia bicolor Terminalia prunioides Acacia mellifera Rhus tenuinervis Acacia chariessa Mondulia sericea Acacia grandicornuta Ximenia americana
58	o	Colophospermum mopane Kirkia acuminata Sclerocarya birrea Terminalia prunioides Commiphora mollis C. glandulosa
60	o	Ricinodendron rautanenii Terminalia sericea Combretum apiculatum
61	o	Catophractes alexandri Grewia retinervis Combretum imberbe Acacia erioloba
62	o	Colophospermum mopane Combretum apiculatum Acacia erioloba Combretum hereroense

Site no.	Stand/ Obs pt	Woody species and Relative Abundance
		Combretum imberbe
		Terminalia sericea
63	o	Colophospermum mopane
		Acacia nigrescens
		Acacia fleckii
		Bauhinia petersiana
64	o	Burkea africana
		Grewia retinervis
		Grewia flava
65	o	Combretum imberbe
		Acacia tortilis
		Acacia nigrescens
		Colophospermum mopane
67	o	Acacia tortilis
		Acacia nilotica
		Acacia stuhlmannii
		Acacia arenaria
		Acacia grandicornuta
		Acacia borleae
		Acacia nebrownii
68	o	Acacia nigrescens
		Zisiphus mucronata
		Acacia tortilis
69	o	Terminalia sericea
		Croton gratissimus
		Acacia fleckii
		Acacia erioloba
		Ochna pulchra
		Bauhinia petersiana
		Burkea africana
70	o	Acacia robusta
		Acacia gerrardii
		Acacia erioloba
		Acacia nilotica
		Combretum hereroense
		Acacia tortilis
71	o	Acacia fleckii
		Acacia tortilis

Site no.	Stand/ Obs pt	Woody species and Relative Abundance
		Acacia robusta
		Colophospermum mopane
72	o	Acacia tortilis
		Acacia luederitzii
		Acacia mellifera
		Grewia flava
74	o	Acacia borleae
		Acacia luederitzii
		Acacia tortilis
		Acacia stuhlmannii
75	o	Acacia nigrescens
		Combretum apiculatum
		Acacia tortilis
		Acacia mellifera
		Acacia erioloba
76	o	Acacia nilotica
		Acacia nigrescens
		Acacia tortilis
		Acacia erioloba
		Acacia mellifera
77	o	Acacia borleae
		Acacia nilotica
		Acacia stuhlmannii
		Acacia mellifera
78	o	Acacia luederitzii
		Acacia stuhlmannii
		Acacia nilotica
79	o	Tarchonanthus camphoratus
		Acacia erioloba
		Acacia mellifera
		Acacia tortilis
		Grewia flava
80	o	Acacia nigrescens
		Acacia tortilis
		Zisiphus mucronata
81	o	Colophospermum mopane
		Acacia nigrescens
		Combretum imberbe

Site no.	Stand/ Obs pt	Woody species and Relative Abundance
82	o	Colophospermum mopane Combretum imberbe Commiphora hereroense Commiphora glandulosa
83	o	Colophospermum mopane Combretum apiculatum Commiphora glandulosa Rhigozum brevispinosum Acacia nigrescens
84	o	Terminalia sericea Combretum hereroense Combretum apiculatum Acacia fleckii Dichrostachys cinerea Grewia flava
85	o	Commiphora glandulosa Acacia erioloba Acacia nigrescens Combretum imberbe
86	o	Combretum apiculatum Terminalia sericea Euclea undulatum Ozoroa paniculosa Rhigozum brevispinosum
87	o	Acacia nigrescens Colophospermum mopane Combretum apiculatum Terminalia sericea
88	o	Colophospermum mopane Combretum imberbe Terminalia prunioides
89	o	Terminalia prunioides Terminalia sericea Colophospermum mopane
90	o	Albizia harveyi Kirkia acuminata Combretum mossambicensis

Site no.	Stand/ Obs pt	Woody species and Relative Abundance
		Colophospermum mopane
91	o	Combretum apiculatum
		Acacia grandicornuta
		Terminalia prunioides
92	o	Commiphora glandulosa
		Combretum apiculatum
		Kirkia acuminata
		Commiphora mollis
		Commiphora marlothii
		Terminalia prunioides
		Sterculia africana
		Acacia nigrescens
		Steganotaenia araliacea
		Pappea capensis
		Croton gratissimus
		Gardenia resiniflua
		Grewia bicolor
		Grewia flava
		Canthium burtti
93	o	Kirkia acuminata
		Commiphora mollis
		Combretum apiculatum
		Acacia erubescens
		Acacia nigrescens
		Gardenia resiniflua
		Vangueria infausta
		Clerodendron glabrum
		Strychnos madagascariensis
		Ozoroa paniculosa
		Flueggea virosa
95	o	Colophospermum mopane
		Combretum apiculatum
		Terminalia sericea
		Terminalia prunioides
96	o	Colophospermum mopane
		Terminalia prunioides
		Acacia erubescens
		Sclerocarya birrea
		Acacia nigrescens
		Acacia nilotica
		Acacia tortilis

Site no.	Stand/ Obs pt	Woody species and Relative Abundance
		Acacia ataxacantha
		Albizia anthelmintica
97	o	Colophospermum mopane
		Dichrostachys cinerea
		Grewia bicolor
98	o	Acacia nilotica
		Acacia nigrescens
		Acacia tortilis
		Terminalia prunioides
99	o	Colophospermum mopane
		Acacia erubescens
		Acacia erioloba
		Acacia tortilis
		Acacia ataxacantha
		Terminalia prunioides
		Combretum apiculatum
		Acacia nigrescens
100	o	Colophospermum mopane
		Acacia erubescens
		Combretum apiculatum
		Acacia mellifera
101	o	Colophospermum mopane
		Terminalia prunioides
		Acacia fleckii
		Acacia erioloba
		Acacia nilotica
		Acacia nigrescens
		Acacia ataxacantha
		Albizia harveyi
104	o	Kirkia acuminata
		Commiphora mollis
		Vangueria infausta
		Albizia harveyi
		Commiphora glandulosa
		Colophospermum mopane
		Cissus cornifolia
		Terminalia prunioides
		Acacia tortilis
		Combretum apiculatum
		Lannea stuhlmannii
		Dichrostachys cinerea

Site no.	Stand/ Obs pt	Woody species and Relative Abundance
		Acacia nigrescens
		Zisiphus mucronata
105	o	Kirkia acuminata
		Adansonia digitata
		Colophospermum mopane
106	o	Kirkia acuminata
		Colophospermum mopane
		Commiphora mollis
		Sclerocarya birrea
		Combretum apiculatum
107	o	Terminalia sericea
		Combretum apiculatum
		Kirkia acuminata
		Colophospermum mopane
		Sclerocarya birrea
108	o	Colophospermum mopane
		Dichrostachys cinerea
		Acacia nigrescens
		Acacia gerrardii
		Acacia tortilis
		Ziziphus mucronata
		Combretum imberbe
		Catophractes alexandri
109	o	Terminalia sericea
		Albizia harveyi
		Acacia nigrescens
		Combretum apiculatum
		Kirkia acuminata
		Commiphora mossambicensis
		Sclerocarya birrea
		Lannea stuhlmannii
		Markhamia acuminata
		Cissus cornifolia
112	o	Colophospermum mopane
		Ximenia americana
		Dalbergia melanoxylon
		Grewia monticola
114	o	Ziziphus mucronata
		Acacia karoo

Site no.	Stand/ Obs pt	Woody species and Relative Abundance
		Combretum imberbe
115	o	Colophospermum mopane
		Acacia erubescens
		Kirkia acuminata
		Terminalia prunioides
		Lonchocarpus capassa
116	o	Combretum imberbe
		Combretum hereroense
		Zisiphus mucronata
		Terminalia randii
		Acacia erubescens
		Acacia karoo
117	o	Colophospermum mopane
		Combretum imberbe
		Dichrostachys cinerea
118	o	Commiphora glandulosa
		Acacia erubescens
		Acacia nigrescens
		Kirkia acuminata
		Combretum apiculatum
119	o	Kirkia acuminata
		Acacia erubescens
		Commiphora mossambicensis
		Commiphora mollis
		Colophospermum mopane
		Sclerocarrya birrea
		Acacia nigrescens
		Albizia anthelmintica
120	o	Kirkia acuminata
		Combretum apiculatum
		Commiphora glandulosa
		Acacia nigrescens
		Commiphora mossambicensis
		Colophospermum mopane
		Terminalia prunioides
121	o	Grewia monticola
		Commiphora glandulosa
		Dalbergia melanoxylon
		Grewia bicolor
		Colophospermum mopane
		Dichrostachys cinerea
		Combretum apiculatum
		Combretum hereroense

Site no.	Stand/ Obs pt	Woody species and Relative Abundance
		Commiphora angolensis
122	o	Albizia anthelmintica
		Colophospermum mopane
		Terminalia prunioides
		Commiphora glandulosa
		Acacia nigrescens
123	o	Colophospermum mopane
		Dalbergia melanoxylon
		Commiphora glandulosa
		Lannea stuhlmannii
124	o	Terminalia prunioides
		Acacia nigrescens
		Albizia harveyi
126	o	Grewia tenuinervis
		Albizia anthelmintica
		Colophospermum mopane
		Acacia hebeclada
		Kirkia acuminata
		Grewia flavescens
		Dalbergia melanoxylon
		Lonchocarpus capassa
127	o	Albizia anthelmintica
		Commiphora glandulosa
		Grewia bicolor
		Dalbergia melanoxylon
		Colophospermum mopane
		Albizia harveyi
		Dichrostachys cinerea
		Grewia monticola
		Rhigozum brevispinosum
		Boscia foetida ssp rehmanniana
		Combretum elaeagnoides
		Ximenia americana
		Grewia flavescens
128	o	Colophospermum mopane
		Acacia nilotica
		Acacia grandicornuta
		Acacia nigrescens
		Acacia senegal
		Albizia anthelmintica
		Ximenia americana
129	o	Colophospermum mopane

Site no.	Stand/ Obs pt	Woody species and Relative Abundance
130	o	Colophospermum mopane Dalbergia melanoxylon Acacia senegal Commiphora glandulosa Dichrostachys cinerea Grewia bicolor Grewia flava Terminalia sericea Albizia anthelmintica
131	o	Albizia anthelmintica Dalbergia melanoxylon Acacia fleckii Dichrostachys cinerea Colophospermum mopane Acacia nigrescens Sclerocarya birrea
132	o	Commiphora angolensis Bauhinia petersiana Acacia fleckii Commiphora glandulosa Vangueria infausta Acacia harveyi Combretum collinum Combretum apiculatum Grewia bicolor
133	o	Terminalia prunioides Catophractes alexandri Colophospermum mopane Acacia mellifera
134	o	Colophospermum mopane Grewia bicolor Acacia nigrescens Grewia villosa Dichrostachys cinerea Catophractes alexandri Commiphora glandulosa Rhigozum brevispinosum
135	o	Colophospermum mopane Lonchocarpus capassa Acacia nigrescens

Site no.	Stand/ Obs pt	Woody species and Relative Abundance	>3 m	0.5-3 m	<0.5 m
		Combretum apiculatum			
		Terminalia sericea			
		Commiphora mossambicensis			
		Dalbergia melanoxylon			
		Albizia harveyi			
136	o	Acacia senegal			
		Ximenia americana			
		Colophospermum mopane			
137	o	Colophospermum mopane			
		Acacia nigrescens			
		Acacia gerrardii			
138	o	Catophractes alexandri			
		Boscia foetida ssp. rehmanniana			
		Acacia grandicornuta			
139	o	Albizia anthelmintica			
		Colophospermum mopane			
		Acacia senegal			
140	o	Catophractes alexandri			
		Croton gratissimus			
		Colophospermum mopane			
		Boscia foetida ssp rehmanniana			
		Grewia bicolor			
		Grewia monticola			
		Albizia anthelmintica			
		Acacia gerrardii			
1	s		>3 m	0.5-3 m	<0.5 m
		Ochna pulchra	1		2
		Terminalia sericea	2		
		Acacia fleckii	2		
		Grewia retinervis		2	
		Ziziphus mucronata	+		
		Securidaca longipedunculata	+		
		Ximenia caffra		+	
		Strychnos cocculoides	+		
		Burkea africana	1	2	2
		Dichrostachys cinerea		+	
		Tarchonanthus camphoratus		+	
		Lannea discolor	+		
		Elephantorrhiza elephantina			+
		Ricinodendron rautanenii	+		
		Bauhinia petersiana		+	
		Croton gratissimus		+	

Site no.	Stand/ Obs pt	Woody species and Relative Abundance	>3 m	0.5-3 m	<0.5 m
	8	s			
		Catophractes alexandri		2	
		Sesamothamnus lugardii		2	
		Commiphora angolensis		2	
		C. pyracanthoides		2	
		Aloe marlothii		2	
		Boscia foetida ssp. rehmanniana		2	
		Rhigozum brevispinosum		2	
		Grewia bicolor			
		G. flava			
		Terminalia prunioides			
		Acacia erubescens			
	12	s	>3 m	0.5-3 m	<0.5 m
		Acacia erioloba	2		
		A. fleckii	+		
		Terminalia sericea	+	+	
		Grewia retinervis		1	
		Dichrostachys cinerea	2	1	
		Tarchonanthus camphoratus		1(pockets)	
		Combretum hereroense (glabrus and hairy)		+	
		Grewia flava		+	
		Ziziphus mucronata	+	+	
		Rhus tenuinervis		+	
		Acacia hebeclada			
		Maytenus senegalensis		+	
		Ozoroa paniculosa			
		Acacia nilotica			
		A. tortilis		+	
		Combretum apiculatum	+		
		Elephantorrhiza elephantina			+
		Grewia flavescens var.olukondae			
	38	s	>3 m	0.5-3 m	<0.
		Colophospermum mopane		1	
		Acacia tortilis	1		
		Combretum apiculatum	+	+	
	40	s	>3 m	0.5-3 m	<0 m
		Sclerocarya birrea			
		Acacia nigrescens			
		Commiphora glandulosa			
		Dichrostachys cinerea			
		Albizia harveyi			
		Colophospermum mopane		2	

Site no.	Stand/ Obs pt	Woody species and Relative Abundance			
		Acacia erubescens	+		+
		Cephalocroton mollis			
		Grewia flavescens var.olukondae			
		Ormocarpum trichocarpum			
43	s		>3 m	0.5-3 m	<0.5
		Commiphora angolensis			
		Colophospermum mopane			
		Rhigozum brevispinosum			
		Grewia flava			
		G. bicolor			
		Acacia nigrescens			
		Commiphora mollis			
		Croton gratissimus			
		Acacia nilotica			
		Dichrostachys cinerea			
		Cissus cornifolia			
46	s		>3 m	0.5-3 m	<0.5
		Acacia nigrescens			
		A. fleckii			
		Colophospermum mopane		3	
		Terminalia sericea	1		
		Combretum apiculatum			
		Ricinodendron rautanenii			
		Bauhinia petersiana			
		Commiphora glandulosa			
		C. angolensis			
		Combretum imberbe			
		Sclerocarya birrea			
		Dichrostachys cinerea			
		Euclea crispa			
		Acacia erioloba			
		Grewia flava			
		Flueggea virosa			
		Rhus tenuinervis			
		Triaspis nelsonii			
47	s	Acacia erioloba			
		Combretum imberbe			
		Acacia nigrescens			
		Combretum apiculatum			
		C. hereroense			
		Terminalia prunioides			
		Grewia flava			

Site no.	Stand/ Obs pt	Woody species and Relative Abundance			
		Ozoroa paniculosa			
		Colophospermum mopane			
		Acacia fleckii			
		Bolosanthus speciosus			
		Bauhinia petersiana			
		Flueggia virosa			
		Terminalia sericea			
48	s		>3 m	0.5-3 m	<0.5m
		Colophospermum mopane	2		
		Acacia robusta			
		Grewia villosa			
		Acacia tortilis			
		Boscia foetida ssp. rehmanniana			
		Grewia bicolor			
		Terminalia prunioides	1		
		Dichrostachys cinerea			
		Kirkia acuminata	+		
		Commiphora mollis			
		C. glandulosa			
		C. angolensis			
		Croton gratissimus			
		Acacia nigrescens	+		
56	s		>3 m	0.5-3 m	<0.
		m			
		Colophospermum mopane	1	2	
		Terminalia prunioides	+	1	
		Combretum apiculatum		+	
		Grewia flava		1	
		Rhigozum brevispinosum		+	
		Acacia erioloba	1	1(2)	
		A. nigrescens	+	+	
		Terminalia sericea	(dead)	+	
		Bauhinia petersiana		+	
		Combretum hereroense		+	
		Rhus tenuinervis		+	
		Grewia monticola		+	
		Ozoroa paniculosa		+	
		Croton gratissimus		+	
		Dichrostachys cinerea		+	
		Mondulia sericea		+	
		Commiphora glandulosa		+	
		C. mollis		+	
		Acacia chariessa			
		Maytenus senegalensis		+	
59	s		>3 m	0.5-3 m	<0.5
		Colophospermum mopane	1	2	

Site no.	Stand/ Obs pt	Woody species and Relative Abundance			
		Commiphora glandulosa	1		
		C. mollis	1		
		Sclerocarya birrea	+		
		Dichrostachys cinerea		+	+
		Combretum apiculatum	1		
		Grewia monticola		+	
		Ximenia americana		+	
		Grewia bicolor		+	
		Combretum imberbe	+		
		Elephantorrhiza elephantina			1
		Terminalia sericea		(+)	+
		Acacia erioloba	+	+	
		A. nigrescens	+	+	
		Albizia harveyi	+		
66	s		>3 m	0.5-3 m	<0.5 m
		Colophospermum mopane			
		Acacia tortilis			
		A. mellifera			
		Rhus tenuinervis			
73	s		>3 m	0.5-3 m	<0.5 m
		Acacia mellifera	2	2	
		A. luederitzii	2		
		A. tortilis	+	+	
		Grewia flava			
		Commiphora glandulosa			
		Flueggia virosa			
		Combretum hereroense			
94	s		>3 m	0.5-3 m	<0.5 m
		Kirkea acuminata	2		
		Commiphora mossambicensis	2		
		Acacia nigrescens	+		
		Combretum apiculatum	1	2	
		Terminalia prunioides		+	
		Sclerocarya birrea	+	+	
		Cassia abbreviata		+	+
		Markhamia acuminata	+	+	
		Steganotaenia araliacea		+	
		Clerodendrum glabrum		+	
		Flacourtia indica		+	
		Strychnos madagascariensis	+	+	
		Vangueria infausta		+	
		Terminalia sericea	+		
		Colophospermum mopane	+	+	
		Boscia foetida ssp. rehmanniana			
		Grewia monticola		1	

Site no.	Stand/ Obs pt	Woody species and Relative Abundance	>3 m	0.5-3 m	<0.5
102	s				
		Ricinodendron rautanenii	+		
		Combretum collinum	1	2	
		Terminalia sericea	+	+	
		Acacia ataxacantha	+		
		Bauhinia petersiana		+	
		Cassia abbreviata	+		
		Lonchocarpus capassa	+	+	
		Albizia amara		+	
		Albizia harveyi		+	
		Vangueria infausta		+	
		Combretum apiculatum	+		
		Acacia erubescens	(+)		
103	s		>3 m	0.5-3 m	<0.5
		Markhamia acuminata	1	1	
		Steganotaenia araliacea	+	+	
		Pappea capensis	+		
		Commiphora mollis	3		
		C. marlothii	+		
		Ficus sp.	+		
		Sclerocarya birrea	1		
		Lannea stuhlmannii			
		Kirkia acuminata	+		
		Grewia flavescens		1	
		Canthium burtti	1		
		Albizia amara	+		
		Lonchocarpus capassa	+		
		Croton gratissimus		+	
		Erythrina latissima	+		
		Gardenia resiniflua	+		
110	s		>3 m	0.5-3 m	<0.5
		Colophospermum mopane	1	4	
		Terminalia prunioides	+	+	1
		Acacia nigrescens	+-1	+	
		Commiphora glandulosa			+
		Grewia bicolor			+
		Euclea crispa			+
		Aloe littoralis		+	
		Grewia flava		+	
		Combretum apiculatum			rar
111	s		>3 m	0.5-3 m	<0.5
		Dalbergia melanoxylon	+-1		

Site no.	Stand/ Obs pt	Woody species and Relative Abundance			
		Acacia erubescens	+-1		
		Dichrostachys cinerea		+	
		Euclea crispa			+
		Acacia nilotica	+		
		Cissus cornifolia		+	
		Ximenia americana		+	
		Combretum apiculatum	+	+	
		Grewia monticola			
		Acacia nigrescens	+		
		Colophospermum mopane	3	4	
		Lannea discolor	+		
		Lannea stuhlmannii	+		
		Commiphora glandulosa		+	
		Albizia anthelmintica	+		
		Euclea undulatum			
		Ormocarpum trichocarpum			
113	s		>3 m	0.5-3 m	<0.
		m Sclerocarya birrea			
		<+			
		Commiphora mollis	1	+	
		C. glandulosa	1	+	
		C. mossambicensis	1	+	
		Combretum apiculatum	+		
		Colophospermum mopane	2	1-+	
		Terminalia prunioides	1	+	
		Dichrostachys cinerea		+	
		Acacia nigrescens		+	
		Grewia monticola		+	
		G. bicolor		+	
		Elephantorrhiza goetzii		+	
		Grewia flavescens		+	
		Ximenia americana		+	
		Kirkia acuminata	2(1)	2(1)	
		Boscia foetida ssp. remanniana		+	
		Lannea stuhlmannii	+	+	
		Markhamia acuminata	+		
		Cissus cornifolia		+	
125	s		>3 m	0.5-3 m	<0.5
		Combretum collinum	1		
		C. zeyheri	+		
		Lonchocarrpus nelsii		+	
		Bauhinia petersiana			
		Acacia ataxacantha			
		Dichrostachys cinerea			

Site no.	Stand/ Obs pt	Woody species and Relative Abundance		
-	-			
		Boscia albitrunca	+	
		Commiphora angolensis		+-1

Site no.	Stand/ Obs pt	Grass species
2	o	
3	o	
4	o	
5	o	
6	o	
7	o	
9	o	
10	o	
11	o	
13	o	
14	o	
15	o	
16	o	
17	o	
18	o	
19	o	
20	o	
21	o	
22	o	
23	o	
24	o	
25	o	
26	o	
27	o	
28	o	
29	o	
30	o	
31	o	
32	o	Eragrostis trichophora
		Stipagrostis uniplumis
		Digitaria milanjiana
33	o	
34	o	Aristida barbicollis
		Aristida congesta
		Enneapogon cenchroides
		Eragrostis porosa
		Stipagrostis uniplumis
35	o	
36	o	
37	o	
39	o	
41	o	Aristida adscensionis
		Aristida rhiniochloa
		Eragrostis porosa
		Eragrostis viscosa
		Milinis repens
42	o	
44	o	

Site no.	Stand/ Obs pt	Grass species
45	o	
49	o	
50	o	
51	o	
52	o	
53	o	Eragrostis porosa
		Stipagrostis uniplumis
54	o	
55	o	
57	o	
58	o	
60	o	
61	o	
62	o	
63	o	
64	o	
65	o	
67	o	Chloris virgata
		Cymbopogon caesius
		Panicum coloratum
		Setaria incrassata
		Sorghum versicolor
		Sporobolus cordofanus
68	o	
69	o	
70	o	
71	o	
72	o	
74	o	
75	o	
76	o	
77	o	
78	o	
79	o	
80	o	
81	o	Aristida adscensionis
		A. congesta
		A. stipitata
		Cymbopogon caesius
		Digitaria milanjiana
		Enneapogon cenchroides
		Eragrostis rigidior
		Heteropogon contortus
82	o	
83	o	
84	o	
85	o	

Site no.	Stand/ Obs pt	Grass species
86	o	Aristida congesta Digitaria milanjiana Eragrostis cilianensis Digitaria milanjiana Pogonarthria fleckii Schmidtia pappophoroides Stipagrostis uniplumis
87	o	
88	o	
89	o	
90	o	
91	o	
92	o	
93	o	
95	o	
96	o	
97	o	Aristida adscensionis A. rhiniochloa Chloris virgata Eragrostis cilianensis Tragus berteronianus
98	o	
99	o	
100	o	
101	o	
104	o	
105	o	
106	o	
107	o	
108	o	
109	o	
112	o	
114	o	
115	o	
116	o	
117	o	
118	o	
119	o	
120	o	
121	o	
122	o	
123	o	
124	o	
126	o	
127	o	Aristida adscensionis

Site no.	Stand/ Obs pt	Grass species
		A. congesta
		Eragrostis aspera
		Melinis repens
		Tragus berteronianus
128	o	Aristida adscensionis
		A. rhiniochloa
		Panicum maximum
		Sporobolus cordofanus
129	o	Dichanthium annulatum var. papillosum
		Ischaemum afrum
		Setaria incrassata
		Sorghum versicolor
130	o	Cynodon dactylon
		Enneapogon cenchroides
		Eragrostis porosa
		Stipagrostis uniplumis
		Tragus beteronianus
		Urochloa brachyura
131	o	Aristida congesta
		A. meridionalis
		Cynodon dactylon
		Dactyloctenium giganteum
		Eragrostis rigidior
		Urochloa brachyura
132	o	
133	o	
134	o	
135	o	
136	o	
137	o	
138	o	
139	o	
140	o	
1	s	Aristida congesta
		A. stipitata
		Digitaria milanjiana
		Eragrostis cilianensis
8	s	Aristida congesta
		Eragrostis porosa
		Stipagrostis uniplumis
12	s	Aristida barbicollis
		Stipagrostis uniplumis
38	s	Aristida barbicollis
		Chloris virgata
		Eragrostis porosa

Site no.	Stand/ Obs pt	Grass species
		Urochloa trichopus
40	s	Aristida adscensionis
		A. barbicollis
		A. rhiniochloa
		Eragrostis porosa
		E. rigidior
		E. superba
		E. viscosa
		Stetaria pumila
43	s	Eragrostis rigidior
		Enneapogon cenchroides
		Melinis repens
		Schmidtia pappophoroides
		Stipagrostis uniplumis
		Tragus berteronianus
46	s	Aristida congesta
		A. stipitata
		Eragrostis trichophora
		Digitaria milanjiana
		Melinis repens
		Schmidtia pappophoroides
		Tragus berteronianus
		Urochloa trichopus
47	s	Eragrostis trichophora
		Pogonarthria fleckii
		Schmidtia papophoroides
		Stipogrostis uniplumis
48	s	Brachiaria deflexa
		Eragrostis porosa
		Setaria verticillata
		Urochloa trichopus
56	s	Aristida congesta
		Melinis repens
		Pogonathria fleckii
		Schmidtia pappophoroides
		Urochloa trichopus
59	s	Aristida congesta
		Pogonarthria fleckii
		Schmidtia pappophoroides
		Stipagrostis uniplumis
66	s	Digitaria milanjiana

Site no.	Stand/ Obs pt	Grass species
		Eragrostis superba
		Fingerhuthia africana
		Heteropogon contortus
		Panicum coleratum
		Setaria incrassata
		Sorghum versicolor
73	s	Aristida adscensionis
		A. rhiniochloa
		Enneapogon cenchroides
		Eragrostis porosa
		Tragus berteronianus
94	s	Aristida rhiniochloa
		Digitaria milanjiana
		Heteropogon melanocarpus
		Melinis repens
		Setaria pumila
102	s	Aristida barbicollis
		Eragrostis porosa
		Eragrostis rigidior
		Tragus berteronianus
103	s	Aristida adscensionis
		Brachiaria deflexa
		Enteropogon macrostachys
		Eragrostis aspera
		E. porosa
		Setaria petiolata
		S. pumila
		Tragus berteronianus
		Urochloa panicoides
110	s	Enteropogon macrostachys
		Eragrostis sp.
		Heteropogon contortus
		Sporobolus cordofanus
111	s	Aristida rhiniochloa
		Brachiaria deflexa
		Enteropogon macrostachys
		Eragrostis superba
		Sporobolus festivus
113	s	Aristida adscinsionis
		Enteropogon macrostachys
		Schmidtia pappophoroides
		Urochloa oligotricha
		U. trichopus

JF8
Part IV

Station Name	Month	Max. Temp Celsius	Min. Temp Celsius	% Relative Humidity 0800hrs	% Relative Humidity 1400hrs	Rainfall mm	PET mm	Wind Speed Km/h	Air Frost Days	Ground Frost Days
SATAU	Jul	24.6	6.1	66.0	26.0	0.0	102.0	7.2	0.7	3.9
	Aug	27.7	8.9	56.0	22.0	0.0	135.0	8.4	0.2	0.9
	Sep	31.7	13.4	46.0	22.0	2.0	169.0	9.9		0.1
	Oct	33.6	17.5	49.0	27.0	27.9	187.0	11.0		
	Nov	32.5	18.5	60.0	35.0	66.0	175.0	9.6		
	Dec	31.5	19.1	71.0	44.0	53.6	166.0	8.9		
	Jan	31.0	19.3	76.0	51.0	111.1	160.0	8.2		
	Feb	30.6	18.9	79.0	50.0	67.4	147.0	8.0		
	Mar	30.5	17.9	76.0	46.0	25.3	152.0	8.1		
	Apr	29.3	15.1	72.0	39.0	14.9	137.0	7.3		
	May	27.1	9.8	68.0	29.0	0.0	116.0	6.7		0.8
	Jun	24.6	6.4	67.0	29.0	0.0	94.0	6.9	0.8	6.2
VICTORIA FALLS	Jul	24.6	5.6	65.0	29.0	0.0	97.0	4.3		
	Aug	27.5	8.3	52.0	25.0	1.0	130.0	5.1		
	Sep	31.6	13.0	41.0	20.0	2.0	165.0	5.8		
	Oct	33.0	17.2	45.0	25.0	24.0	196.0	6.7		
	Nov	31.8	18.1	59.0	36.0	77.0	174.0	5.6		
	Dec	29.8	18.0	75.0	50.0	188.0	160.0	4.9		
	Jan	29.4	18.2	81.0	55.0	185.0	157.0	4.5		
	Feb	29.1	17.8	83.0	55.0	138.0	136.0	4.6		
	Mar	29.3	16.9	80.0	50.0	71.0	144.0	4.9		
	Apr	28.7	13.9	74.0	41.0	23.0	125.0	4.4		
	May	27.1	9.4	68.0	33.0	2.0	107.0	4.2		
	Jun	24.4	5.7	68.0	31.0	1.0	87.0	4.1		
SAVUTE	Jul	27.9	4.7			0.0				
	Aug	31.4	8.0			0.0				
	Sep	35.7	14.0			6.1				
	Oct	35.9	18.2			30.3				
	Nov	35.6	19.4			52.6				
	Dec	32.6	19.3			123.7				
	Jan	32.2	19.0			110.6				
	Feb	31.8	18.7			110.9				
	Mar	32.7	18.0			72.2				
	Apr	32.3	14.2			28.7				
	May	30.5	9.7			0.0				
	Jun	27.9	6.1			0.0				

APPENDIX 4 : EXPLANATION OF THE SOILS LEGEND ATTACHED TO THE SOILS COVERAGE IN THE CHOBE NATIONAL PARK GIS

This explanation is compiled from the Revised General Soil Legend of Botswana (1990) and the legends and reports published with the following 1:250 000 map sheets :

- Kasane
- Savute
- Linyanti
- Basutos
- Nxai Pan
- Maun.

Mapping Units :

Simple Mapping Units: A simple mapping unit is comprised of the indicated soil unit for more than 80% of its area.

Compound Mapping Units: A compound mapping unit represents either a soil association or a soil complex. The soil units comprising such a mapping unit are listed in descending order of occurrence, the last one representing at least 20% of the total area. These are referred to as the major soil unit, associated soils (up to three) and included soils (up to three more), so a compound mapping unit may contain up to seven soil types.

Soils occurring in the Study Area :

Alluvial soils

A1 - Pellic Vertisol, partly sodic — Deep to very deep, poorly to imperfectly drained, dark greyish brown to very dark grey clay. Flat to almost flat.

A4b	- Calcic Cambisol	Moderately deep to very deep, imperfectly drained, dark greyish brown to brown clay loam to clay. Flat to gently undulating.
A5	- Gleyic Solonetz, partly saline	Deep to very deep, poorly to imperfectly drained, very dark grey to dark greyish brown sandy clay loam to clay. Flat.
A7	- Gleyic Luvisol, partly sodic	Deep to very deep, poorly to imperfectly drained, dark grey to greyish brown sandy clay loam to clay. Flat.
A7a	- Gleyic Luvisol, partly sodic	As for A7, but sandy loam.
A7b	- Calcic Gleyic Luvisol, partly sodic	Deep to very deep, poorly to imperfectly drained dark grey to greyish brown sandy clayloam to sandy clay. Flat to almost flat
A9	- Calcic Luvisol	Deep to very deep, imperfectly to moderately well drained, dark brown to yellowish brown sandy clay loam to clay. Flat to gently undulating.
A9a	- Arenic Calcic Luvisol	Deep to very deep, imperfectly to moderately well drained, dark greyish brown to brown, loamy fine sands to sandy loams. Almost flat to gently undulating.
A9b	- Calcic Luvisol	As for A9, but with petrocalcic horizon.
A9c	- Calcic Luvisol,	Deep to very deep, imperfectly drained, dark greyish partly (strongly) sodic and/or saline brown sandy clay loam to clay.
A14a	- Orthic Luvisol	Moderately deep to very deep,imperfectly to moderately well drained, dark grey to greyish brown, fine sandy loams to sandy clays. Flat to gently undulating.

A15a	- Arenic Orthic Luvisol	Moderately deep to very deep, imperfectly to moderately well drained, very dark grey to greyish brown sands over loamy sands to sandy clay loams. Flat.
A19	- Ferralic Arenosol	Deep to very deep, well to somewhat excessively drained, dark red to yellowish brown sands to loamy sands. Flat to gently undulating.
A21	- Calcic Arenosol	Moderately deep to very deep, moderately well to well drained, dark greyish brown to yellowish brown sands to loamy sands. Flat to undulating.
A21a	- Petrocalcic Arenosol	As for A21, but with a petrocalcic horizon within 125 cm. Flat to undulating (calcrete ridges).
A24	- Eutric Fluvisol	Very deep, poorly to imperfectly drained dark greyish brown to black sandy loam to clay. Flat to almost flat.
A24a	- Arenic Eutric Fluvisol	Very deep, poorly to imperfectly drained, dark greyish brown to white, sands to loamy sands. Flat (channels, floodplains).
A24b	- Arenic Eutric Fluvisol	Very deep, poorly to imperfectly drained, dark greyish brown to black loamy sands to sandy loams. Flat (channels).
A30	- Calcic Gleysol	Deep to very deep, poorly to imperfectly drained, very dark grey to grey sandy clay to clay. Flat.
A31a	- Eutric Gleysol	Very deep, poorly to imperfectly drained, black to dark greyish brown sandy clay loams to clays. Flat.
A31b	- Eutric Gleysol, partly sodic	As for A31a, but sandy loam. Flat (channels)

A40	- Eutric Arenosol	Deep to very deep, moderately well to somewhat excessively drained, very dark greyish brown to white, sands to loamy sands. Flat to gently undulating.
A40a	- Eutric Arenosol	As A40, but massive.
A40b	- Eutric Arenosol	As A40, but gently undulating to undulating. Occurring as ridges e.g., old river channel deposits.
A41	- Luvic Arenosol	Very deep, moderately well to well drained, massive very dark greyish brown to brown fine sand to loamy fine sand. Flat.
A42	- Vertic Mollic Gleysol	Deep to very deep, poorly to imperfectly drained, grey to black loams to clays. Flat.
A42a	- Vertic Mollic Gleysol	As for A42, but overlying greyish brown to white sand within 100 cm. Flat.
A42b	- Mollic Gleysol, partly sodic	As for A42a, but with diatomaceous earth within 50 cm. Flat.
A42c	- Calcic Mollic Gleysol	As for A42, but with calcic horizon within 125 cm. Flat.

Soils on Basic Igneous Rocks

B1	- Eutric Regosol, lithic	Very shallow to shallow, well to somewhat excessively drained, reddish brown to dark brown sandy loam to clay loam. Undulating to hilly.
B1a	- Eutric Regosol, lithic	As B1, but almost flat to gently undulating.
B5a	- Chromic Luvisol, petric/partly lithic	Shallow to moderately deep, well drained, reddish brown to strong brown, sandy clay loam to sandy clay. Undulating to rolling (on basalt).

B6	- Calcic Luvisol	Moderately deep to deep, moderately well to well drained, dark brown to reddish brown clay loam to clay. Undulating to hilly.
B6a	- Calcic Luvisol, petric	As for B6, but shallow to moderately deep and well drained. Undulating to hilly.

Soils on Highly Calcareous Material

C2	- Calcaric Regosol	Very shallow to shallow, imperfectly to well drained, very dark grey to brown sandy loam to clay loam. Undulating.
C3	- Petrocalcic Arenosol	Very shallow to shallow, moderately well to well drained, reddish brown to dark greyish brown sands to loamy sands. Flat to undulating.
LC5b	- Calcic Luvisol, partly petrocalcic	Shallow to moderately deep, poorly to imperfectly drained, very dark greyish brown to brown sandy loam to sandy clay. Flat.

Lacustrine soils

L3	- Takyrik Solonchak, sodic	Very deep poorly drained very dark greyish brown to light olive grey loam to clay. Flat, receiving.
L6	- Calcic Gleysol, partly sodic	Very deep, poorly to imperfectly drained very dark grey to grey sandy clay to clay. Flat.
L6a	- Calcic Gleysol, partly sodic	Deep to very deep, poorly to imperfectly drained very dark grey to grey loam to clay overlying greyish brown to white fine sand within 100 cm. Flat.
L6b	- Calcic Gleysol, partly sodic	As for L6a, but overlying diatomaceous earth within 50 cm.

L7	- Eutric Gleysol, partly sodic	Very deep, poorly to imperfectly drained very dark grey to grey sandy clay to clay. Flat.
L9	- Eutric Fluvisol	Very deep, very poorly to poorly drained light yellowish brown to olive grey to black stratified complexes of coarse sand to silt to clay. Flat.
L11	- Calcic Arenosol	Deep to very deep, moderately well to well drained, very dark grey to pale brown fine sands to loamy sands, having a calcic horizon within 125 cm from the surface and calcareous between 0 - 50 cm.
L11a	- Calcic Arenosol	Deep to very deep, moderately well to well drained, dark grey to pale brown fine sands to loamy sands. Non-calcareous between 0-50cm. Almost flat to gently undulating.
L12	- Petrocalcic Arenosol	Moderately deep, well to somewhat excessively drained light brownish grey to very pale brown fine sand to loamy fine sand, massive calcrete at mod. depth, calcareous 0-50 cm. Flat to slightly undulating.
L12b	- Petrocalcic Arenosol	As L12, but non-calcareous between 0-50 cm.
L16	- Eutric Arenosol	Very deep, well to somewhat excessively drained, dark grey to pale brown fine sands to loamy fine sands. Non-calcareous between 0-100cm. Almost flat to gently undulating.
L20	- Calcic Cambisol	Deep to very deep, imperfectly drained, very dark greyish brown to brown sandy clay loam to clay, having a calcic horizon. Flat.
L22	- Orthic Luvisol	Deep to very deep, imperfectly drained, dark greyish brown to brown sandy clay loam to clay. Flat.

L22a	- Arenic Orthic Luvisol	Deep to very deep, imperfectly to moderately well drained, dark greyish brown to brown loamy sand to sandy clay loam. Flat.
AL22a	- Arenic Orthic Luvisol	Deep to very deep, imperfectly to moderately well drained, dark greyish brown to brown loamy sand to sandy clay loam. Flat.
L23	- Gleyic Luvisol, partly sodic/saline	Deep to very deep, poorly to imperfectly drained, dark grey to greyish brown, sandy clay loam to clay.
L23a	- Gleyic Luvisol, petric, partly sodic/saline	Moderately deep to deep, poorly to imperfectly drained, dark grey to greyish brown sandy clay loam to clay. Flat (slightly) receiving.
L24	- Calcic Luvisol	Deep to very deep, imperfectly drained, very dark greyish brown to brown fine sandy loams to clay. Almost flat to gently undulating.
L24a	- Calcic Luvisol, sodic phase	As for L24, but sodic and partly saline phase. Flat.
L24b	- Calcic Luvisol, petrocalcic	As for L24, but with petrocalcic horizon within 125 cm. Flat.
L24c	- Arenic Calcic Luvisol, partly petrocalcic	Very deep imperfectly to moderately well drained,very dark greyish brown to brown loamy sands to sandy clay loams. Flat to gently undulating.
L25	- Pellic Vertisol	Deep to very deep, poorly to imperfectly drained, very dark greyish to dark greyish brown clay. Flat.
L25b	- Pellic Vertisol	As for L25, but poorly drained. Flat (drainage ways), receiving.

L25c	- Pellic Vertisol, petric, partly sodic	Moderately deep to deep, poorly to imperfectly drained, very dark grey to dark greyish brown clay. Flat normal to slightly receiving.
L26	- Vertic Calcic Gleysol, partly petrocalcic	Moderately deep to deep, poorly to imperfectly drained, dark grey to very dark grey clay. Flat.
L28	- Calcic Gleyic Luvisol, partly petrocalcic	Deep to very deep, poorly to imperfectly drained, dark grey to greyish brown, sandy clay loam to clay. Flat.
L28a	- Calcic Gleyic Luvisol, sodic	As L28, but sodic.
L29	- Vertic Gleyic Luvisol, partly petric	Moderately deep, imperfectly drained, dark grey to greyish brown, sandy clay to clay. Flat (slightly receiving).
L31	- Arenic Eutric Nitosol	Very deep, imperfectly to moderately well drained, yellowish red to yellowish brown loamy sands to sandy clay loam. Flat to gently undulating.
L32	- Arenic Ferric Luvisol	Very deep, moderately well to well drained, brown to yellowish red, loamy sands to sandy clay loam. Gently undulating, normal.
L35	- Luvic Chernozem	Deep to very deep, imperfectly to moderately well drained, dark grey to greyish brown sandy loams to clay. Flat.
L35a	- Gleyic Luvic Chernozem, partly sodic	Deep to very deep, poorly to imperfectly drained very dark grey to dark grey sandy clay loam to clay. Flat, normal to slightly receiving.

L36	- Calcic Chernozem (partly sodic)	Deep to very deep poorly to imperfectly drained, very dark grey to greyish brown sandy clay loams to clay. Flat.
L37	- Mollic Gleysol	Very deep, poorly to imperfectly drained, black to very dark grey loam to clay with a base saturation of >50% in all parts of the subsoil. Flat.
L37a	- Mollic Gleysol	Deep to very deep, poorly to imperfectly drained black to very dark grey loam to clay, base saturation of <50% in some parts of the subsoil. Flat
L37b	- Calcic Mollic Gleysol	As for L37, but having a calcic horizon within 125 cm. Flat.
L37c	- Vertic Mollic Gleysol	Very deep, poorly to imperfectly drained, very dark grey to black clay. Flat.
L40	- Luvic Arenosol	Very deep, moderately well to well drained,Very dark greyish brown to brown fine sand to loamy fine sand. Flat to gently undulating.
L41	- Eutric Planosol	Deep to very deep, imperfectly drained, dark yellowish brown to brown sandy clay loam to clay. Flat to gently undulating.
L42	- Solodic Planosol, partly saline	Deep to very deep, poorly to imperfectly drained, very dark grey to dark greyish brown sandy clay loam to clay. Flat to gently undulating.
L43	- Albic Luvisol	Deep to very deep, imperfectly to moderately well drained, grey to light brownish grey fine sands abruptly overlying dark greyish brown to pale brown massive loamy sands to sandy loams. Flat to gently undulating.

L43a	- Calcic Albic Luvisol, partly sodic	As for L43, but having a calcic horizon or soft powdery lime within 125 cm. Flat to gently undulating.
L44	- Ferralic Arenosol	Deep to very deep, well to somewhat excessively drained, dark yellowish brown to red sands to loamy sands. Almost flat to gently undulating.

Soils on Rocky outcrops

R - very shallow soils on steep hills, ridges and escarpments.

Soils on "Coarse Grained Sedimentary Rocks" or Kalahari Sands. These units may be prefixed with a "K" or an "L", denoting an origin from Kalahari sands.

KS3	- Ferralic Arenosol	Deep to very deep, well to somewhat excessively drained, yellowish brown (chromas of 5 or more) fine and fine-medium sands. Flat to undulating.
KS5	- Ferralic Arenosol	Deep to very deep, well to somewhat excessively drained, red to strong brown fine and fine-medium sands to loamy fine sands. Flat to undulating.
KS5a	- Luvic Arenosol	As for KS5, but showing lamellae of clay accumulation. Flat to undulating.
KS5b	- Luvic Arenosol	Deep to very deep, well to somewhat excessively drained, greyish brown to brown, fine and fine-medium sand to loamy fine sand. Flat to almost flat.
S6	- Ferralic Arenosol	Deep to very deep, somewhat excessively drained,red to yellowish brown fine sands and loamy fine sands. Undulating to rolling, dunes.
KS10	- Arenic Ferric Luvisol	Deep to very deep well to somewhat excessively drained, red to yellowish red loamy fine sand and fine-medium sands over sandy loams. Flat to undulating.

KS13a	- Petrocalcic Arenosol	Moderately deep to very deep,well to somewhat excessively drained, greyish brown to yellowish red, fine sand and loamy fine sand. Flat to undulating.
KS16	- Dystric Arenosol	Deep to very deep, somewhat excessively drained, dark greyish to light yellowish brown, fine and fine-medium sands to loamy sands. Flat to undulating.
KS17	- Eutric Arenosol	Deep to very deep, well to somewhat excessively drained, dark greyish brown to light yellowish brown fine and fine-medium sands to loamy fine sands (non-calcareous between 50-100 cm). Flat to undulating.
LS17d	- Eutric Arenosol	Deep to very deep,well to somewhat excessively drained, dark greyish brown to light yellowish brown fine sands. Undulating (dunes, beach ridges).

X - Association of soil units L22a - 31 - 24.

Y - Association of soil units L41 - 26 - 22a

Z - Association of soil units L22a - S17

PS - Permanently inundated areas.

APPENDIX 5 : EXISTING RIVER DRAW-OFF WATER RIGHTS FOR CHOBE AND LINYANTI

Water Right No.	File No.	Owner	Location	Quantity m^3
-	WR/B/6/383	Francistown	Kasane	72.0
AO327	WR/A/6/12A	Builders	Kasane	21.9
AO328	WR/A/6/12B	Wenela	Kazungula	27.3
BO614	WR/B/6/60	Wenela	Kasane	2728.0
AO537	WR/A/6/71	CBDT	CNP	4.6
AO539	WR/A/6/70	DWNP	Serondela	4.6
AO587	WR/A/6/7	DWNP	Kachikau	0.45
BO308	WR/B/13/24	Police	Kasane	260.0
B2249	WR/B/6/358	DWA Ngoma Enterprises	Muchenje	200.0

Source : Department of Water Affairs 1992

APPENDIX 6 : DETAILED DESCRIPTIONS OF PLANT ASSOCIATIONS

A. Wetland Plant associations

i Perennial Swamp

A small area of the Linyanti swamp falls within the CNP. Apart from a limited description of the Linyanti wetlands by Williamson (1979), no suitable description of the plants has been undertaken.

SMEC (1990) describes perennial swamp habitats as inundated by water throughout the year, but not necessarily permanently inundated. Communities belonging to the reeds, the bulrush and *Miscanthus junceus*, cover extensive areas with large stands. Communities have a wide range of associates probably due to the variability of hydrological regimes and the instability of some river systems. The variability and instability of the hydrological regimes is considered to be the key to allowing co-dominants to survive side by side. All plants in the perennial swamp are aquatics, major species are as follows :

Cyperus papyrus, Cyperus articulatus, Phragmites australis, Schoenoplectus corymbosus, P. mauritianus, Pycreus nitidus, Typha capensis, Vossia cuspidata, Miscanthus junceus, Nymphaea caerulea, Nymphoides indica

ii Seasonal Swamp

Small area of seasonal swamp occurs on the Linyanti, although this of much less importance than in the Okavango system. The seasonal swamp is defined as seasonally inundated areas which are sufficiently regularly and deeply flooded to support the growth of all life forms of aquatics (SMEC, 1990). It is the presence or absence of the aquatic plants and the depth and duration of flooding, which determines the seasonal swamp boundary with the dryer wetland category; flooded grassland. A detailed description of the species composition of the seasonal swamp of the Okavango is contained in SMEC (1990) and DWNP (1991).

iii *Flooded Grasslands*

The largest area of floodplain grasslands occurs along the Chobe river, where the relics of the seasonally flooded swamp reported by Miller in 1939 (FGU, 1988) has disappeared, probably under high utilisation by herbivores. Another ribbon of flooded grassland occurs along the bed of the Ngwezumba river where infrequent flooding keeps it free of woody plants. The grass species in the bed of the Ngwezumba consist of dryland species associated with the surrounding areas.The species reported for the area are (After FGU, 1988) :

Cyperus digitatus, C. articulatus, C. esculentus, Setaria sphacelata, Hemathria altissima, Echinochloa stagnina, Panicum maximum, Panicum repens, Panicum manicatum (?), Dactyloctenium giganteum, Digitaria eriantha, Digitaria ciliaris, Digitariella remotigluma (?), Brachiaria nigropedata, Brachiaria deflexa, Brachiaria brizantha, Eragrostis rigidior, Eragrostis jeffreysii(?), Eragrostis lappula, Paspalum scrobiculatum, Cynodon dactylon, other species that may occur on the flooded grasslands are; Eragrostis inamoena, Aristida junciformis, Panicum dregeanum, Eragrostis tricophora, Brachiaria humidicola, Panicum coloratum, Imperata cylindrica, Trachypogon spicatus, Andropogon spp, Cyperus longus.

iv *Seasonal fresh water pans*

This habitat is floristically rich. Within the MGR the following species are found exclusively at pans (DWNP, 1991, SMEC 1990), it is therefore expected to be similar to the pans of the CNP :

Oryza breviligulata, Aponogeton junceus ssp. rehmannii, Elytrophorus globularis, Schoenoplectus maritimus, Diplachne fusca, S. senegalensis, Panicum impeditum, Kyllinga albiceps, P. pilgerianum, Cyperus difformis, P. repentellum, Courtoisia cyperoides ssp. africanus, P. schinzii, Heteranthera callifolia, Echinochloa colona, Wolffiella repanda, Oryzidium barnardii, W. hyalina, Pycreus chrysanthus, Marsilea macrocarpa, Lagarosiphon muscoides, M. minuta, Commelina subulata, M. nubica, M. vera.

B. Dryland associations on fluvial soils

i Riparian woodlands

Three distinctly different riparian woodland area occur within the park :

(1) The least developed and most patchy is the patches which occur along the seasonal rivers which infrequently flow. Patches occur if an incised channel exists and the water table remains high. The species composition is similar to that occurring around pans and on termitaria.

(2) Linyanti riparian woodland and island clumps occurs in a broad continuous band along the river. The most common species, in decreasing order of importance, are (Coulson, 1992) :

TREES : *Croton megalobotrys, Combretum imberbe, Combretum hereroense, Berchemia discolor, Diospyros mespiliformus, Acacia erioloba, Acacia nigrescens, Lonchocarpus capassa, Garcinia livingstonei, Acacia luederitzii, Peltophorum africanum, Terminalia prunoides, Ziziphus mucronata, Maytenus senegalensis, Terminalia sericea, Colophospermum mopane, Boscia albitrunca, Ficus sycamorus.*

SHRUBS : *Combretum mossambicense, C. hereroense, C. megalobtrys, L. capassa, Diospyros lycioides, C. imberbe, M. senegalensis, A. erioloba, Dichrostachys cinerea, Euclea divinorum.*

(3) Chobe river : The riparian has changed from what was described as a forest by Selous in 1874 (Selous, 1881), through to a few relic species which survive because of their unpalatable nature, or because they occur on steep river banks which are inaccessible to elephant. At present the most detailed description of the riparian woodland comes from Simpson (1975) although the vegetation is being described at present by the DWNP and by private research.

In less damaged areas of the riparian Simpson described the vegetation as large trees up to 24 m tall forming a dense canopy. The dominant species were *Acacia albida, Garcinia livingstonei, Combretum imberbe, Diospyros mespiliformus,*

near to the river while further from the water the following species dominated; *Acacia nigrescens, Acacia tortilis, Trichilia emetica, Kigilia africana, Tabernaemontana elegans, Xeroderris stuhlmannii, Lonchocarpus capassa* the woody understorey was made up of *Croton megalobotrys, Phoenix reclinata, Gardenia jovis-tonatus, Rhus tenuinervis*. There was the occasional *Grewia spp. Acalpha ornata, Ximenia americana, Securinega virosa*. A dense mass of tangled vegetation was produced by lianas and climbers such as *Tacazzea apiculata, Artabotrys brachypetalus, Capparis tormentosa.*

As the canopy gets progressively opened up, Simpson describes the vegetation as having relic species of *Acacia nigrescens, A. tortilis L. capassa*, with the more hardy understorey species thickening their growth form and with *Capparis tormentosa* and *Acacia ataxacantha* spreading over the vegetation. Further breakdown of the riparian vegetation has led to open thickets of *Dichrostachys cinerea, Combretum elaeagnoides, Combretum mossambicense, Grewia biclor, Maytenus senegalensis* and *Acacia* spp.

ii *Acacia savanna/shrublands*

Selous (1881 pp 129) described the riverine woodlands vegetation as an open area with patches of bush and many fine wide-branching *Acacia erioloba*. The areas present status as described by Simpson (1975) is more of a shrubland/savanna, the larger tree species were (many are now dead) *Acacia nigrescens, A. tortilis, Berchemia discolor, Combretum imberbe, C. apiculatum, Lonchocarpus capassa*. The bush consists of *Dichrostachys cinerea, Combretum elaeagnoides, C. mossambicense, Terminalia sericea, Ziziphus mucronata* and *Acacia* spp. At present there is an opening up of the bush as elephant activity clears areas of the *Dichrostachys*, in the openings there are patches of *Cynodon dactylon* together with *Aristida, Hyparrhinia, Eragrostis, Digitaria, Setaria, Dactyloctenium, Panicum, Andropogon, Heteropogon, Urochloa* spp..

iii *Acacia erioloba and Acacia luederitzii open savanna Along the Savute channel (After Vandewalle, 1989).*

A line of mature *A. erioloba, A. luederitzii* and occasional large *Combretum imberbe* trees occur along both banks of the Savute channel. *Lonchocarpus nelsii* dominates the upper canopy of scrub which is two metre tall while *Baphia massaiensis* and *Salacia luebbertii* are dominant below one metre.

A short section of the western verge of the Savute marsh is flanked by a belt of woodland (on lacustrine soils) in which tall, mature and well developed *A. erioloba* and *A. luederitzii* trees form a non-overlapping canopy. The woodland varies in width from approximately 50 m to 150 m. *Combretum hereroense, Rhus tenuinervis* and *Acacia tortilis* dominate the sparse scrub layer. Dense patches of *Grewia flavescens* occur.

Utilisation by grazers and browsers was high while sections of the woodland have been flooded in the recent past. Many trees were drowned during a 1979 flood period evidenced by a number of dead stumps extending beyond the present range of the woodland into the marsh. Dead trees occurred within the present woodland, some having been ringbarked by elephants while others having died from old age. A striking feature of this woodland is the uniform size of the trees. All are mature and there is an absence of young *Acacia* in the lower size classes.

The belt of Acacia woodland along the western verge of the marsh tapers in the south where it is replaced by a small section of *L. capassa* woodland.

iv *Acacia erioloba savanna on deep sands (After DWNP, 1991)*

Dense uniformly aged stands of this species occur. In many areas the single aged composition of specific stands means that the community structure may change rapidly once the lifespan of the trees is reached. In addition, large-scale die-off in this community may occur as a result of the effects of elephant feeding on these trees.

Episodic events seem to trigger the growth of A. erioloba stands which develop into woodland. Examples of these areas at various stages of growth occurred on the Savute marsh after it dried up at the end of the 19th century. As the woodland dies back, a mixed

acacia/ sandveld woodland develops dominated by Acacia spp, C. megalobotrys, L. nelsii and Dichrostachys cinerea.

v *Mixed savanna (historic floodplain)*

A mixture of old channel sediments and past ponding has increased the clay component of these soils so that species that occur are similar to those found around pans, at the fringe of floodplains and on termitaria. These are mopane dominated savannas with the following species : *Colophospermum mopane, Combretum imberbe, Lonchocarpus capassa, L. nelsii, Acacia erioloba, A. luederitzii, A. tortilis, Combretum zeyheri, C. hereroense, C. collinum, Dichrostachys cinerea.*

vi(a) *Mopane woodland (Historic floodplain). After Vandewalle (1989).*

The Linyanti river has flooded a wider area in the past compared to the present floodplain (Shaw, 1985). This has resulted in the deposit of a belt of alluvial sediments in a wide band adjacent to the present course of this river which supports a mosaic of C. mopane woodland an scrub. Tall open woodlands with large trunked trees, unlike those found in the Mababe, are characteristic of these sandier areas.

vi(b) *Mopane dense to open savanna (historic floodplain).*

This plant association is similar to the above except that the canopy is more open forming a mosaic of mature trees and shrubs. There are areas of *Burkea africana* and *Terminalia sericea* covering large areas of the area between the lacustrine soils of the Savute and the Linyanti river. South of the Savute channel the mopane vegetation is more uniform with lower densities of *Burkea africana* and *Terminalia sericea.*

vii *Londiscarpus nelsii/Terminalia sericea on old river sediments*

This community is located on deep arenosols and old river channels forming a shrubland. The old river sediments generally lead down to the Linyanti and tend to act as conduits for elephant. The *Lonchocarpus* and *Terminalia* are important browse for elephant which crop the shrub into browsing hedges at a suitable browsing height.

viii *Burkea africana/Terminalia sericea (after Vandewalle, 1989)*

These areas differ only slightly from the neighbouring *Burkea* woodlands because they occur on less sandy, alluvial soils and the tree layer is sparse with a more dense, tall scrub layer of predominantly *T. sericea*. *Colophospermum mopane* in patches along the river courses.

C. Dryland associations on lacustrine soils

i *Savute marsh/edaphic grassland (after Vandewalle, 1982), (108 km²)*

Although the marsh is usually a dry grassland and not a true wetland, it is periodically flooded and is then characteristic of a marsh. The soils are dark, heavy clays which become waterlogged during years of good rains. As a result of the occasional flooding and annual waterlogging, the marsh is a grassland. A number of grass and sedge species occur and in places remnant hydrophytes indicate that the marsh was flooded in the recent past. The average water holding capacity of soil in the marsh is around 10 times greater than the hydromorphic soils of other grasslands in the study area. Several grass communities were recognised in the marsh grassland. *Cynodon dactylon* occurs throughout the area and mono-specific *Cynodon* 'lawns' are characteristic around the margins of the marsh. Locally abundant grasses are *Imperata* var. *africana*, *Panicum repens*, *Eragrostis* spp., *Chloris gayana*, *Sorghum versicolor* and *Phragmites* sp.. Clays at the southern extreme of the marsh belong to the montmorillonitic group. Under water-logged conditions the clays swell due to the absorption of large amounts of water into the spaces between the clays layers. When they dry, they contract and crack often forming characteristic hexagonal features. Large underground cavities occur in the area as a result of the swelling and contracting of these clays. *Bothriochloa insulpta* is common in the contraction cracks of the clays while *Cynodon dactylon* occurs in the depression areas between the cracks.

ii(a) Edaphic grasslands (hydromorphic soils) (after Vandewalle, 1989)

Small grassland areas occur within wooded vegetation types on hydromorphic soils associated with seasonal pans. These areas are either large, containing several pans, or limited small patches with a single pan.

Other more extensive grasslands occur which are associated either with a dense herb or with a sparse presence of woody species. The most predominant non-graminoid species in these grasslands is *Pechuel-Loeschea leubnitziae*, an aromatic perennial herb, although many annual herbs appeared in the summer months. Associated scrub species such as *Colophospermum mopane, Grewia flavescens, G. flava* and *Combretum hereroense* occur, usually in small, scattered clumps often associated with termitaria. The grass species composition varies but some annuals such as *Eragrostis viscosum, Chloris gayana* and *Urochloa trichopus* are widespread and *Cynodon dactylon*, a perennial grass, is common on most hydromorphic soils. The grassland to the west of Gcoha Hill occurs on calcrete soils and *Sorghum versicolor* in the central region of this grassland indicates the poor drainage conditions of these soils.

ii(b) Edaphic grasslands (basaltic origin)

The open grasslands, described in the Arup Botswana report (1990), had an average ground cover of 37.5 % of which 35.5 % consisted of grasses. The grasses, in order of frequency were : *Setaria sphaceliata, Ischaemum afrum, Cymbopogon excavatus, Hyperthelia disoluta, Brachiaria eruciformus, Bothriochloa radicans, Aristida congesta, Cyperus sp., Sorghum versicolor.*

The other ground cover species include : *Asystasia schimperi, Nidorella resedifolia, Vahlia capensis, Leucas sp.*

The woody species found in patches within the grassed area and around the margins form part of the ecotone between the grasslands and the surrounding mopane woodlands. Woody species, in order of frequency, include : *Colophospermum mopane, Acacia karoo, Acacia nilotica, Indigiofera schimperi, Hibiscus cannabinus, Combretum imberbe, Dichrostachys cineria, Combretum hereroense, Kirkia spp., Lannea spp. Maytenus senegalensis, Rhus pyroides, Ziziphus mucronata.* The broad leafed species, in order of frequency of occurrence, are : *Sphaeranthus penduncularis, Nidorella resedifolia,*

Vahlia capensis, Barleria sp., Corchorus asplenifolius, Blepharis caloneura, Rhyncosia minima, Leucas sp. Vernonia galpini, Cucumis myriacarpus, Asystasia schimperi, Neorautanenia mitis, Corchorus olitorus.

iii *Edaphic shrublands/grasslands*

iii(a) *Acacia hebeclada* (After Vandewalle, 1989)

To the south, the grasslands of the Savute marsh change abruptly to a scrub vegetation. Areas of varying densities of *A. hebeclada* occur in pure stands along the edge of the marsh as well as in 'islands' within the marsh to the south, *Colophospermum mopane* scrub mixes with *A. hebeclada* in places. These areas tend to be grasslands with shrub rather than shrublands.

iii(b) *Cadaba termitaria/Acacia hebeclada* (After Vandewalle, 1989)

South of the marsh in the Mababe depression the scrub becomes more diverse and *C. termitaria* is common. Other species, usually occurring on old termite mounds or higher ground, include *Combretum zeyheri, Commiphora africana, Rhus tenuinervis, Acacia tortilis* and *Colophospermum mopane* while stands of *Acacia arenaria* occur in places.

iii(c) *Acacia tortilis*

The southern Mababe into which the Khwai/Mogogelo rivers occasionally drain, an extensive shrubland composed of *Acacia tortilis* occurs on the poorly draining clays there are areas with *Acacia luederitzii*. Elephant use of the plants has been high, opening up much of the area. The grasses reported for the area are (FGU, 1988) : *Cynodon dactylon, Cenchrus ciliaris, Chloris virgata, Urochloa* sp. with stands of *Sorghum arundinaceum.*

iv Mopane

iv(a) Shrublands, mopane encroached pans

These areas consist of stands of scrub which vary in density from dense enough to exclude fire (mainly on pans in the areas with high livestock activity in the past) to relatively open grassy areas (eg the alluvial fan of the Potopoto/Gautumbi). Most of the pans with mopane shrub are considered by Child (1968) to have been open grasslands. The grasslands probably become encroached with mopane after heavy grazing by livestock during eliminated fire when the Mababe was part of the livestock trek route to Zambia. The hard pan layer produces hydrological conditions which maintains the mopane as shrub.

The vegetation is described by Vandewalle (1989). These scrublands are generally of uniform height rarely exceeding 1,5 m although isolated trees occur. The scrublands vary markedly depending on the locality of the association. The areas to the east of the Savute marsh form almost mono-specific stands while those to the west tend to be a mixture of sparse *C. mopane and Lonchocarpus nelsii.* To the north *C. mopane* is dominant but there is a greater contribution to the cover by over species with *Combretum hereroense* in noticeably high densities. Other species are often associated with abandoned termite mounds but these were not abundant.

The soils differed from the woodlands only in that the sandy clay top soil layer was often more shallow and the hard pan layer a more prominent feature, often compact and of considerable thickness.

iv(b) Mopane shrublands on mixed hydromorphic soils

These mopane shrublands are similar to (iv a) but occur on deeper clay soils and (probably when fire is excluded) can grow through to mopane woodlands.

iv(c) Mopane woodlands on mixed hydromorphic soils (after Vandewalle, 1989)

Colophospermum mopane characteristically forms almost mono-specific stands of closed woodland where trees reach heights of 10 m or more and herbaceous cover is sparse. The scrub layer is either dense or sparse depending on the openness of the tree canopy, is 1,5 - 2 m tall and in open and closed woodlands consists almost entirely of *C. mopane* although *Boscia mossambicensis* is present. Seasonal pans are common and *Combretum imberbe* trees occur around some of the larger pans within the woodlands.

The soils consist of a top sandy to sandy clay layer of variable depth (10 - 50 cm) above a dark clay subsoil which in turn is subtended above deep yellow sands. Within the clay layer there is a hard pan layer which varies in width and compactness from one *C. mopane* area to another. In the woodlands, however, this pan layer is neither very distinct nor compact.

iv(d) Mopane woodland/shrubland mosaic

The vegetation consists of a mosaic of woodlands (ivc) and mopane shrub (iva). The wooded areas are on areas of deeper clay soils and termitaria.

In the southern areas, between the eastern Mababe ridge and Nxai pan, patches of lacustrine soils occur. In these areas the vegetation is predominantly mopane, with an increase in sandveld species. The species, after Verbeek and Telekelo (1990), are : *Combretum apiculatum, C. hereroense, Terminalia sericea, Commiphora sp., Peltophorum africanum, Boscia* sp.

v Magwikwe Sand ridge associations.

The sand ridge changes from well structured and high (ca 27m) in the north to a much deflated band of deep sands in the south, near to the Moremi Game Reserve. Three vegetation communities have been identified by Vandewalle (1989) and described as follows :

(1) *Baikiaea plurijuga - Burkea africana* woodland. *Baikiaea plurijuga* and *B. africana* contribute to a closed woodland with *Combretum elaeagnoides* and

Croton gratissimus scrub. Scattered *Boscia albitrunca* trees contribute to the middle canopy. *Baphia massaiensis* forms a short layer of scrub. Many *B. plurijuga* seedlings occur. The soils are acid (pH 4,3), yellow-brown and have a texture of 98% sand and 2% silt. Fire disturbance is high. Use by elephant is low.

(2) *Acacia erioloba - Acacia luederitzii* savanna/*Baphia massaiensis* scrub (37 km²). Open *Acacia erioloba* and *A. luederitzii* savanna with a scrub layer of *Baphia massaiensis* is associated with the southern regions of the sandridge. At and near the top of the ridge the vegetation is sparse, with *Boscia albitrunca* occurring in the tree canopy while at the base the scrub layer is dense. The density and species compositions on either side of the sandridge differs. On the eastern side the tree canopy is sparse and *Baphia massaiensis, Ochna pulchra, Terminalia sericea* and *Lonchocarpus nelsii* occur in a dense scrub layer. On the western side the tree layer is more dense while the scrub layer is less dense with species such as *Acacia fleckii, A. nigrescens, A. tortilis, Grewia flava, L. nelsii* and *T. sericea.* Ringbarking of trees by elephant and coppicing of shrubs following breakage is common. These sands are white with a pH ranging from 5,8-6,4.

(3) *Combretum elaeagnoides - Croton gratissimus* scrub (13 km²). This association differs from the *B. plurijuga - B. africana* woodland only in that the closed tree canopy is largely absent except for some sparsely distributed trees.

vi *Burkea savanna on deep sands* (after Vandewalle, 1989)

These areas are characterised by a tall open savanna association dominated by *Burkea africana* and occasional *Terminalia sericea* trees. Trees are straight trunked and branch into a crown 10 - 15 m from the base. A wide range of species make up the scrub layer which varies in composition from north to south. In the north the shrubs are mainly *Baphia massaiensis, Combretum psidioides* and *Terminalia sericea.* In the south *T. sericea* disappears from the scrub layer while *Lonchocarpus nelsii* and *Combretum fragrance* become important in the understorey. The vegetation near the Savute channel is more dense than the rest of the Sandveld.

Evidence of past fire disturbance is widespread with burnt stumps and fallen tree trunks being a common feature. Many of the living trees showed blackening of the bark at a

height of up to 2 m. Elephant are an important disturbance factor in the southern areas with uprooting of *T. sericea*, being widespread.

Top-soil texture ranges from 96,8 - 100% sand while sub-soils are made up of 100% sand. Both layers are acid with a consistent pH of 5,4.

To the south, near the dry Tsatsara river valley, the vegetation gradually changes from a *B. africana* dominated savanna to one dominated by *T. sericea* in both the tree and scrub layers. In addition, the contributions of *Lonchocarpus nelsii*, *Combretum fragrance* and *Baphia massaiensis* decrease in the scrub layer. There was evidence of past fire and indications of greater elephant utilisation, particularly in the scrub layer, than in the rest of the Sandveld.

vii *Acacia erioloba savanna and Acacia erioloba savanna/Terminalia sericea scrub* (after Vandewalle, 1989)

In the northern Sandveld there is an abrupt change from *Burkea africana* savanna to *Acacia erioloba* savanna. Tall, mature trees occur with an open canopy and occasional *B. africana* and *T. sericea* individuals are scattered within the savanna. *Terminalia sericea* forms an open scrub layer, but is absent in localities where *A. erioloba* forms a closed tree canopy woodland with an open understorey.

viii *Shrublands : Lonchocarpus nelsii/Combretum hereroense and Acacia/Boscia/Mundulia shrub* (after Vandewalle, 1989)

Although *C. hereroense* and *L. nelsii* are the dominant species, this association is diverse, heterogeneous and patchy. The height of the scrub varies between 1 m and 2 m but is on average about 1,5 m tall. The northern areas of the Mababe are diverse but dominated by *C. hereroense* and a number of *Acacia* species. Further south the areas are predominantly *L. nelsii* with a major contribution of *C. mopane* and to a lesser extent some *Acacia* species. Some of these areas showed signs of having been heavily utilised in the past, particularly the dense scrublands along the banks of the Savute channel where emergent *Acacia erioloba*, *A. luederitzii*, *Lonchocarpus capassa* and *Combretum imberbe* trees occur. Other than *L. nelsii* and other dominants, species contributing to the scrub layer are *Combretum collinum*, *C. zeyheri*, *Acacia tortilis* and *A. erioloba*. *Dichrostachys*

cinerea occurs in places in dense stands approximately 1 m tall which suggests that these areas have been heavily utilised and disturbed (possibly past cultivation).

Acacia - Boscia - Mundulea sericea scrub; These are tall (3 - 4 m), open scrubland areas with shrubs clumped in an open grassland and occasional trees occur. Acacia species included *A. tortilis, A. erioloba, A. fleckii* and *A. luederitzii. Boscia albitrunca, B. foetida* and *Mundulea sericea* were other abundant species. Less abundant species were *Grewia bicolor, G. flavescens, Dichrostachys cinerea, Terminalia sericea, Rhus tenuinervis* and *Peltophorum africanum. Combretum hereroense, C. zeyheri, C. imberbe* and *C. collinum* occur in low densities.

ix *Combretum hereroense shrubland/grassland*

Within the Kalahari sands areas, reworking of the sands by water, has resulted in patches of harder soils which form small edaphic grasslands/shrublands. These are important areas for wildlife, providing diversity within the sandy areas and often contain watering points late into the dry season. The woody species are dominated by *Combretum hereroense, C. zeyheri* and *Bauhinia thonningii.* The grasses tend to be tall, dominated by *Cymbopogon, Hyparrhenia* and *Eragrostis* spp.

D. Dryland associations on aeolian and partially reworked Kalahari sands

i(a) *Baikiaea plurijuga woodlands (deep sands)*

i(b) *Baikiaea plurijuga dense - open savanna*

The *Baikiaea plurijuga* associations vary from woodlands to savanna due to changes in rainfall and fire frequency. Nearer to the Chobe river, rainfall is higher and the woodland areas occur although fire has effectively opened the canopy to produce a savanna in much of what would have been a woodland area. In areas free of regular fires the regrowth of young teak trees is noticeable, forming dense stands of teak. *Baikiaea* occurs on deep, pale red, free draining Kalahari sands with no seasonal water table. In the Savute area the sands are typically acid (4,1 - 4,5) pH) (Vandewalle, 1989).

The composition of the teak woodlands has be described by the Norwegian Forestry Society (1992). The common tree species are : *Baikiaea plurijuga, Burkea africana, Pterocarpus angolensis, Guibourtia coleosperma, Afzelia quanzensis,*

Erythrophleum africanum, Amblygonocarpus andongensis, Diospyros batocana, Kirkia acuminata, Dialium engleranum, Terminalia sericea, Brachystegia boehmii, B. spiciformis, Pseudolachnostylis maprouneifolia. Of the trees occurring within the teak woodlands and on the harder soils, the following are considered to be of commercial value : *B. plurijuga, P. angolensis, B. africana, K. acuminata, G. coleosperma, A. quanzensis, B. spiciformis, A. andongensis, E. africanum, C. mopane.* The most common shrubs are; *Baphia massaiensis, Bauhinia petersiana, Commiphora mossambicensis Grewia flavescens.* Grasses are; *Pogonarthria squarrosa, Panicum maximum, Digitaria milanjiana, Aristida stipitata, Schmidtia pappophoroides, Dactyloctenium aegyptium.*

The *Baphia* appears to increase with high fire frequency. As the sands become shallower, the teak woodland changes to one with increasing numbers of *Guibourtia coleosperma*, changing to a *Burkea african savanna* and finally to *Colophospermum mopane.* All of the *Pterocarpus angolensis* observed were partially debarked, making this valuable timber species susceptible to fire.

ic *Baikiaea plurijuga/Guibourtia coleosperma/Burkea africana woodland*

Similar to No. (i), but with an increase in *G. coleosperma, B. africana* and *Erythrophleum africanum.*

ii *Burkea africana dense - open savanna (reworked sands)*

In these savannas teak still occurs although most of the teak woodland species disappears and sandveld species such as *Terminalia sericea* increase. In some areas high numbers of *Erythrophleum africanum* persist. Dense stands of savanna occur to the north of the CNP and along channel areas. Fire frequency is high, and *Burkea* recruitment appears to be low.

In the south east of the CNP there are numerous *Ricinodendron rautanenii* the fruit of which is used by many wildlife species including elephant. In addition to the trees being dominated by *Burkea africana, Pterocarpus angolensis, Terminalia sericea, R. rautanenii*, there are also an increase in the sandveld species such as *Terminalia sericea, Boscia albitrunca, Combretum albopunctatum, C. apiculatum, C. zeyheri, Lonchocarpus nelsii, Croton*

gratissimus, Dichrostachys cinerea, Grewia sp. (Partially after Verbeek and Telekelo, 1990).

iii *Mopane dense - open savanna with Kalahari woodland species (Partially lacustrine soils)*

The mopane savanna where aeolian sands occur adjacent to the lacustrine soils have been described by Arup (1990) to have a grass cover of 39.5 % with the most frequently occurring woody species to be : *Colophospermum mopane, Combretum imberbe, Indigiofera schimperi, Acacia karoo, Combretum hereroense, Hibiscus cannabinus, Combretum molle, Bauhinia thonningii, Acacia nigrescens, Lonchocarpus capassa, Acacia nilotica, Bolusanthus speciosus.* Of the broad leafed species, *Sphaeranthus penduncularis,* and *Sesbania penduncula* are important. In sandy areas, *Burkea africana* also occurs.

To the south of the CNP there is an increase of sandveld species with a decrease in the teak species, the most common species are : *Colophospermum mopane, Combretum apiculatum, C. hereroense, T. sericea, Bauhinia petersiana, Acacia mellifera, A. erioloba, Grewia* sp. (Partially after Verbeek and Telekelo, 1990).

E. Miscellaneous dryland associations

i *Savanna on basalt outcrops*

Basalt outcrops occur along the Chobe river. The outcropping forms much of the escarpment and contains a combination of teak woodland species, alluvial sands species and rock outcrop species. The dominant tree in many areas was *Acacia nigrescens* but although some seedlings were observed, most of the adult trees had been debarked and were dead. *Colophospermum mopane* and *Combretum apiculatum* were important in areas near Ngoma, with *Adansonia digitata* and *Sterculia africana.* The shrubs were dominated by *Combretum eleagnoides, C. zeyheri* and other *Combretum* spp.

ii *Hills*

The Gubatsa and Goha hills have been described by (Vandewalle,1989). The Chinamaba hills are isolated in the south east of the park. The hills form isolated islands with vegetation that are diverse and distinct from the surrounding plains. On Goha Hill the top canopy forms a closed woodland, up to 15 m in height, with *Kirkia acuminata* as the dominant species. Associated species include *Albizia tanganyicensis*, *Lonchocarpus nelsii*, *Dalbergia melanoxylon* and *Grewia monticola*. Species that occur preferentially at the base of the hill are *Ximenia americana*, *Colophospermum mopane*, *Adansonia digitata* and *Capparis tomentosa*.

The vegetation on the lower Gubatsa Hills forms a diverse woodland with an open top canopy. *Kirkia acuminata*, *Albizia tanganyicensis*, *Steganotaenia araliacea*, *Diplorhynchus condylocarpon*, *Sclecrocarya birrea*, *Berchemia discolor*, *Commiphora pyracanthoides* and *Combretum apiculatum* are some common species on the hill while at the base *Lonchocarpus nelsii*, *Combretum imberbe*, *C. hereroense* and *Croton megalobotrys* are present.

APPENDIX 7 : PAST LAND USE WHICH AFFECTED VEGETATION

(Partially after Child, 1968)

Livestock areas and trek routes from 1900. Shaded areas were subject to heavy grazing and a high frequency of early burning

Wagon and stock routes

Study area

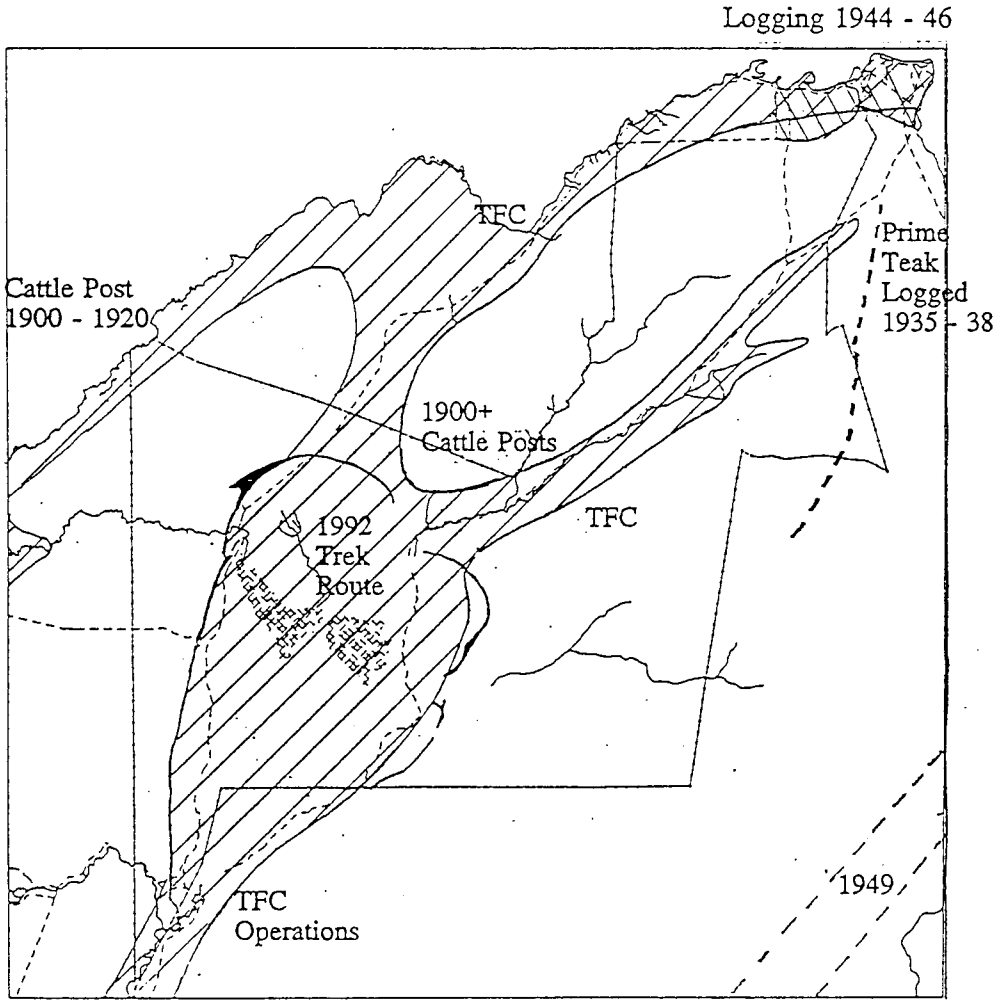
National Park Boundary

River

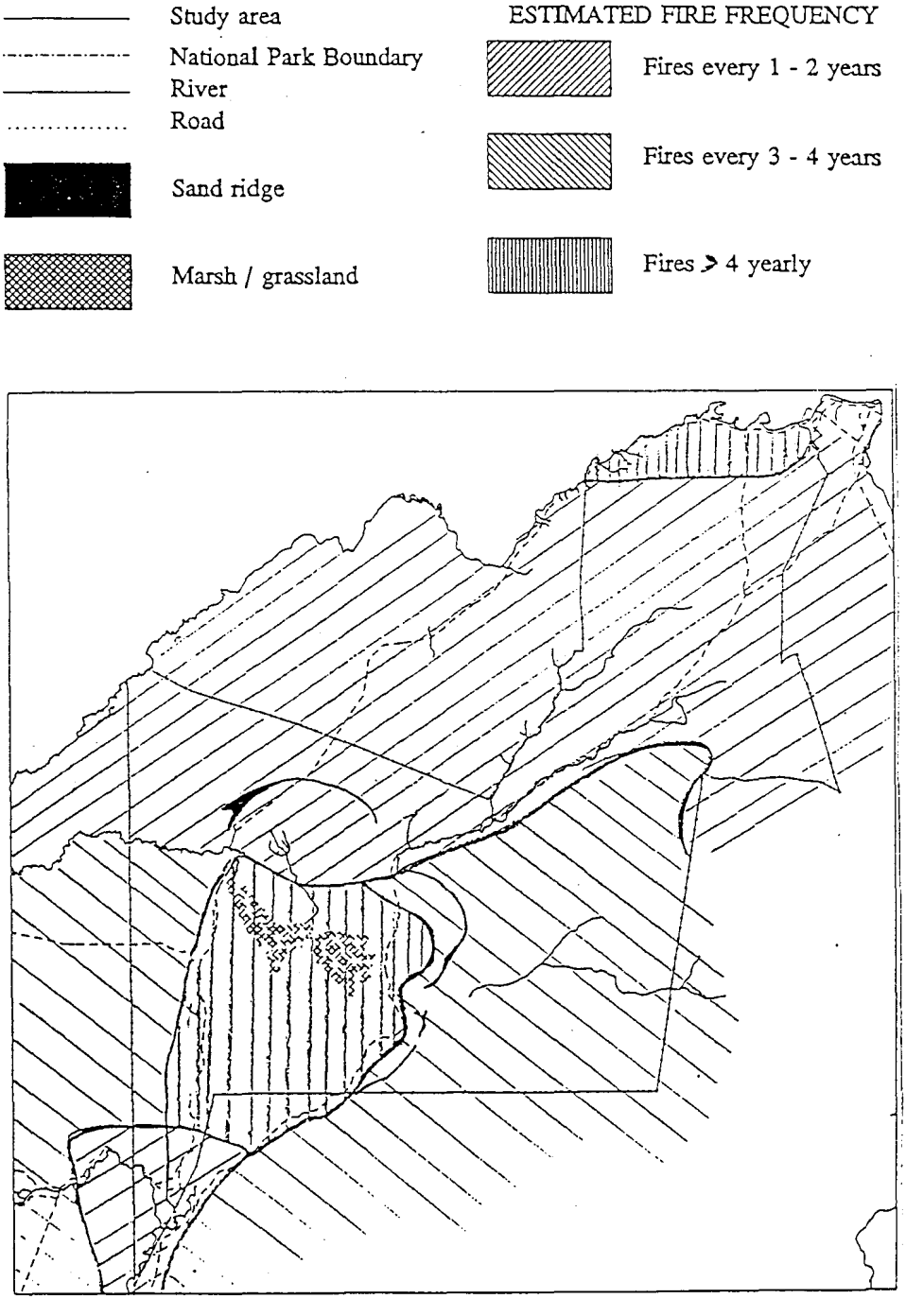
Road

Sand ridge

Marsh / grassland



APPENDIX 8 : ESTIMATED FIRE FREQUENCY



Based on field observations, landsat imagery (August 1983, July 1987) and interviews with DWNP staff and private researchers.