Chapter 5
Wildlife Resources and Human Wildlife Conflict

October 2010

Republic of Botswana

Chapter details

This chapter is part of the Project Development of a Makgadikgadi Framework Management Plan (MFMP) prepared for the Government by the Department of Environmental Affairs in partnership with the Centre for Applied Research.

This chapter is authored by the following persons: Dr. Chris Brooks and Dr. G. Maude with inputs from Thoralf Meyer, Dr. Graham McCulloch and Dr. Jaap Arntzen

Citation:

Authors, 2010, Chapter title. In: Centre for Applied Research and Department of Environmental Affairs, 2010. Makgadikgadi Framework Management Plan. Volume 2, technical reports, Gaborone.

Table of Contents

List of Tables

List of Figures

Abbreviations

AEWA	African-Eurasian Migratory Waterbirds
AWP	Artificial Water Points
BLB	BirdLife Botswana
BSAP	Biodiversity Strategy Action Plan
CBD	Convention on Biological Diversity
CHA	Controlled Hunting Areas
CITES	Convention on International Trade of Endangered Species
CKGR	Central Kalahari Game Reserve
CLMAs	Community Land Management Associations
CTA	Conditioned Taste Aversion
DWNP	Department of Wildlife and National Parks
FGD	Focus group discussion
FMD	Foot and Mouth Disease
GIS	Geographic Information System
GPS	Global positioning System
IBA	Important Bird Area
IUCN	World Conservation Union
KCS	Kalahari Conservation Society
KDE	Kernel Density Estimation
MCA	Multi Criteria Analysis
MFMP	Makgadikgadi Framework Management Plan
MPNP	Makgadikgadi Pans National Park
MWS	Makgadikgadi Wetland System
NDP	National Development Plan
NSAID	Non-Steroidal Anti-Inflammatory Drug
ODMP	Okavango Development Management Plan
PAs	Protected Areas
PAC	Problem Animal Control
TDS	Total dissolved solids
WMA	Wildlife Management Area

1 Introduction

1.1 Aims and Objectives

The main objective of the report is to define the population trends and status of the principal wildlife and birdlife species within the boundaries of the Makgadikgadi Framework Management Plan (MFMP) area and to assess the current state of human wildlife conflicts within the Makgadikgadi wetland region, with a view to identifying viable recommendations for effective mitigation.

For the purposes of this report, the term wildlife encompasses all medium-to-large non-domestic mammal species and all bird species for which, where possible, detailed distribution patterns and population trends have been provided, plus all smaller mammals, reptiles, amphibians and invertebrates, for which a more simplistic inventory is provided in light of data gaps for these less visible species.

One of the objectives of this report is to highlight where within the boundaries of the MFMP area human-wildlife conflict occurs, what are the principal causes of that conflict and which mitigation strategies will be most effective at controlling and limiting that conflict.

1.2 Wildlife Diversity in the Makgadikgadi

The wildlife and birdlife inventory, as well as their estimated population densities and distribution data, has been gathered and adapted from a series of independent and government based census work and surveys conducted across the Makgadikgadi region since the 1960s. These data indicate that for some species there is a cause for concern with improved conservation and protection required for many wildlife species within the system to halt numerical declines and spatial retreats. Improved monitoring of most species is required to help improve our knowledge of current population levels and distribution patterns. However, although the records are in many cases incomplete, there is a significant mass of information to help inform and define conservation and land use management strategies for the region.

The Makgadikgadi Wetland System (MWS) supports a rich and diverse fauna community, and has been identified as a biodiversity hotspot in the country's Biodiversity Strategy Action Plan (BSAP-SR, 2003). There exists a community of wildlife species well adapted to the unique and often extreme conditions of this saline and highly variable wetland system. In some instances this has led to endemism and, in other cases, is manifest in adaptive feats of physiology and behaviour that have been recorded among some individual species and populations.

One such important behavioural adaptation, which spans many faunal groups and is essential to life in the MWS for many species, is migration. The ability to move in and out of the system to take advantage of a bountiful food source during the wet season and leave during drought, when conditions render survival almost impossible, is a key life history trait that sustains much of the systems faunal biodiversity. Maintaining connectivity to other nearby systems, and in the case of birds, to an extensive network of habitats that span the region, which connects global

populations, is without doubt one of the most important challenges facing the conservation and effective management of the MWS' fauna.

The conservation of both wildlife and bird resources within the Makgadikgadi wetlands is crucial. The wetlands are an 'important bird area' (IBA), forming one of the most significant breeding grounds for flamingos and pelicans within Africa and a migratory destination for tens of thousands of other water birds. The majority of the area covered by open pan within the Makgadikgadi system is unprotected, leaving vital breeding and important feeding areas for migratory wetland birds vulnerable to degradation. The region is also home to the largest migration of medium sized herbivores in southern Africa and one of the largest remaining on the continent. The zebra and wildebeest migration that moves annually across the Makgadikgadi forms a keystone within the ecological dynamics of the system and also enables the region to support a viable eco-tourism business that is centred around the migration and its associated predators.

Large mammals are, in many cases, responsible for the main generators of economic benefits in the region, but can also be responsible for much of the human-wildlife conflicts. Some large mammals form important flagship species that are used to rally conservation efforts, e.g. elephant and lion. Due to their size and resource requirements many of the species walk considerable distances and cover large home ranges in search for preferred resources and mating opportunities, e.g. elephant, zebra and wildebeest. Single species conservation efforts can, therefore, have significant land use conservation benefits that enable whole ecosystems to be protected. However an Ecosystem Approach has been applied within the MFMP. This approach encompasses the integrated management of living resources, as well as the land and water resources upon which they depend to promote their conservation and sustainable use in an equitable way.

A total of 14 Orders, 32 Families, and 91 species of mammal are recorded as occurring in the Makgadikgadi wetlands. Of these, nine are listed on the IUCN Red Data List; Wild Dog, Lion, Leopard, Cheetah, Elephant, Hippopotamus, White Rhino, Brown Hyaena and the Black-footed Cat. Forty-two, out of a total number of 73 mammal species recorded in the Makgadikgadi Pans and Nxai Pans National Park, were small mammal species.

One hundred and four waterbird species, 32 of which breed here, migrate to the pans each rainy season to feed and breed, augmenting the resident terrestrial birds to give a total bird count for the area of 385 species. Some of these are globally threatened and/or of particular conservation importance, 18 in all, including Wattled Crane, Grey Crowned Crane, Chestnut-banded Plover, Black-winged Pratincole, and Greater and Lesser Flamingo. Large numbers of birds are regularly counted at Nata Sanctuary, Mea Pan, the Sua spit area and at Rysana Pan. Extreme variation in annual flooding, among and within seasons, however, makes it very difficult to identify trends in the waterbird populations. Nonetheless, the mean annual total number of birds in the MWS is in excess of 30,000 waterbirds.

Barbel and bream fish species survive and breed in the deep waters of Sua Pan in years of exceptional rainfall and flooding. Reptiles and amphibians are important components of the ecosystem and are of value to the remote-area communities in Botswana. Eighteen species of amphibian and 14 families and 71 species of reptiles have been identified in the MWS, with collections from Xhumaga, along the Boteti, Nata Sanctuary and some of the other smaller pan

wetland areas showing the greatest species diversity. One species is endemic to the MWS; the Makgadikgadi Spiny Agama (*Agama makarikarica*), while the Rock Python (*Python sebae natalensis*) and the Nile Crocodile (*Crocodylus niloticus*) are listed as protected.

1.3 Human-Wildlife Conflict

Human-wildlife conflict is an issue for concern for many regions of Botswana, the rest of Africa and the world as a whole. Mitigation strategies have been defined for many conflict situations and the role of this report is not to 're-make the wheel', but identify those mitigation strategies that are best suited to the Makgadikgadi. The aim of human-wildlife mitigation strategies is to try and reduce the negative socio-economic impact of wildlife on people that live within conflict zones, while ensuring that the conflict does not lead to the decline of the wildlife populations through proactive measures by communities.

Human-wildlife conflict is most prevalent around protected areas (PAs), where wildlife populations are greatest, and between protected areas where migratory corridors cross unprotected community land. While there are many ecological factors that regulate the levels of conflict, the intensity of conflict is primarily affected by land use zoning, or the lack of it, with high intensities of opposing forms of land use in close proximity coming into direct conflict. Human wildlife conflict is therefore in many regards a form of land use conflict.

2 Approach, Methods and Activities

2.1 Approach

The objectives of the Wildlife Resources Component, as defined by the MFMP Inception Report are to assess the trends in wildlife and bird resources through an investigation of their historical and recent population levels, while defining their distribution patterns. This information is to be combined with an assessment of the current level of human-wildlife conflicts within the region to help generate effective mitigation strategies specific to the Makgadikgadi.

To achieve these objectives, it was important to gather and analyse the following data;

1. The Department of Wildlife and National Parks (DWNP) aerial census data on the current estimates of wildlife populations and distribution patterns within Botswana, refining the data to provide accurate estimates of wildlife within the FMP study area
2. The Birdlife Botswana records of sightings and nest surveys within the Makgadikgadi area
3. Independent researchers data on density and distribution patterns of study animals within the region
4. Historical census data on wildlife populations in the region
5. Historical anecdotal evidence of wildlife density and distribution patterns in the region

Using these data, we have generated a series of distribution maps that highlight areas of critical importance for key species within the system (where data was sufficient to do so) and developed graphs of populations' trends. On a species by species approach these data (in association with other background information) have then be used to help assess why species may be declining, which are more susceptible to conflict with humans and livestock and where, which have greater land use requirements and why, which are more susceptible to ecological fluctuations, which may be a concern to the Department of Veterinary through disease transmission and which may have the potential to stimulate tourism development.

The causes of human-wildlife conflict are diverse and it is important to consider ecological factors, human factors and land use factors, but addressing land use factors through effective land use planning possibly provides the best approach to successfully mitigating for human-wildlife conflict in the long-term. The approach taken for the assessment of human-wildlife conflict within the MFMP area is directed towards addressing human-wildlife conflict as, primarily, a land use issue. While all forms of conflict mitigation pertinent to the Makgadikgadi situation will be taken into consideration to help reduce the current levels of conflict, it is believed that identifying effective land use options provide the best way forward.

When a land use approach is taken, the problems of human-wildlife conflict can be integrated with other conflicts in the region, such as livestock-arable conflicts, the impacts of rangeland degradation through increased livestock densities, surface water constraints and human settlement patterns, the conservation of biodiversity hotspots Vs agricultural expansion. The mitigation of human-wildlife conflict can then be integrated within a larger, more holistic land use strategy that tries to optimise land use for all of the above competing land claims through a multi-criteria zoning strategy.

Implementation of human-wildlife mitigation at a larger regional and national scale in association with other land use conflicts helps to integrate different government departments to drive through changes in land use. The land use / zoning approach does not prevent other mitigation strategies from also being used to help alleviate conflict or enable rural communities to maximise benefits from the use of wildlife in their area.

As a signatory to the Convention on Biological Diversity (CBD), it was felt to be important for the MFMP to recognise the importance of the Ecosystem Approach. By defining a land use approach as the most optimal form of human-wildlife conflict mitigation and wildlife conservation, the use of the Ecosystem Approach would seem to be even more pertinent. The Ecosystem Approach forms the primary framework for the implementation of the Convention on Biological Diversity, helping to ensure its three main objectives are met, namely; the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilisation of its genetic resources.

The Ecosystem Approach is a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way. It is the primary framework for action under the Convention on Biological Diversity and comprises twelve principles:

- **Principle 1.** The objectives of management of land, water and living resources are a matter of societal choice.
- **Principle 2.** Management should be decentralised to the lowest appropriate level.
- **Principle 3.** Ecosystem managers should consider the effects (actual or potential) of their activities on adjacent and other ecosystems.
- **Principle 4.** Recognising potential gains from management, there is usually a need to understand and manage the ecosystem in an economic context. Any such ecosystem-management programme should: a) Reduce those market distortions that adversely affect biological diversity;
- Align incentives to promote biodiversity conservation and sustainable use; and internalise costs and benefits in the given ecosystem to the extent feasible.
- **Principle 5.** Conservation of ecosystem structure and functioning, in order to maintain ecosystem services, should be a priority target of the ecosystem approach.
- **Principle 6.** Ecosystems must be managed within the limits of their functioning.
- **Principle 7.** The ecosystem approach should be undertaken at the appropriate spatial and temporal scales.
- **Principle 8.** Recognising the varying temporal scales and lag-effects that characterise ecosystem processes, objectives for ecosystem management should be set for the long term.
- **Principle 9.** Management must recognise that change is inevitable.
- **Principle 10.** The ecosystem approach should seek the appropriate balance between, and integration of, conservation and use of biological diversity.
- **Principle 11.** The ecosystem approach should consider all forms of relevant information, including scientific and indigenous and local knowledge, innovations and practices.
- **Principle 12.** The ecosystem approach should involve all relevant sectors of society and scientific disciplines.

As part of the Convention on Biological Diversity, it clearly states that when undertaking developments within important wilderness regions it is first imperative to take stock of the ecological aspects of the area, with specific attention paid to collecting and detailing information on the;

- Detailed indication of the protected and biodiversity significant areas;
- Specifications on the ecosystems, habitats, species;
- Quantitative and qualitative information on the loss of habitats and species (main reasons, trends);
- Indexing of species;
- Identified threats;
- Existing zones, ecological zones and existing tourism zones within the ecological zones;
- Ecologically sensitive zones and zones where ecological disasters have or will most likely take place;

This component report helps to fulfil these objectives to ensure that the development of the Makgadikgadi Wetland occurs along a sustainable approach.

There are various management approaches to help ensure that development occurs along sustainable paths and that ecosystem functions are maintained. Some of the key land use approaches to sustainable development include the conservation of, and development of:

- **core areas**, where the conservation of biodiversity takes primary importance, even if the area is not legally protected
- **corridors**, which serve to maintain vital ecological or environmental connections by providing physical (though not necessarily linear) linkages between the core areas
- **buffer zones**, which protect the network from potentially damaging external influences and which are essentially transitional areas characterized by compatible land uses.
- **sustainable-use areas**, where sufficient opportunities are provided within the landscape matrix for both the exploitation of natural resources and the maintenance of ecosystem functions.

This functional approach therefore maintains ecosystem processes by conserving a representative array of habitats, allowing species populations access to a sufficient area of habitat (for foraging, the dispersal of juveniles or the recolonization of other habitat patches), allowing seasonal migration, permitting genetic exchange between different local populations, allowing local populations to move away from a degrading habitat (caused, for example, by global warming) and securing the integrity of vital environmental processes (such as periodic flooding).

In addition to this conservation dimension, the approaches identify appropriate opportunities within the landscape for the exploitation of natural resources – agriculture, forestry, fishing, human settlement, recreation etc. If these activities are planned and managed in a sensitive way and at an appropriate scale, they offer the prospect of securing the sustainable use of natural resources.

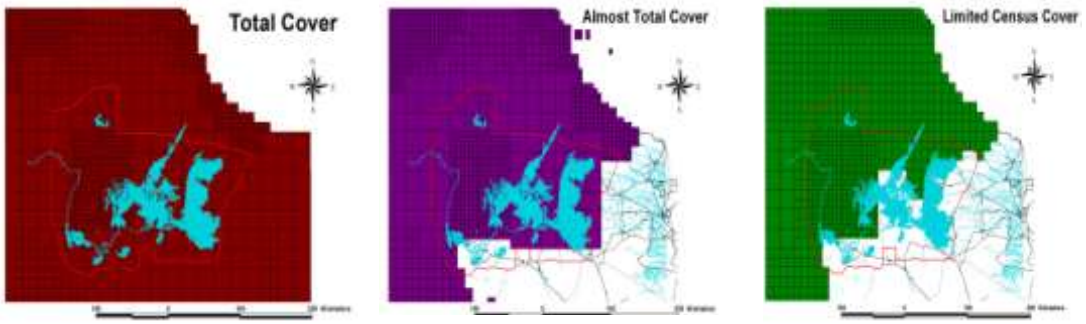
2.2 Methodology to determine population density, distribution and trends in population size

2.2.1 Use of DWNP aerial census data

The Department of Wildlife and National Parks (DWNP) Geographic Information System (GIS) based aerial survey data (Botswana Aerial Survey Information System (BASIS), 2001) from 1990 to 2004 were analysed to assess wildlife distribution and density patterns within the FMP area, with aerial census reports from 1996 to 2006 analysed to estimate the total population sizes within the area. The difference between the number of survey reports and years of GIS data analysed relates to differences in the availability of GIS compatible DWNP data sets to available reports. Aerial census reports prior to 1996 have limited availability, as they are not accessible in soft copy, with many hard copies missing from the record, while more recent surveys have not been digitised into GIS *format*. Data from both the wet and dry season census were used to assess differences in seasonal distribution patterns, but only dry season census data was used to estimate population size due to more continuous and recent data sets available for dry season census.

There are significant differences amongst years in both the dry and wet season coverage of aerial census for the Makgadikgadi region limiting the application of several years of census data. Years with total coverage of the study area include only the; 1990, 1994 and 1995 wet seasons and the 1994, 2002 and 2003 dry seasons, with an almost total coverage of the area (except the area to the south of the MPNP around Mopipi through to Mosu) for the 1995, 1996, 1999, 2001, 2004 and 2006 dry seasons and the 1999 wet seasons census (Figure. 1). The survey for the area was complete for only a limited number of years, with many of the surveys covering only a portion of the FMP study area. Coverage was either a) complete, b) almost complete apart from the areas to the south of the MPNP from Mopipi through to Mosu) limited to the protected areas of the National Park and WMAs. The 2002 and 2004 wet season censuses were conducted only over **the** Makgadikgadi Pans National Park in an attempt to define the seasonal migration patterns of the zebra and wildebeest populations.

Figure 1: DWNP aerial survey coverage of the Makgadikgadi wetlands region



These gaps in the data set reduce the accuracy of the total population estimates for the FMP area and underestimate the spatial distribution of most species within the system. These limitations must be taken into account when assessing the analysed data. Due to these limitations only the 1996, 1999, 2001, 2002, 2003, 2004 and 2006 data sets were used to estimate the population sizes for each species. This data set includes those censuses that did not cover the areas around Mopipi through to Mosu and will therefore limit the accuracy of

livestock estimates more than that of wildlife species, which have a limited distribution within this part of the MFMP area. Relative confidence in the estimates provided is therefore higher for wildlife species.

The analysis of density and distribution patterns will however be affected to a greater extent, as more of the census data with poor coverage had to be used to help determine wet season distribution patterns. The dry season density and distribution patterns were generated using only the total and almost total census data detailed above, thereby reducing the proportional density estimates for all species only in the south of the MFMP area. The wet season density and distribution maps however used the 1991, 1992, 1993, 2002 and 2004 wet season census data sets that had only partial coverage of the region, along with the 1990, 1994, 1995 and 1999 wet season census that had total coverage. Years with poor coverage provide no population estimates for the area due east of the Makgadikgadi Pans National Park, or to the south of the park. These wet season data will therefore skew the estimated density and distribution patterns of all species, but will impact on livestock estimates more than wildlife estimates, as all National Parks and WMAs are covered within these wet season surveys.

2.2.2 Analysis of DWNP aerial census data

The DWNP aerial census data is collected across 47 survey areas stratified across the whole country according to the stratified systematic transect sampling method (Norton-Griffith, 1978, 1979). Of these 47 irregular shaped survey areas, seven are within the MFMP study area and a further three within the greater MIMP area. These seven survey areas are either included within the MFMP area in their totality, or only partially. To account for partial coverage, the proportion of each survey area within the MFMP area was assessed and the percentage Figure used as a correction factor, with the resulting percentage of each species from that partially covered area used in the estimate of the total population size within the MFMP area. Table 1, details the survey areas within the MFMP area, their total size and proportion within the area.

Table 1: DWNP aerial census survey areas contained within the MFMP boundary, with relative proportions of each area within the boundary defined

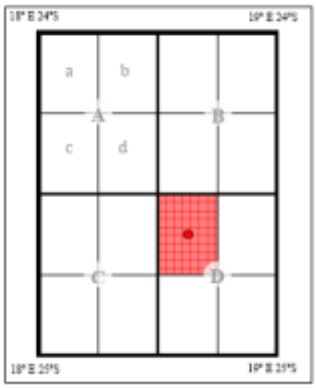
DWNP Survey Area	Total Size (km^2)	% within FMP area
36D-Ngamiland	10,564	14
37Nxai	2,225	100
39D-Ngamiland	13,877	24
40D-Makgadikgadi	10,407	100
41D-Makgadikgadi	13,877	89
42D-Central	29,984	3
43D-Central	66,855	9

The data generated from these aerial surveys is then analysed by DWNP using Jolly's (1969) method for sampling blocks of unequal size to obtain density and variance estimates, from which wildlife biomass is calculated in terms of livestock units, where one livestock unit equals 450kg, so that a buffalo of 450kg equals 1 livestock unit, while a 26kg springbok equals 0.118 livestock units and a 1,725kg elephant equals 2.74 livestock units. Density and distribution

patterns are spatially represented within DWNP's GIS program BASIS in terms of these livestock units, so that a relative estimate of 5 springbok within a given area is represented by a density of 0.59 (5 x 0.118) livestock units. Relative densities of each species are then spatially presented using a quarter degree squares grid format in the GIS software package ArcView 3.2 (Hooge *et al.*, 1992). The quarter degree grids are refined across some areas of the census survey range to eighth and sixteenth degree squares. For each census an estimate is given of the biomass/km^2 in livestock units of each species present within each quarter, eighth or sixteenth degree square. The relative density and distribution defined within that seasonal census can therefore be displayed for each species using the ArcView 3.2 software system.

To produce a consensus map of the spatial distribution patterns of each species, the total estimated biomass within each quarter, eighth or sixteenth degree square for each species from every survey year were counted. This provided a total estimated biomass of each species within every quarter, eighth or sixteenth degree square for a period of over 10 years and thereby highlighted areas that were repeatedly used by each species in either the wet or dry season with a higher relative biomass per square. The total estimated biomass per given square was then represented as a single 'sighting' point per livestock unit, with the sighting point represented as a grid references at the centre of that quarter, eighth of sixteenth degree square. These grid references were then converted to decimal degree coordinates to make them compatible with the ArcView 3.2 software (Figure 2). Decimal degree coordinates at the centre of each quarter, eighth and sixteenth degree square were defined and used to represent each single livestock unit estimated within that square for every species. Each livestock unit was used to represent a single sighting to build up a data base of observations, each represented by the coordinates at the centre of that square. The greater the occurrence of any species within any square the more sightings recorded and the greater the number of estimated livestock units or 'sightings', the greater the relative preference for that area by each species, so that relative occurrence was defined for a period covering over 10 years. These data points helped identify and highlight areas of critical importance for every species across the MFMP area by analysing the points using a kernel home range estimation technique.

Figure 2: Coordinates representing each single livestock unit for specified species



Source: Samways & Associates, 2007

The kernel density estimation technique (KDE) was used to calculate the density and distribution patterns sightings (livestock units) of each species using the animal home range extension of ArcView 3.2 (Hooge *et al.*, 1992). KDE is a contouring method of home range estimation (Worton, 1989) and is considered superior to other home range estimations such as minimum

convex polygons as it is less biased by distant points and is therefore less likely to include unused landscapes (Hemson, 2005). KDE produces a utilisation distribution, or isopleths, with the contour height (isopleth width) at a given location indicating the concentration of use at that location relative to the rest of the home range.

Kernel home ranges depicted in this report represent the density and occurrence of sightings (livestock unit estimates from DWNP aerial census surveys) for each species. The 95% range provides a buffer around 95% of the livestock units estimated to occur for that species within the study area, i.e. 95% of occurrence, so that the core of the kernel home range identifies that area that contains 25% of occurrence for that species over the 10 year period.

2.2.3 Limitations of all aerial census data

Population estimates and density distribution patterns are generated from the aerial surveys conducted by the Department of Wildlife and National Parks (DWNP). While these surveys have been conducted on an almost annual basis, the area covered by each survey has varied. Only those surveys conducted between 1994 and 2003 covered the majority of the country, while others were restricted to either just northern Botswana, the north and west of Botswana, or just the Kgalagadi, while the 1989/1991 survey was conducted over a two year period (CSO, 2005). The data presented on the herbivore populations must be viewed in light of the limitations of aerial census. Aerial surveys do not provide precise or accurate estimates of animal populations. The accuracy of the point estimates is adversely affected by populations that occur in low densities and / or within a clumped distribution. At best, aerial surveys underestimate the actual population by approximately 13%, and at worst by up to 59% due to among other reasons, incomplete counts, which may miss 12-77% of any population (Caughley, 1974). These variations occur around the point estimate, which itself is liable to be bound by upper and lower confidence intervals of at best 20-25% and at worst by over 100% of the actual estimate (Redfern *et al*., 2002).

The variation in the population estimate is also critically affected by survey effort, which in Botswana varies widely between different regions. The highest quality surveys or those conducted with the narrowest transect widths occur along the Chobe, at 3 min (4.8km) intervals, surveying a total of 14% of the region. This Figure decreases to 7% across the Makgadikgadi and Nxai Pans NP, but down to 4% across the majority of the country, including the rest of the MFMP study area. Therefore depending upon the location there will potentially be a further decline in the bias and underestimate of the actual population present. While new survey methods, such as line distance sampling and double counting have reduced these bias estimates within Botswana, achieving highly accurate population estimates on individual wildlife populations from aerial surveys is not a reality. To make matters worse the variance in these estimates is both habitat and species specific, meaning that estimates for different species are more or less accurate than for another species. The difference in these estimates is linked to habitat specific variation in season, rainfall, habitat density and species specific variation in animal size, colouration, average herd size and structure, and also habitat preference. Population estimates are therefore adversely affected for cryptic species such as kudu, small species such as duiker and steenbok, light coloured species such as zebra and species with highly clumped distributions such as buffalo, and in the Makgadikgadi region the clumped herds of the zebra and wildebeest migration. The best estimates within the Makgadikgadi region can therefore be expected for species with more dispersed populations of medium-to-large species

that are not cryptic or too lightly coloured such as gemsbok, giraffe, hartebeest, ostrich and the dispersed bull herds of elephants in the Makgadikgadi.

Over a long period of time, successive surveys conducted using the same methodology do however provide important information about long-term changes in population estimates, even for those species with a poor susceptibility towards aerial census techniques. These trends therefore provide DWNP, wildlife research, land use planners and ecosystem managers with a crucial insight into on-going declines or rises in population levels and have therefore been used within this Framework Management Plan to help determine the population distributions and trends in numbers for wildlife species within the Makgadikgadi region. These notes on the accuracy of aerial survey data are therefore provided to ensure the reader is aware of their potential fallibility.

2.3 Methodology used to define most suitable conflict mitigation strategies

To help identify and refine the identification of the most effective human-wildlife conflict mitigation strategies for the Makgadikgadi region it was important to assess the current and historical level of human-wildlife conflict in the region, using the DWNP's Problem Animal Control (PAC) data and firsthand accounts from communities within the region using Focal Group Discussions (FGDs) conducted for this project.

FGDs were held at four villages within the region, spatially differentiated to ensure a representative response from communities within the MFMP area. During April and May of 2010, FGDs were held at Gweta and Phuduhudu in the north of the MFMP area and Rakops and Mmatshumo in the south of the MFMP area. It was expected to find a greater degree of hostility towards wildlife in the north of the study area in light of increased wildlife numbers and potential exposure to conflict, while increased problems from livestock-arable conflict were expected from the south of the study area. At each FGD, a representative assemblage of community members ranging from 18-22 individuals were asked a series of questions about their relative impact of wildlife to their livelihoods and asked their opinions about the best or most suitable forms of mitigation to help reduce conflict in their area.

The PAC data was only made available towards the end of the project cycle and to ensure the assessment of human wildlife conflict had a spatial component we used a multi-criteria analysis (MCA) that evaluated the relative level of potential conflict for resources that is evident around most of the major settlements within the FMP area. When the PAC data was analysed the results were compared with the MCA.

To ensure all of the possible land use conflict issues were assessed in relation to the human-wildlife conflict issues in the Makgadikgadi, this report made use of the Land Use Plan review undertaken for the Land Use Component. This review noted all issues of conflict identified within each land use plan developed since 1987 within the area of the MFMP area. All of these data were combined with expert knowledge of the region to firstly identify conflict hotspots and then use a peer assessed multi-criteria assessment approach to rank these hotspots in order of priority, i.e. level of current conflict and potential for effective mitigation.

3 Major Findings

3.1 Wildlife Inventory and Species Status for the Makgadikgadi Wetlands

This section of the report focuses on the medium to large sized mammals, which in many cases are the species responsible for generating the main wildlife associated economic benefits for the region through their potential to sustain, in some cases, both consumptive and non-consumptive tourism, but are also, in some cases, responsible for most of the human-wildlife conflict within the region. They are the most visible species and in many instances form flagship species that are used as rallying points for conservation efforts. Due to their size and resource requirements many of the species walk considerable distances and cover large home ranges in search for preferred resources and mating opportunities, so that single species conservation efforts can have significant land use conservation benefits that enable whole ecosystems to be protected.

3.1.1 Herbivores

The following herbivore species form a vital component of the Makgadikgadi wetlands ecosystem dynamics. They help regulate grassland sward composition and structure, provide a food base for the regions predators and provide a significant contribution towards the economic productivity of the region through sustainable consumptive tourism. Aerial census data is however not available for all of the species, due to their size and cryptic nature and there are no estimates of numbers or distribution available for; bushbuck, hippo and rhino, although numbers of known individuals are available for hippo and rhino, while estimates for common duiker and steenbok must be taken as suspect due to their relative visibility from a plane.

Table 2: Current population estimates for wildlife species in the MFMP area

	1996	1999	2001	2002	2003	2004	2006
African elephant	323	1,023	728	355	904	1,305	1,561
Blue wildebeest	3,391	19,605	3,949	10,314	8,009	3,071	10,843
Burchell's zebra	12,124	29,123	15,974	13,766	13,519	20,137	18,249
Cape buffalo							92
Common duiker	170	217	220	232	417	115	104
Eland		96		124	34	10	43
Gemsbok	1,311	1,571	1,657	2,186	1,842	2,398	3,148
Giraffe	1,209	1,597	657	697	411	913	1,139
Greater kudu	3,539	1,909	2,187	1,604	1,500	1,525	1,166
Impala			292	941	1,001		245
Red hartebeest	1,994	754	349	1,377	513	189	339
Roan							11
Sable	133						
Springbok	6,170	2,214	8,096	332	2,141	1,764	3,938

Steenbok	1,467	2,409	827	1,846	1,406	368	767
*Ostrich	4,869	4,046	5,526	7,119	4,689	3,089	6,625
* Included within this table as a medium-to-large sized herbivore							

Source: DWNP aerial census surveys 1996-2006

Table 3: Proportion of the Makgadikgadi wildlife population in relation to the Botswana national population

	Estimated National Population of Botswana in 2006	Average of Botswana National population estimate between 2001-2006	Makgadikgadi Population as a % of the mean total of the National population between 2001-2006
African Elephant	154,658	131,054	1.2
Blue Wildebeest	15,251	33,950	31.9*
Burchell's Zebra	49,151	42,844	42.6*
Cape Buffalo	59,396	47,688	0.2
Common Duiker	560	6,301	1.7
Eland	4,700	22,515	0.2
Gemsbok	11,851	85,934	3.7
Giraffe	10,871	10,754	10.6*
Greater Kudu	8,427	24,628	4.7
Impala	54,482	52,352	0.5
Red Hartebeest	1,277	39,011	0.9
Roan	665	627	1.8
Sable	1,999	2,555	0.0
Springbok	6,426	35,353	11.1*
Steenbok	4,185	32,790	2.3
Ostrich	13,055	51,692	12.8*
* wildlife and livestock populations with close to or more than 10% of the Botswana national population			

Table 4: Hunting quotas of medium-to-large sized herbivores for the controlled hunting areas within the MFMP area (2010)

	Citizen areas hunting quota		Community areas		Private concessions		total
Species	CT8	CT21	NG49	CT10	NG47	CT12	
African Elephant	0	0	22	0	22	22	66
Burchell's Zebra	2	0	2	2	3	2	11
Blue Wildebeest	2	0	1	1	1	2	7
Cape Buffalo	0	0	7	0	7	4	18
Duiker	10	10	0	4	4	0	28
Eland	0	0	0	0	1	1	2
Gemsbok	0	0	2	0	1	2	5
Greater Kudu	5	4	3	2	3	2	19
Impala	0	0	0	0	0	5	5
Red Hartebeest	0	0	0	0	0	0	0
Springbok	4	4	1	2	1	0	12
Steenbok	10	10	15	6	9	5	55
Ostrich	10	10	2	2	1	0	25
Warthog	0	0	2	0	2	2	6
Porcupine	0	0	0	0	1	1	2
Monkey vervet	0	0	0	0	0	2	2
Baboon	6	6	5	7	0	7	31
Crocodile	0	0	0	0	0	0	0
Lion	0	0	0	0	0	0	0
Leopard	0	0	0	0	0	0	0
Hyaena spotted	1	1	1	1	0	0	4
Caracal	0	0	0	0	0	5	5
Fox, bat-eared	0	0	0	0	0	5	5
Jackal, black backed	0	0	2	0	0	0	2
Jackal, side-striped	0	0	1	0	0	0	1

3.1.2 Key herbivore population trends

To help focus this report on developing viable recommendations to help conserve wildlife and birdlife within the Makgadikgadi region we have kept the detailed review of individual species limited to those species that have:

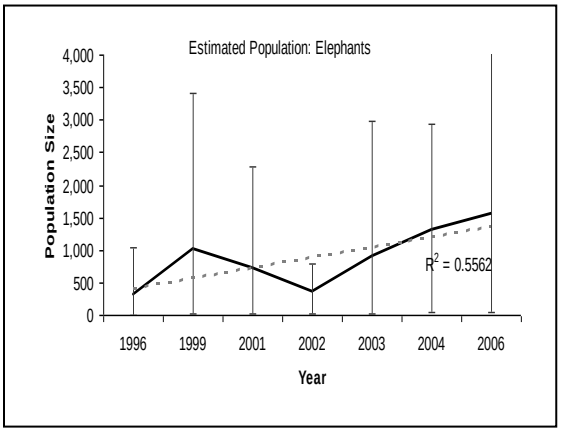
a. The most extensive distribution patterns across the region and through whose conservation key regions of the Makgadikgadi would be protected, i.e. keystone species;
b. Are responsible for the majority of human-wildlife conflict in the region;
c. Those species that are responsible for the greatest economic generation for the region (determined as those flagship species that attract tourists into the region

and those species which generate the most income through commercial exploitation / hunting); and

d. Those species that have the greatest bearing on government policy through the implications of disease transmission.

The herbivore populations within the MWS have shown a varied response to ecological variability and human development over the past 10 years; with some populations showing a significant increase within the region, some a significant declining population and others with a stable population. Variability within the annual estimates is also an artefact of the problems associated with aerial census and the trends in Figures, rather than the actual Figures should be assessed more closely.

Figure 3: Herbivore Populations with an increasing trend



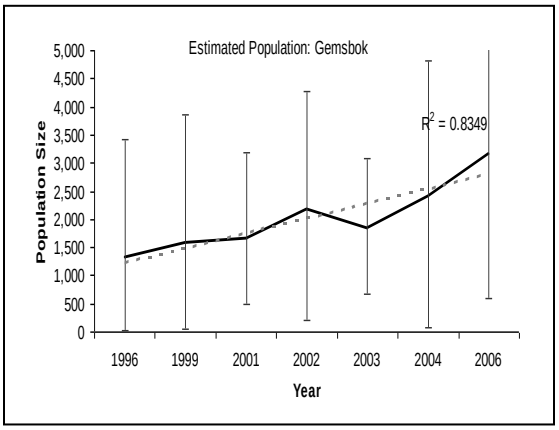
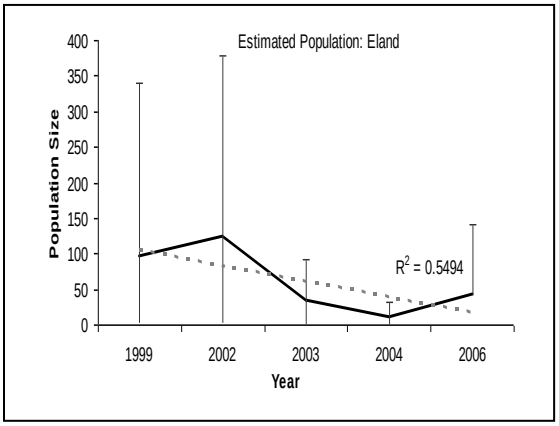
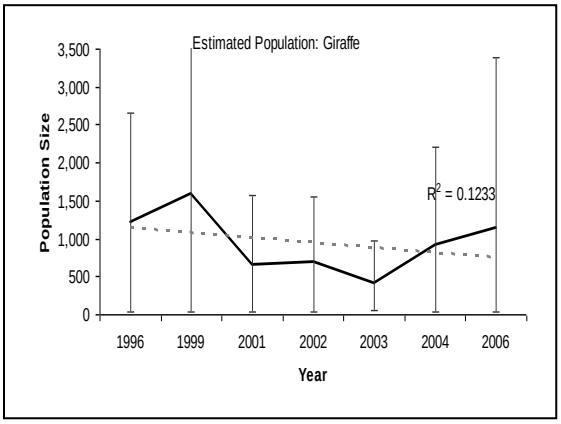
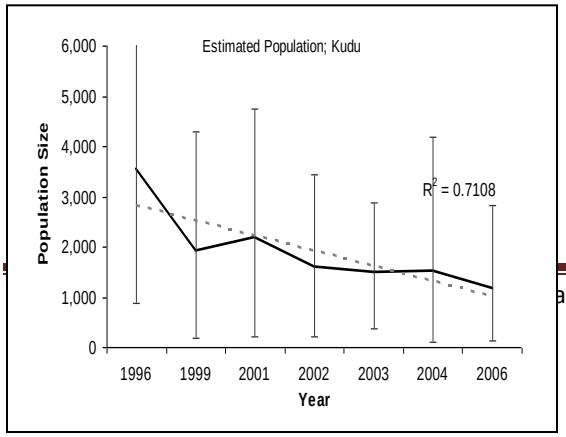
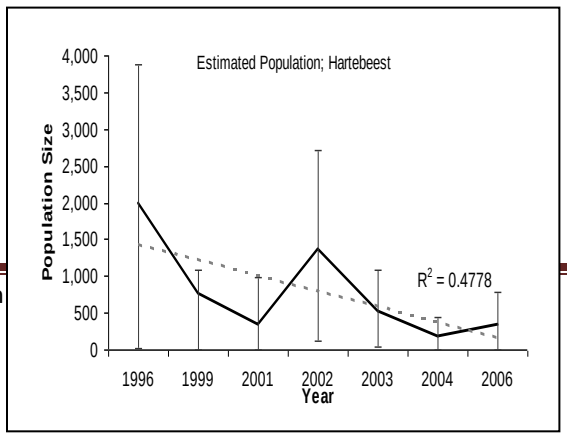


Figure 4: Herbivore populations with a decreasing trend









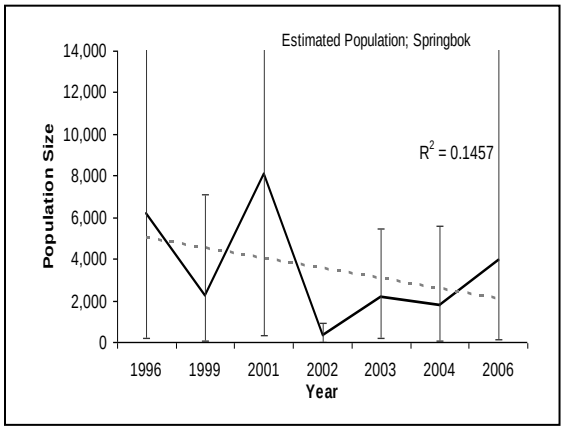
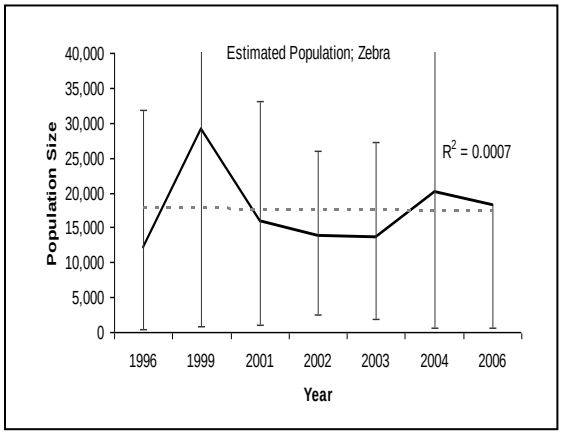
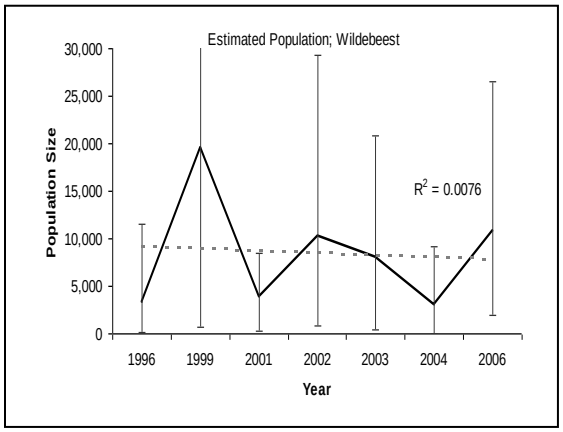


Figure 5: Herbivore populations with a stabilising population





3.1.3 Species-specific herbivore density and distribution patterns and population trends

Buffalo

a. Ecology, habitat and food preferences

This is one of the most successful African mammals in terms of geographical range, abundance and biomass. It is not however ideally suited to arid environments, but can move into these areas along river courses and during wetter periods. It is a bulk grazer and prefers dense habitats with thick cover, which is not widely available within the Makgadikgadi, apart from along the Boteti River. A herd forming species, it is not uncommon to see herds from 50 up to 1,500, with any single herd not containing all of those animals within a single range. Home range size, herd size and grass productivity are all interrelated, with larger home ranges in areas of poorer resource quality. Their food preferences are similar to zebra; also a bulk grazer and they can compete for the same resources (Estes, 1992).

b. Population estimate in the MFMP area

The population estimate for buffalo is detrimentally affected by the highly clumped nature of the population, so that entire herds are often missed between wide transect widths. However, there is little evidence of buffalo within the system during the dry season apart from a resident herd that occurred along the Boteti River in the 1990s. This herd was translocated from the region to the Okavango Delta in the mid 1990S due to fears of foot and mouth disease transmission. Since then only nomadic herds have been sighted entering the system, again along the Boteti River and within the Nxai Pan area with the latest 2006 survey that estimated 92 to occur in the northern part of the system. Herds numbering 30-60 do move into the system however on an annual basis and there is the possibility that some may remain and re-establish a more permanent population along the Boteti River again.

c. Spatial distribution within the Makgadikgadi region

The spatial distribution of buffalo is very restricted during the dry season (see Figure 6). Buffalo are a water dependent species restricting spatial distribution. The CT5 area to the northeast of the MFMP area would seem to be a core range for them on a year round basis, with more extensive movements noted in the wet season. These movements are, in the majority, contained within the northern parts of the MFMP area.

d. Research and monitoring within the Makgadikgadi region

There has been no research and limited monitoring of the buffalo population within the Makgadikgadi system. It was however, believed that the translocated herd from the Boteti was Foot and Mouth disease free and could have been used a baseline stock population for a managed game farm population. Such animals are worth considerable sums within South Africa. More attention is required to observe their movements to try and determine which migration routes they use. Are the animals seen along the Boteti River from the Okavango Delta, or do they move all the way from Hwange Park and CT5?

e. Current threats to the population within the Makgadikgadi region

The DWNP and Department of Veterinary are currently concerned about the increasing presence of buffalo along the Boteti. There is a risk of disease transmission, considering the high density and occurrence of cattle along the Boteti River. The new fence separating wildlife from cattle along the Boteti has enabled CT8 to be declared a Foot and Mouth Disease (FMD) free

area, improving the relative economic value of the beef. However, poor maintenance of the fence could lead to increased risks of disease transmission and there is a risk that any new resident herds may be translocated back to the Delta if the fence is not fully maintained in the future.

f. Current threats caused by the population to the rest of the Makgadikgadi region

Buffalo pose a significant risk of disease transmission, especially FMD to the cattle of the FMP region. Expansion of the range with increased rainfall and the poor maintenance of the Makgadikgadi conflict fence heighten the potential for disease transmission.

Cape buffalo have been known to act as a maintenance host of FMD since the 1960s (Lamarque *et al*., 2008). On average 40% of buffalo occurring in FMD prevalent areas of Botswana are carriers of the disease. These infected animals remain disease carriers for at least five years even if removed from further infection (Ecosurv, 2001). The risk of spreading FMD through the migratory and nomadic movement of buffalo from FMD prevalent areas into disease free areas is very high and an issue of significant economic concern for Botswana.

Buffaloes have also been firmly linked with the transmission of 'Theileriosis disease', or 'Corridor disease' to cattle. *Theileria parva* is a cattle-adapted variant of *Theileria parva lawrenci* borne by buffalo. Infection with this organism, which is generally silent in buffalo, causes very high mortality rates in cattle, making farming of cattle in the presence of both buffalo and a suitable vector, a hazardous undertaking (Bengis *et al*., 2002, Lamarque *et al*., 2008). The main vector is a tick, with both *Rhipicephalus appendiculatus* and *R. zambesiensis* the principal vectors, both of which occur in the north and east of Botswana (Ecosurv, 2001).

Buffaloes are also carriers of Brucellosis, with potentially 6.5% of any herd infected. Eland are also potential carriers, but the relative impact of disease transmission is limited within Botswana as Brucellosis is already endemic within the national cattle herd. Buffalo may also risk the spread of further diseases such as: Rift Valley Fever, Heart water, and Bovine Tuberculosis (Ecosurv, 2001).

g. Conservation actions recommended:

1. Improved monitoring of the buffalo herds in the Makgadikgadi is required. There is concern about the proximity of buffalo along the Boteti River with cattle on the other side of the fence.
2. Global Positioning System collaring of the nomadic herds must be undertaken to determine which migratory corridors they are using. It is possible they are following the same route as the migratory zebra from the Okavango, but it is also possible that they move west from Hwange and CT5 in the wet season towards Nxai Pan and then south in the Makgadikgadi.
3. Developing a resident herd of buffalo along the Boteti would mean that this area becomes a 'big 5' destination and would improve the attractiveness of the region to tourists – the expansion of the buffalo herd should therefore be encouraged (with veterinary and DWNP monitoring). It is essential that the Makgadikgadi fence is well maintained if this situation is to be a reality. There must be no gaps left in the fence through damage, by for example elephants that buffalo could then escape through into CT8.

Figure 6: Kernel density and distribution patterns of buffalo in the wet and dry season

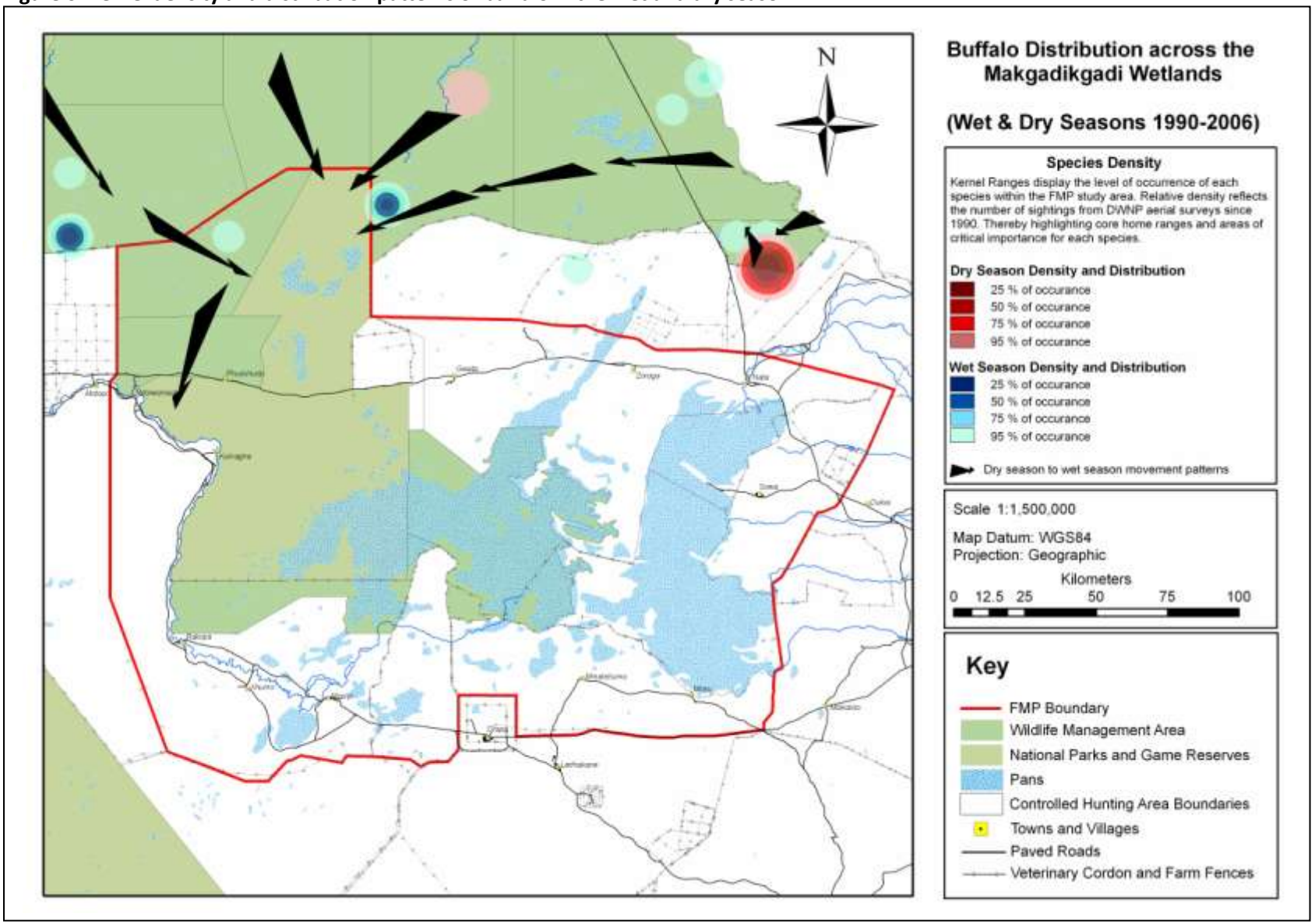
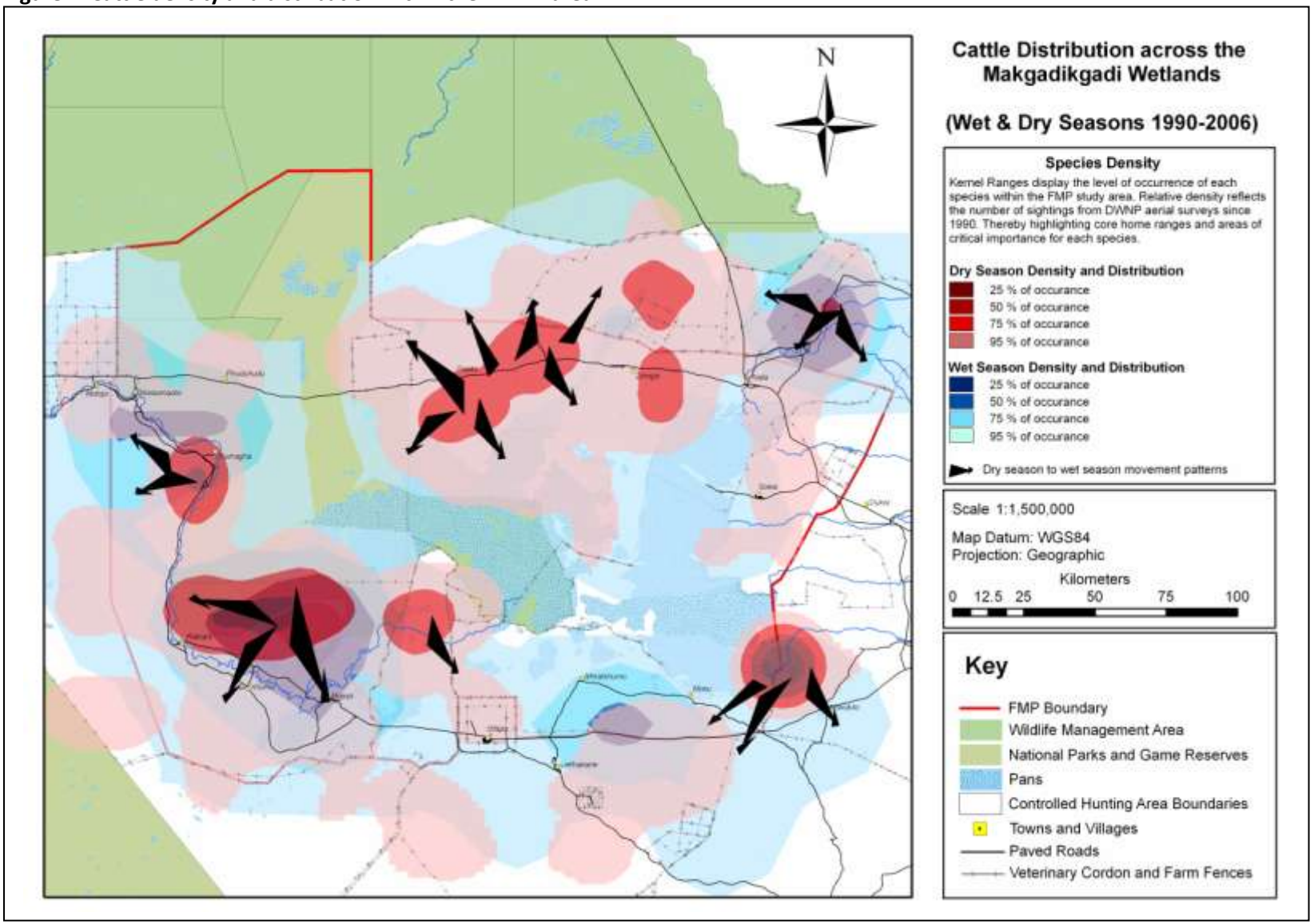


Figure 7: Cattle density and distribution within the MFMP area



Elephant

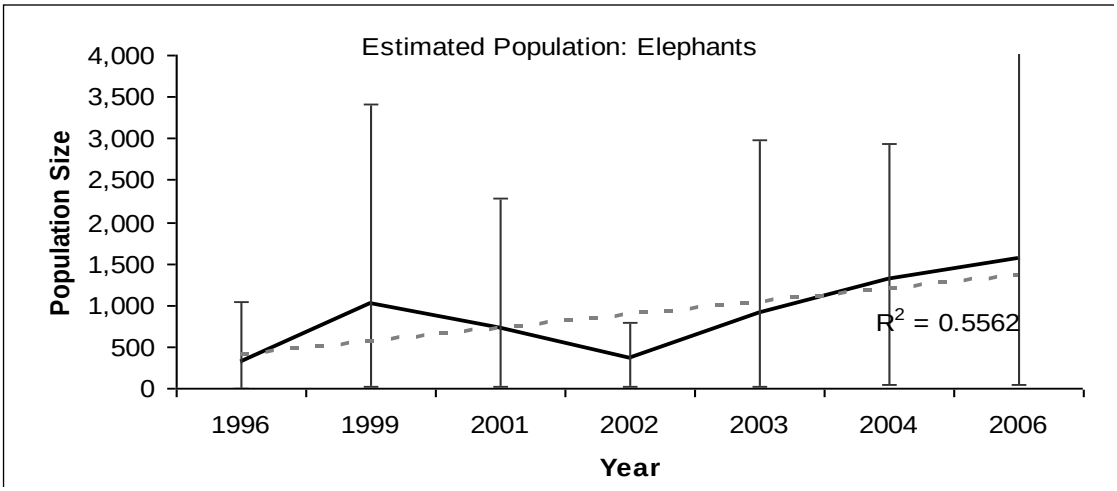
a. Ecology, habitat and food preferences

Elephants can subsist in virtually any habitat that provides adequate food and water. They generally select the most nutritious parts of any plant available, preferring grasses in the wet season and woody plants in the dry season, requiring 4-6% of its body weight in food per day (on average 150-300kg per day) and requiring up to 280L of water per day, for which they can walk up to 80km (Estes, 1992). The MFMP area has limited surface water availability, limiting their range, while ideal forage is restricted to areas of increased shrub and tree density in the north, west and north-east of the MFMP area. The Makgadikgadi elephants concentrate their food selection on *Acacia* shrublands and Mophane woodlands within these areas, while a significant impact to the riparian woodland along the Boteti River has been observed from elephant activity in the last 10 years. Limited access to water along the Boteti River, due to the alignment of the western Makgadikgadi fence concentrates elephant activity and it can be expected that further loss of riparian habitat will occur within these areas. Other impacts and changes to habitats through elephant activity are starting to become noticed in the east of the MPNP and in areas of CT11.

b. Population estimate within the Makgadikgadi region

The population estimate within the Makgadikgadi has increased annually since 2002. This increase may have been initiated earlier if it had not been for the dry years of 2002 and 2003. The increased size of the population from less than 500 in 2002 to over 1,500 still represents, however, only a tiny fraction of the increase within the national elephant population; currently estimated at over 155,000. The Makgadikgadi elephant population consists almost entirely of bulls that have moved south from the centre of their home range in the Chobe region. There are limited breeding herds, apart from some that may enter in to the region during the wet season.

Figure 8: Elephant population estimates for the MFMP area

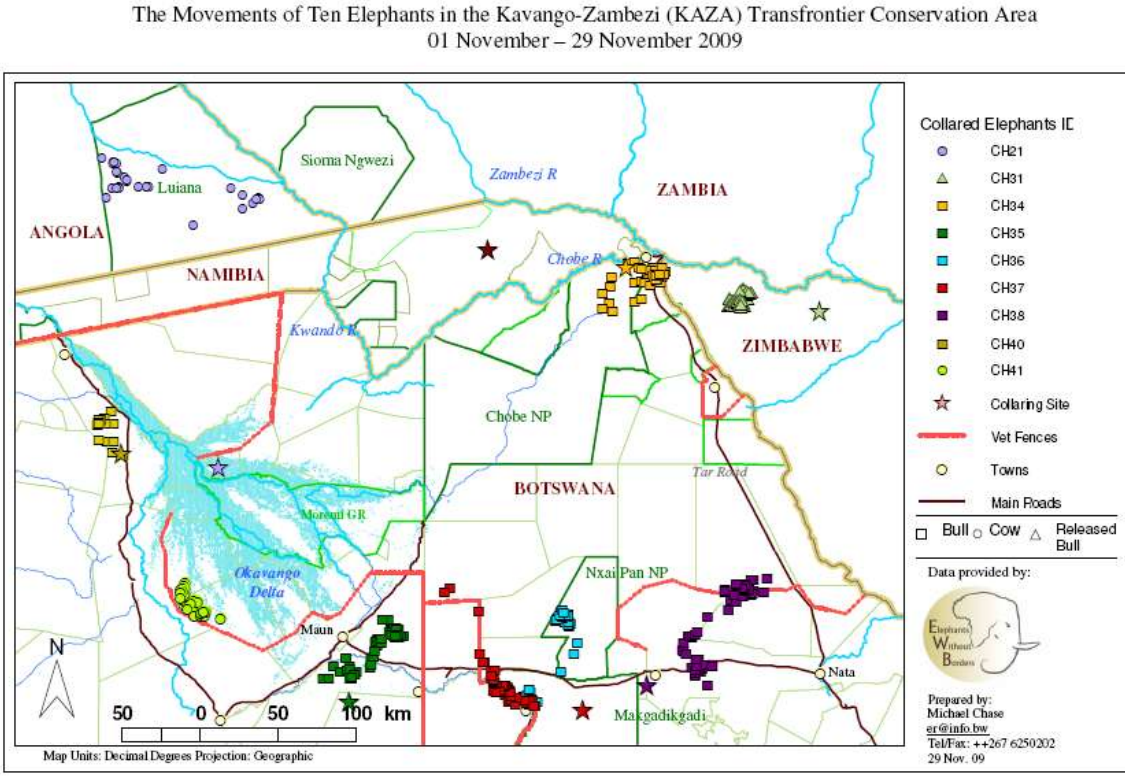


c. Spatial distribution within the Makgadikgadi region

The spatial distribution of elephants in the dry season depicts their increasing level of presence across the system. Dry season distribution patterns are regulated by the availability of surface water, concentrating elephants around the Boteti River, Nxai Pan artificial water points and the

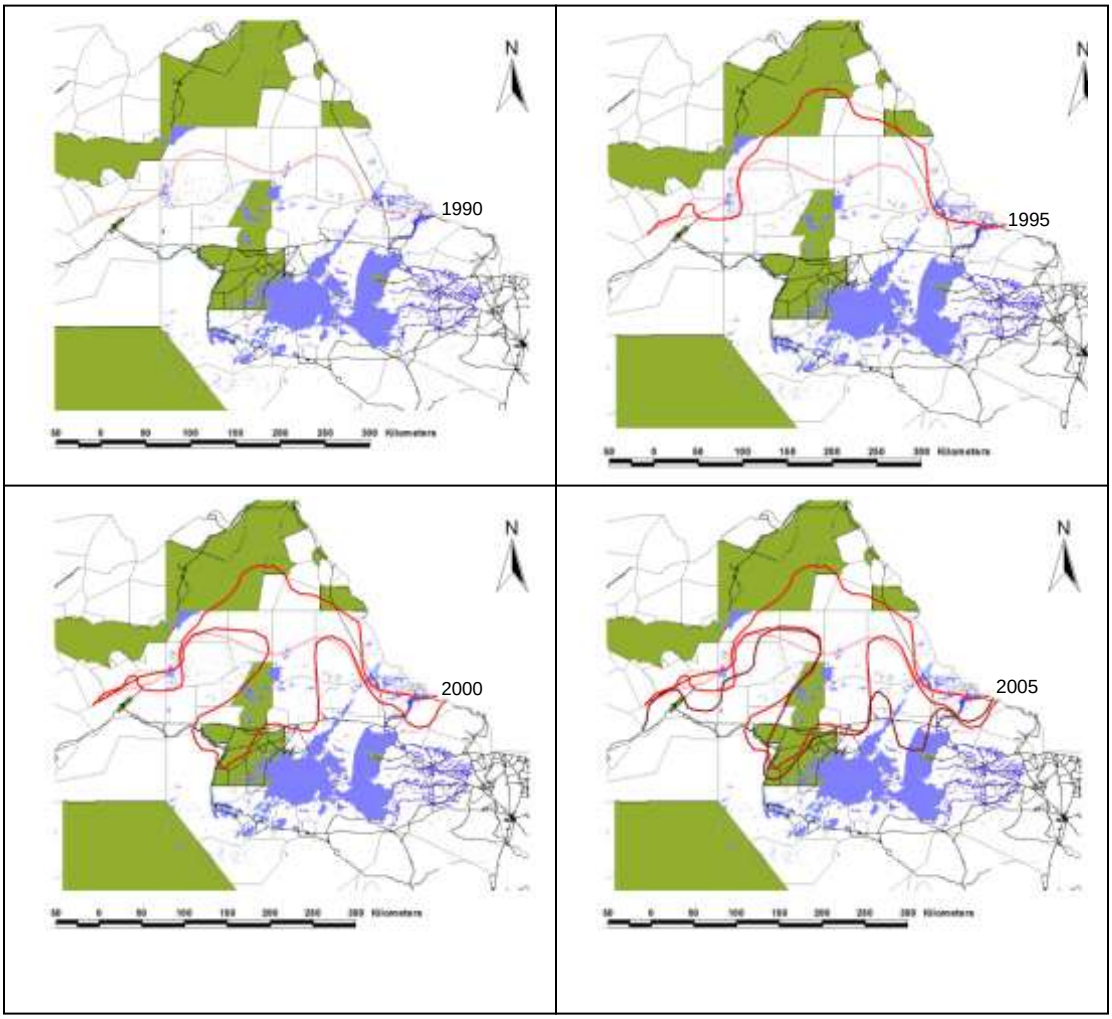
Nata River within the FMP boundary. However, extensive movement is in evidence southeast from Nxai Pan towards Gweta and south of Zoroga. The wet season distribution is concentrated within the woodlands to the north of the MFMP area, demonstrating the importance of these marginal areas for nomadic movement of wildlife. It was anticipated that greater concentrations would have been found further south that depicted, but this may be an artefact of the survey years used in the assessment. The last wet season survey was in 2004, and greater movement into the region has been observed in the past six years. It is recommended that further wet season surveys are conducted across the region in the wet season to assess current distribution patterns

Figure 9: Movement records of elephants into the MFMP area from CT5 and Delta



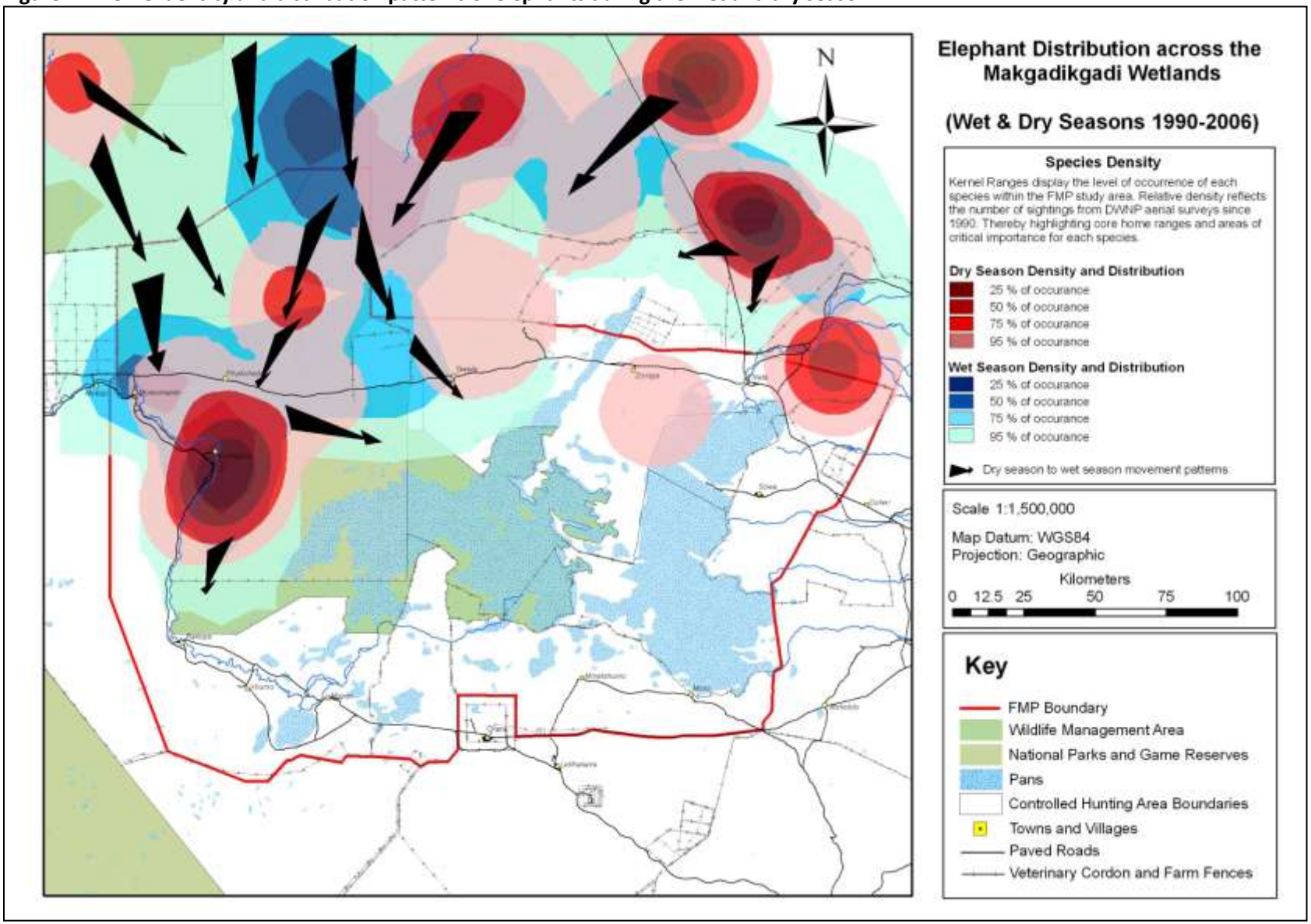
Source: Mike Chase, 2010.

Figure 10: The spread of the elephant population



Source: DWNP aerial survey records since 1990.

Figure 11: Kernel density and distribution patterns of elephants during the wet and dry season



d. Research and monitoring within the Makgadikgadi region

Until recently there have been no dedicated research efforts on elephants within the Makgadikgadi region. However, their increasing presence within the region has stimulated the elephant researcher Dr. Mike Chase to investigate this trend. He has recently collared several elephant bulls in the region to monitor seasonal movement patterns and habitat preferences. These data will provide great insight into elephant behaviour in the region and can be used to help develop effective mitigation strategies for farmers within the region.

e. Current threats to the population within the Makgadikgadi region

The increase in the elephant population poses a cause for concern in the region. Local communities in the north of the FMP area from Xhumaga to Nata complain of increasing levels of conflict with elephants, which are raiding their fields and damaging their crops. It is not anticipated that these problems will subside unless targeted mitigation is implemented. The Makgadikgadi elephant population should be expected to continue to increase and broaden their geographical distribution, especially during the current wet cycle. The population is currently increasing at a mean rate of 1.7 per annum (taken as a mean rate of increase from 2002-2006), with a multiple rate of increase of 1.2 between 2004 and 2006.

In February 2010 two elephants were killed by the DWNP PAC staff for crop raiding. It is anticipated that these events will continue to occur until effective mitigation strategies are implemented. A World Bank Funded human-wildlife conflict mitigation project is about to be implemented by DWNP. The project has identified a series of settlements across northern Botswana to implement a series of mitigation practices. This includes the settlements of Xhumaga and Moreomaoto on the Boteti River within the MFMP area. The results of this project should help to develop viable mitigation strategies for elephant conflict within the region and help to reduce the threats placed upon the expanding elephant population. The hunting quota for elephants has been increased within the controlled hunting areas (CHAs) in the north of the FMP area and surrounding regions. Twenty two bull elephants can now be hunted per CHA per annum, totalling 66 elephants in the MFMP area and a further 132 elephants in the surrounding area. As the hunting quota restricts eligible elephants to mature bulls, there is the possibility that such a large off-take of a small select sub-population of elephants will start to affect their population dynamics.

f. Current threats caused by the population to the rest of the Makgadikgadi region

The increasing spread of the elephant population across the Makgadikgadi region poses a significant cause for concern. Elephants were identified as the number one problem animal from the FGDs held in both Gweta and Phuduhudu, causing significant damage to arable crops. The increasing spread can be expected to continue, at least over the short-term, while increased rainfalls provide greater resource availability to the south of the MWS. The spread of the population highlights the need for improved community awareness in effective conflict mitigation strategies, especially in regions where people are not accustomed to problems associated with elephants.

g. Conservation actions recommended

An elephant management plan has been prepared for Botswana (2007) and recommendations should therefore follow those of the management plan, where the overall goal is to "*conserve and optimise elephant populations while ensuring the maintenance of habitats and biodiversity, promoting the contribution of elephants to national development and to the communities within*

their range at the same time minimising their negative impacts on rural livelihoods". The plan further states that management should be precautionary, selecting strategies that present the least risk (minimum regret) and be process based and adaptive to changed circumstances. The Makgadikgadi FMP area covers four different zones within the Elephant management plan; the elephant free zone (CT8, CT19, CT21, CT13, CT14 & CT15), reduce conflict zone (CT4, CT5, CT6, CT7, CT10, CT11, NG49 & NG51), maximise benefits (NG47) and protected areas (NG48 & CT9).

The primary management strategies for elephants within the elephant free zone are to reduce human-elephant conflict, while in the reduce conflict zone the primary objectives are to reduce human-elephant conflict to an acceptable level, although this level is not determined within the report and to prevent, reduce or reverse unacceptable elephant induced environmental changes and to optimise the utilisation of and benefits from elephants. In the maximise benefits zone the primary objectives are to prevent, reduce or reverse unacceptable elephant-induced environmental changes and to optimise the utilisation of and benefits from elephant,, while in the national parks the primary objective are also to prevent, reduce or reverse unacceptable elephant induced environmental changes, while optimising the utilisation and benefits from elephants.

Table 5: Elephant management plan activity recommendations from the elephant management plan (2007) for the elephant free zone within the MFMP area

Borders	Erect new elephant proof fences where necessary to link all fences around Central District (the proposed fences along the Makgadikgadi Pans NP, the Ngwasha Fence and the fence along the Zimbabwe border). Responsibility for maintenance of fences falls to the DAHP except along the border of the Tuli block where the land owners will take this responsibility
All areas	Remove all elephants to maintain an elephant-free region in part of Central District Rigorously keep all fences in a good state of repair Remove any new elephant immigrants Record and report on all activities

Table 6: Elephant management plan activity recommendations from the Elephant management plan (2007) for the reduce conflict zones within the MFMP area

All areas	Place animals from citizen hunting quota on auction to highest bidders Funds from auction to go in part to a fund accessible by all CBOs in the country and partly to communities in HEC areas
CT11	Investigate the use of chemical, acoustic or other deterrents to protect individual trees Provide facilities for encouraging photographic/game-viewing tourism. Review and determine tourist/tourism carrying capacity of the areas and adjust the number of developments accordingly. Distribution of benefits among participants should be appropriate.
CT10	CT10 will become part of the elephant-free zone once the fence around Makgadikgadi Pans National Parks has been erected.
NG51	Government agencies are responsible for maintaining fences Elephants should be chased out of areas and barriers made elephant-proof

Table 7: Elephant management plan activity recommendations from the elephant management plan (2007) for the maximise benefits zones within the MFMP area

NG42, NG43, NG47, CT1, CT2, CT3	Trophy hunting of bull elephants in 21 day hunting packages to optimise returns (already in place)

Table 8: Elephant management plan activity recommendations from the elephant management plan (2007) for the protected areas within the MFMP area

Nxai Pan	Protect Baines and other Baobabs by unobtrusive means (e.g. trenches filled with sharp rocks encircling the trees)
Makgadikgadi Pans	Reduce elephant densities if vegetation change exceeds LACs

The elephant management plan states that "*In parts of Makgadikgadi Pans National Park the vegetation is unique and fragile (e.g. stands of Hyphaene palms). Artificial water supplies have been installed to simulate water in the Boteti River in an attempt to mitigate the effects of the game-proof fence that has been built along the western boundary of the Park and others may be developed in future. These are likely to attract elephant. Elephants have only been recorded (in recent times) since 2001 and the riparian area suitable for elephants is very limited in extent and may only support limited numbers. In the southern part of Nxai Pan National Park, Baines Baobab trees are an important tourist attraction. Baobabs can be destroyed or made unsightly by elephants*."

There is therefore a need to start monitoring the state and rate of change in certain vegetation classes within the Makgadikgadi system. This includes the Boteti riparian woodland, large stands of baobabs in the north of the area and the palm belt to the east of the Makgadikgadi NP.

Wildebeest

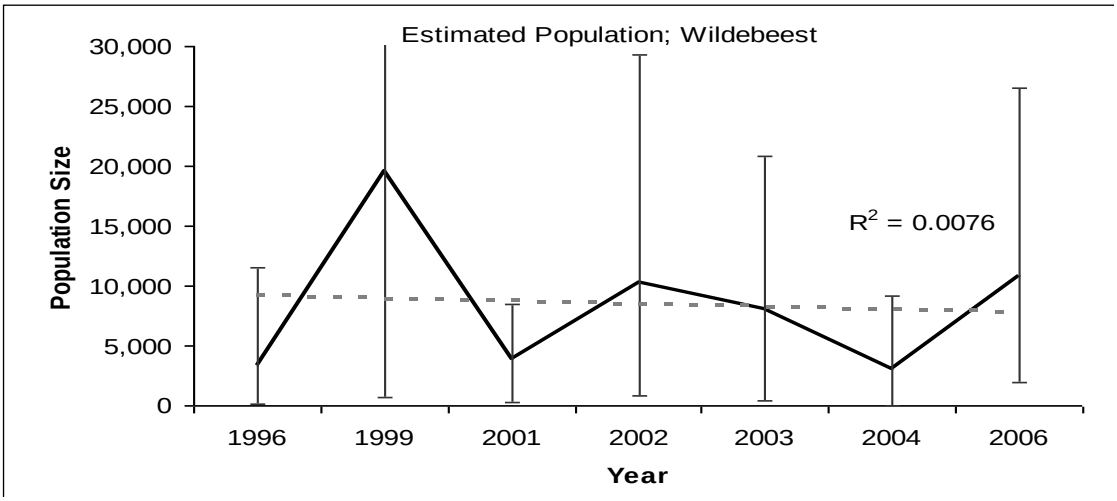
a. Ecology, habitat and food preferences

The blue wildebeest is synonymous with migratory populations of African ungulates moving across open savannas. Their physiology is superbly adapted to mowing down short grass plains and they favour open grasslands covered in stolloniferous colonial grasses that respond well to intensive grazing, enabling large herds to maintain the grasses at an optimal nutritional state through cyclic grazing. Such grasses often dominate light, alkaline soils with hardpan in semi-arid environments such as the Makgadikgadi grasslands (Estes, 1992). The south and eastern areas of the Makgadikgadi Pans National Park are therefore one of the most ideal places for wildebeest within Africa. They generally require water on a daily basis, or at most every other day, limiting their movement away from water. However, in the Kalahari wildebeest are behaviourally adapted to surviving without surface water, getting their water requirements from eating wild melons. While such melons (Tsama melons) do occur within the Makgadikgadi they are not common in most years and the Makgadikgadi wildebeest population is thought to be more water dependent that their Kalahari neighbours. This limits them to grazing resources within 10-15km of surface water.

b. Population estimate within the Makgadikgadi region

The population estimate within the Makgadikgadi has shown considerable oscillation over the past few decades, with a potential decline in numbers since 1996. The DWNP aerial census shows a peak in 1999, as with zebra, that may be an artefact of the census. The population is otherwise estimated to be in the region of 3,000 – 10,000, but probably towards the lower end of this range.

Figure 12: Estimated wildebeest population



The population has, since the drying of the Boteti River suffered from extensive resource competition with cattle, which moved into the park and denuded the wildebeests preferred food resources. Brooks (2005) found that the wildebeest had a mean foraging radius of 5km from the Boteti waterholes, with a maximum foraging distance of 21km, while cattle were found to graze up to 6km on average into the park. This overlap in home range use led cattle to out compete wildebeest for resources during the dry season and may have been the reason for the greater relative decline in the wildebeest population in comparison with the zebra. Zebra had a mean foraging distance of 15km and a maximum of 32km, enabling them to move beyond the area of intense competition for resources. While zebra had improved access to sward resources they had to travel greater distance and spend longer without drinking water. These ecological constraints were believed to be the regulating factors reducing the zebra population.

The erection of the Makgadikgadi conflict fence along the Boteti River stopped the incursion of cattle into the park, increasing relative resource availability for both zebra and wildebeest. It is possible that the increased estimate for wildebeest between 2004 and 2006 is an artefact of this, but further monitoring of the population is required to substantiate this.

There is a significant amount of historical data that show the potential carrying capacity for the area is well above current levels.

- The eradication of Rinderpest in the early 1900s from Botswana may have initiated a rapid increase in the wildebeest population, similar to that observed in the Serengeti during the 1960s and 1970s (see Sinclair & Arcese, 1979; R. D. Estes, personal communication).
- By the 1920s one surveyor estimated a single wildebeest herd in the Makgadikgadi as “one mile wide, which took five hours to pass”.

- Severe droughts in the 1930s caused mass die-offs, with several thousand wildebeest moving as far as Hwange National Park in Zimbabwe, which had recently established artificial waterholes (Cambell, 1979, 1981).
- Alec Cambell, Botswana's chief wildlife warden at the time, estimated the wildebeest population at 60,000 in the early 1960s, after severe drought-associated die-offs in 1958 and 1959, when approximately 40-60,000 wildebeest died.
- In 1959, 19,000 wildebeest skins alone were sold at Nata village in the Makgadikgadi (R. D. Estes, personal communication).
- Further drought-associated die-offs occurred in 1962, when a further 15-20,000 wildebeest died, leaving only 5,000 to 6,000 in the Makgadikgadi by 1967 when the population was counted by R. D. Estes (R. D. Estes, personal communication).
- The Makgadikgadi wildebeest population was still connected with the CKGR population which was to suffer further declines in 1970 lead to a die-off around Lake Xau (Child, 1972)
- By 1974 the wildebeest population within the Makgadikgadi was estimated at 23,495 ± 3,837, showing a significant recovery from the early 1960s (Graham, Dawson & Parker, 1974).
- Further die-offs of Kalahari based wildebeest occurred in 1979 around Lake Xau (Owens & Owens, 1986)
- A massive die-off around Lake Xau in 1983, estimated at >52,000 of Kalahari based wildebeest (Williamson & Mbano, 1988)
- A further die-off occurred again at Lake Xau in 1985 of >5,000 of Kalahari based wildebeest.

Most of these die-offs were associated with droughts in the 1980s, but were significantly exacerbated by the need for wildebeest to negotiate the fences erected around the northern borders of the CKGR to reach the water available at Lake Xau and the Mopipi Dam. Problems were further exacerbated for the wildebeest through direct resource competition with livestock, which had denuded the available grazing around the water supplies, forcing wildebeest to make a 100km round trip between grazing and water resources (Parry, 1987).

Even with these massive declines in the wildebeest population over the past decades, the Makgadikgadi wildebeest population still constitutes almost one third of the Botswana National population. All efforts must be made to ensure that the wildebeest population is buffered against future ecological constraints through improved management of the region.

c. Spatial distribution within the Makgadikgadi region

The spatial distribution of wildebeest is centred around the Boteti waterholes during the dry season, with a small radius of up to 20 km from these waterholes into the park. There is also a sub-population of wildebeest within CT8 that during the wet season move south towards the Central Kalahari Game Reserve (CKGR).

The wildebeest accumulate around the Phefodiafoka fence along the north-eastern border of the CKGR, and may be a remnant of the once spectacular Kalahari wildebeest population. Wildebeest within the CKGR also seem to have an instinctual drive to the Boteti region in times of drought with 17 wildebeest carcasses were recorded within the CKGR along the Kuke and Eastern CKGR boundary fences in 1999. The cause of death was thought to be related to drought conditions and other unspecified issues. There is a strong likelihood that the development of a much mooted corridor between the CKGR and the Makgadikgadi would lead to a migratory

movement of wildebeest and other species becoming re-established. The re-established zebra migration between the Okavango Delta and the Makgadikgadi is testament to the adaptability of species within the system. Migratory movements are known to be a significant factor in the development of larger, more resilient populations (Fryxell & Sinclair, 1988). During the wet season the majority of the population however moves east, following the zebra herds to the south east of the Makgadikgadi Pans National Park. Here, like the zebra their movements are regulated by water availability within sunken grasslands depressions, where they also graze in cyclic patterns maintaining the sward at optimum stages of growth. They also move into CT11 in search of preferred resources.

d. Research and monitoring within the Makgadikgadi region

Dr Chris Brooks undertook extensive field research on the wildebeest population during the early 2000s, with James Bradley continuing this work at present. More information is required about the current status of the wildebeest population to help determine its current size and provide an indication of its response to the development of the Makgadikgadi conflict fence in 2004.

e. Current threats to the population within the Makgadikgadi region

Ecological variability is one of the greatest threats to the wildebeest population. This has been shown by the historical record. The resilience of the system is now lower since the development of the conflict fence. Improved management is essential if the viability of the Makgadikgadi wildebeest population is to be assured. Conflict with livestock is still apparent around the settlement of Phuduhudu and to the east of the park in CT11. Cattle move into the park from both of these areas, denuding preferred grazing resources of wildebeest. The relative impact of this is less for the eastern areas, as resource availability is higher in the wet season, but dry season conflict should be mitigated for. Proposals have been made to move the cattle herds from Phuduhudu into the BLDC ranches of NG45. This would reduce the conflict for resources in this key area of the range.

This species is one of the most numerous of the larger species (along with kudu and hartebeest) to exist outside of the protected areas and WMAs within the MFMP. The population within CT8 may be under extreme pressure from poaching and resource competition with the cattle herds in this region. A further cause for concern is the risk this population poses as a carrier of foot and mouth into this region. The CT8 area, with the new Makgadikgadi fence can now be downscaled from a Foot and Mouth Disease vaccination zone and the occurrence of free moving wildlife may affect this status. However there have been no cases of disease transmission of Foot and Mouth Disease from wildebeest to cattle.

f. Current threats caused by the population to the rest of the Makgadikgadi region

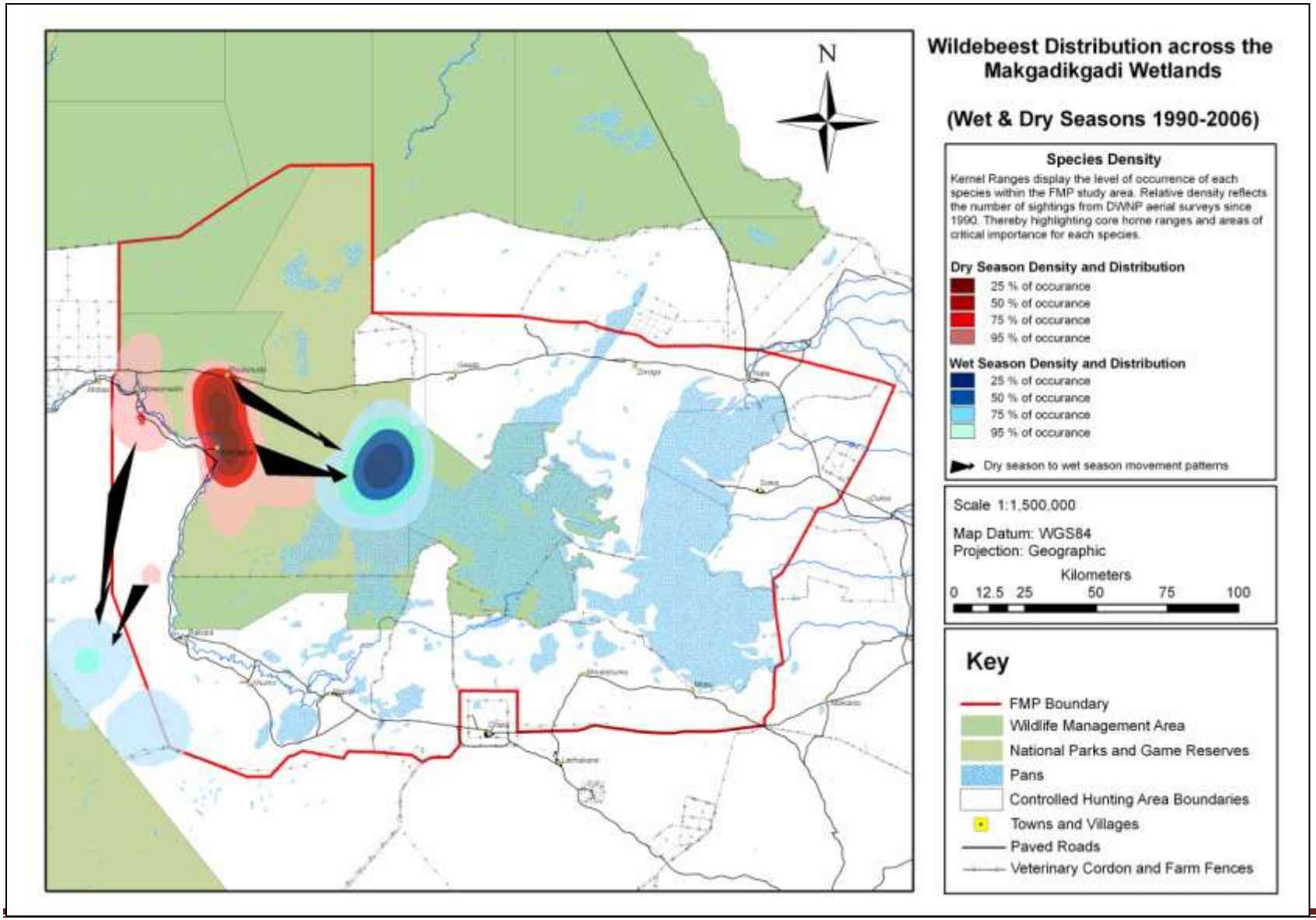
Wildebeest pose potential concerns for the risks of disease transmission and seasonal shedding of Alcelaphine herpesvirus-1 (Bengis *et al*., 2002), Malignant Catarrhal Fever is also endemic within wildebeest.

As a cloven hoofed animal known to walk extensive distances there is a potential risk of wildebeest transmitting FMD to cattle populations. However, while antelope such as wildebeest are potential carriers of the disease, as are all cloven hoof animals, they do not become persistent carriers. Unless a critical population density of animals is present the disease will not persist. Antelopes, especially within the Makgadikgadi region, where densities are in general

low, are not viewed as a high risk and therefore pose limited threat through their movements between FMD prevalent areas into disease free areas (Ecosurv, 2001).

g. Conservation actions recommended:
   1. A high standard of management is required within the Makgadikgadi Pans National Park. It will soon be one of the most fenced protected systems in northern Botswana, reducing its relative resilience to ecological fluctuations. While the Boteti River is flowing at present this status cannot be expected to be maintained full-term. Work must be done to improve the attractiveness of the newly established DWNP waterholes along the length of the Boteti River. Wildebeest were not using them prior to the arrival of the flood waters.
   2. Developing water points in NG49 and in the north western areas of the park would help facilitate the populations improved access to resources and break their restrictive central place foraging strategy they follow with zebra. Greater water distribution would, again as with zebra, reduce their vulnerability to fires.
   3. Develop firebreaks within the National Park to help reduce the risks of losing the majority of the dry season food resources of the population.
   4. Remove cattle from the Phuduhudu area and place them into NG45, this would reduce the impact of resource competition during the dry season.

Figure 13: Kernel density and distribution patterns of wildebeest during the wet season and dry season



Zebra

a. Ecology, habitat and food preferences:

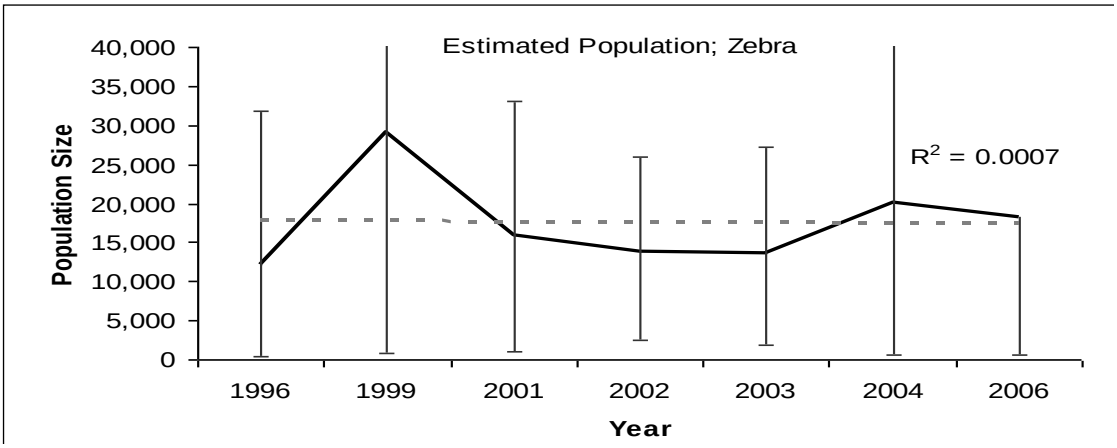
One of the keystone species within the Makgadikgadi system and one of Africa's most adaptable and successful grazers, the plains zebra utilises a broad range of savanna habitats and is equipped to deal with tall, tough grass swards and short grazing lawns. It is however, one of the most water dependent of the plains game (Estes, 1992). The Makgadikgadi region has limited surface available water, restricting their range, which is concentrated around the Boteti River during the dry season, from where they migrate to the open grasslands in the south and east of the Makgadikgadi Pans National Park. The fertile, lacustrine soils (solonchaks and calcisols) of the pans support grasses with higher relative nitrogen, phosphorous and calcium content than the surrounding sandy loam soils (arenosols) (Brooks, 2005). Higher nutrient levels attract the zebra to the open grasslands during the wet season (peak foaling period between December-March), when ephemeral pans fill with rain water. When these pans dry up the zebra return to the Boteti River and the Okavango Delta for the course of the dry season (Brooks, 2005, Bartlam-Brooks in press).

There is an overlap in food preferences of zebra with cattle (Voeten and Prins, 1999, Brooks, 2005). This overlap can lead to competition for resources when resources are limited and there is a spatial overlap between the two species. These requirements were met prior to the erection of the Makgadikgadi conflict fence that follows the alignment of the Boteti River, now separating zebra from cattle (Brooks, 2005). The dry season is the limiting season for the zebra population, with poor resource availability affecting yearling recruitment. The erection of the Makgadikgadi conflict fence stopped cattle from entering the park which were reducing the sward biomass available to wildlife. The subsequent increase in resource availability may be having a positive stimulus on the zebra population through improved yearling recruitment (Brooks, in press).

b. Population estimate within the Makgadikgadi region

The population estimate within the Makgadikgadi has fluctuated over the past 10 years, according to DWNP census records, with the population oscillating around the 19,000 mark. However, as stated earlier within this report, the clumped nature of the zebra herds restricts the accuracy of the estimates, with significant doubt placed on the validity of the 1999 dry season estimate of almost 30,000.

Figure 14: Estimated zebra population within the MFMP area



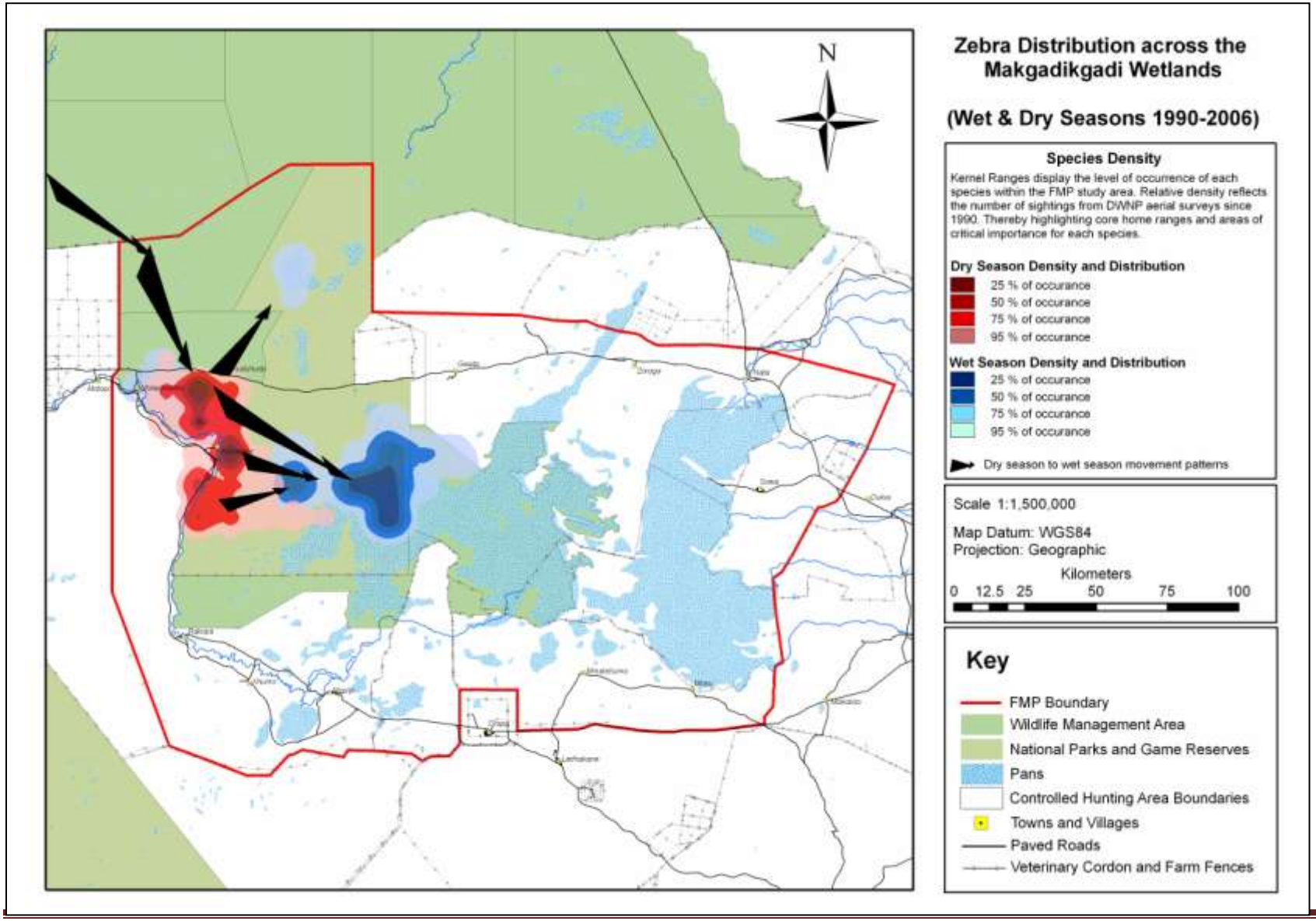
Ground survey work by J. Bradley would however suggest that the population is in recovery following the erection of the fence with a yearling recruitment of 20 per hundred adult females, compared with the results of Dr Chris Brooks prior to the erection of the fence in 2004 of 14 yearlings per hundred adult females. These results compare with the yearling recruitment of the stable Kruger zebra population of 17 yearlings per hundred adult females (Owen-Smith & Mason, 2005), signifying that the population is increasing, although other regulatory factors are in force. Grange *et al*., (2007) state that yearling recruitment of zebra is positively correlated with resource availability in the foals second year, substantiating the field data of Bradley within the Makgadikgadi. Further monitoring is required to validate this potential increase, or stabilisation of the population, but removal of the ecological constraints (limited access to water / resource competition with cattle / extreme foraging distances) that the zebra population was under prior to the erection of the fence may enable the zebra population to increase to a more viable and secure number. Improved access to water sources and subsequently foraging resources would further assist this trend.

The downward trend in the size of the population has been evident since the 1950s, although there have been several oscillations within the population since then. While the recent decline may be attributable to the conflict for grazing resources with cattle, there is substantial evidence that ecological variation within the local environment has been the main cause of population change. While there are more extensive details of the decline of the wildebeest population within the region, there are fewer historical records available for zebra. The DHV (1980) report estimated the zebra population within the Makgadikgadi at 100,295 in 1978, although an earlier estimate in 1974 put the population at 22,748 ± 2,287(Graham, Dawson & Parker, 1974). The highly clumped nature of the population would have made estimates in the 1970s just as difficult as present day and it is likely that a Figure somewhere between these two estimates is correct for the time. However, regardless of the lack of an exact Figure, what is clear is that the population has fallen dramatically since the 1970s. Even though the population has suffered extensive declines over the past decades the Makgadikgadi zebra population still constitutes more than 40% of the entire national zebra population.

c. Spatial distribution within the Makgadikgadi region

The spatial distribution of zebra within the MFMP area is regulated by access to surface available water, with dense concentrations of zebra along the Boteti River during the dry season, especially around Xhumaga and at Meno-a-Kwena; the only two access points to water both before and after the erection of the Makgadikgadi fence.

Figure 15: Kernel density and distribution patterns of zebra in the wet and dry season



The arrival of the rains at the start of the wet season results in a mass migration from the Boteti region to the east and southeast of the Makgadikgadi Park, with a limited movement north towards Nxai Pan. The zebra follow a nutrient gradient from the Boteti to the open grasslands, which are only made accessible for long periods with the arrival of the rains and the availability of drinking water on the grasslands. Rain water gathers in the open pans, flooding the pans in shallow water for periods of up to several months of the year. However, rapid rates of evaporation and high salt content in the soil make this available drinking water highly saline, so that zebra and other species prefer to drink from sunken depressions within the open grasslands that have a lower salinity. The presence of water within these sunken depressions regulates the movement of the zebra migration across the wet season home range (Brooks, in press).

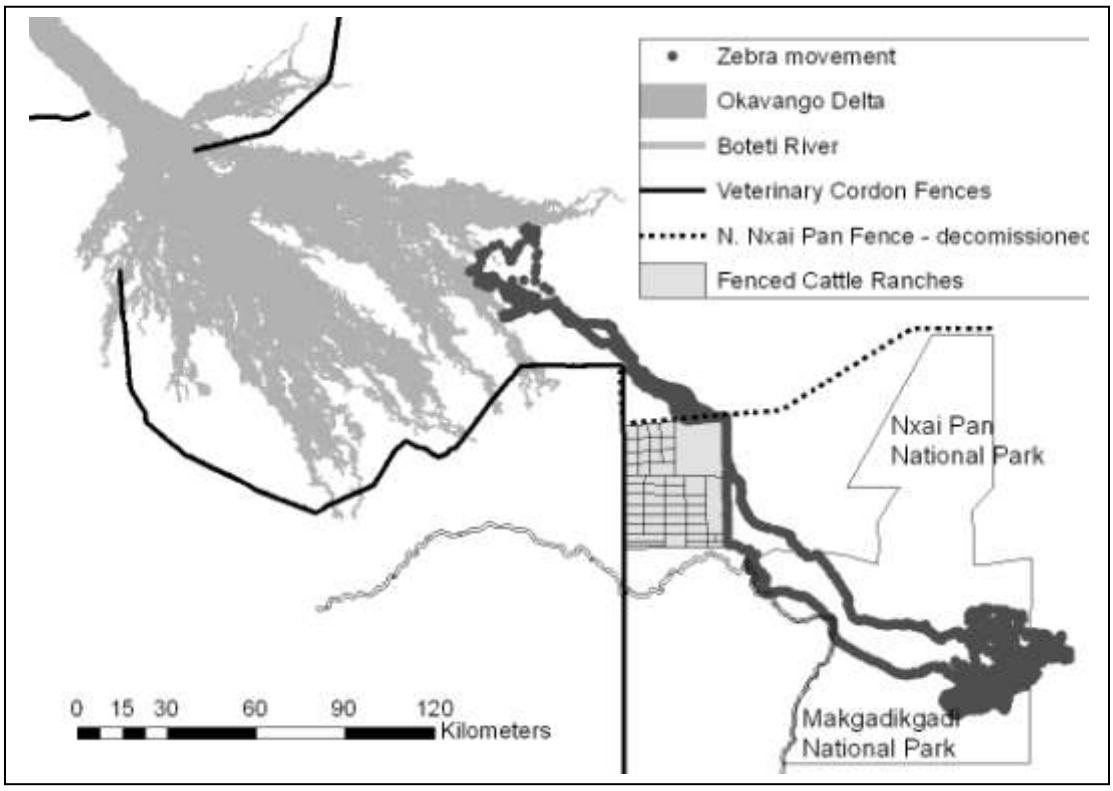
The wet season movement extends beyond the national park's eastern boundary into CT11, as zebra search for fresher water sources and improved grazing. Proposals to fence the eastern side of the Makgadikgadi have long been mooted and inclusion of CT11 within the fence is vital for the viability of the zebra population. Wet season distribution patterns are not as regulated as the dry season. Wet season movement follows the spatially variable rainfall patterns within the localised area of the south and eastern parts of the national park (Figure 15).

The 'resident' zebra population within the Makgadikgadi is joined during the wet season by a further migratory sub-population of the Okavango Delta's zebra population. An unknown number, but estimated to be around 500 zebra (Bartlam-Brooks, pers. comms.) depart from the south-eastern part of Moremi, moving through NG34, NG43 and into the FMP study area at the north-eastern corner of NG45. The zebra move through NG47 and NG49 into the Makgadikgadi Pans National Park. The extraordinary thing about this movement is that the northern buffalo fence, which was aligned along the northern boundary of NG47 was only removed in 2004, following its decommissioning in 1999, so that this migratory movement has become re-established since the dropping of the fence. What this demonstrates is the adaptability of wildlife within the system and that the decommissioning of fences can result in migratory patterns re-establishing themselves after many decades. It is anticipated that the relative importance of this movement will increase as more Delta zebras join the migratory sub-population. A more detailed research project is to be initiated by Harriet Bartlam-Brooks (Figure 16).

The dry season distribution patterns of the zebra population are also regulated by the distribution of water availability along the Boteti River. The Boteti River provides year round surface water, either as pumped and natural water points along its course or, as at present, as a flowing river. Access to the water is restricted by a fence constructed in 2004 to separate wildlife within the park from people and livestock living on the other bank of the Boteti River. The fence follows the alignment of the river within the park, only crossing the river and providing access to water for wildlife at two points; Xhumaga and Meno-a-Kwena. This restricts the movement of the zebra, by forcing them to forage for grass resources under a central place foraging pattern, always returning to the same place for water and limiting their access to grazing resources along the course of the river. Recent artificial water points (AWPs) installed by DWNP in 2007 (10 new boreholes and 2 river extraction points for 12 new AWPs) have not been successful at attracting zebra to drink. Water quality is lower within the AWPs, while thick bush surrounding the AWPs may discourage zebra from using the water sources (Bradley, pers comms). To encourage improved use of these AWPs the surrounding bush needs to be cleared.

Attracting zebra to use these water points will enable them to expand their dry season range along the length of the Boteti River within the park.

Figure 16: Migratory movement paths of zebra between the Okavango Delta and the Makgadikgadi system.



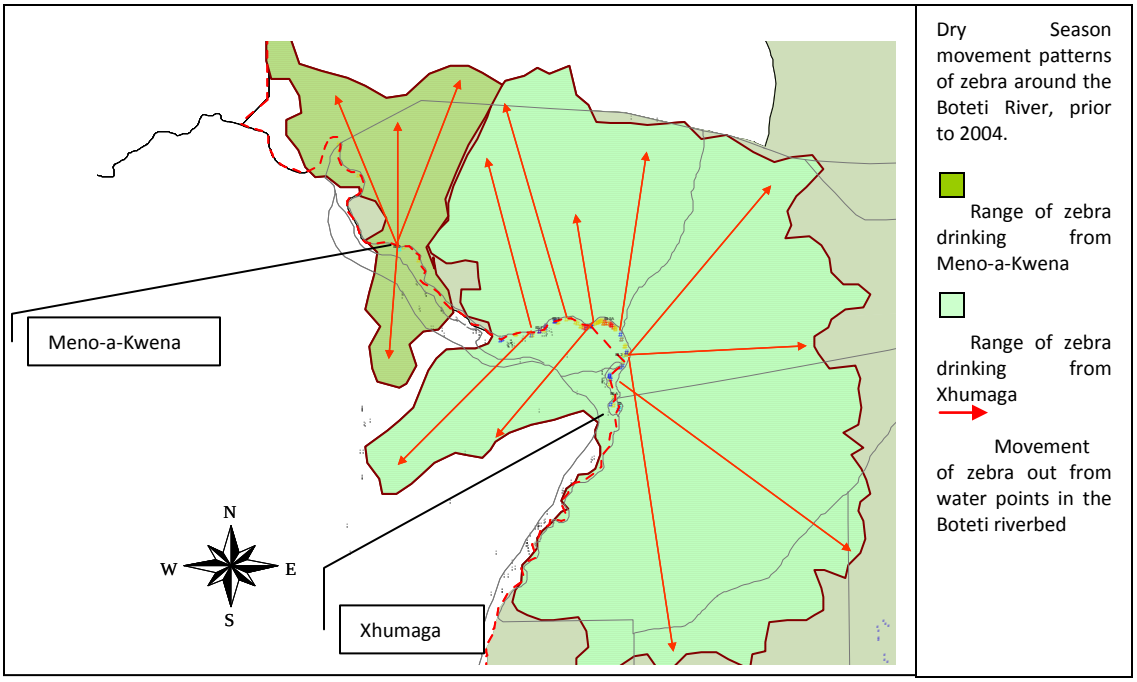
Prior to the erection of the fence, there were 48 main water holes long the Boteti River from Xhumaga Village and upstream for a distance of 25km. Thirteen of the water holes had high concentrations of red and green algae (Cyan bacteria) with TDS and conductivities beyond wildlife use levels (wildebeest TDS limit 38,000ppm, preferred 9,000ppm) (Brooks, 2002). Zebra and elephant both used to create small water pits along the riverbed and near some of the larger pools in the riverbed to enable seepage of water from poor quality main pools with resulting fresher water. There were up to a maximum of 120 of these small and sometimes temporary pools along the same stretch of the river as the main pools with an average TDS of 1,950ppm, with approximately 20 of the pools more substantial and permanent than others. Water availability within the shallow pools was maintained by ground water recharge or seepage from the proximate main pools.

While the alignment of the fence was recommended to zig and zag up the course of the Boteti River, its actual final alignment was within the riparian woodland on the park side of the river, only crossing the river at two points (actually 3, but the third is for a short duration close to the second crossing at Xhumaga); Meno-a-Kwena and Xhumaga. While there was much controversy over the alignment the fence and its impact on restricting access to water for wildlife, relative access to water along the course of the river for zebra was similar to pre-fence conditions. The fence restricted access to all water points apart from those in close proximity to Xhumaga village

and the safari camp at Meno-a-kwena. All other water points were cut off and are now only accessible to livestock. A total of 35 water points were left accessible to wildlife within the fenced area, with 36 water points excluded for use by livestock. The end result of the separation was that, while the fence did not zig zag the separation of water points was almost 50-50, with a similar state of water availability at the two points of Xhumaga and Meno-a-Kwena. One of the major problems with the fence alignment was the exclusion of the riverbed and the important riparian woodland habitat, so that there are no other available access points to the riverbed, either for the development of further artificial water points within the riverbed, or for access to the river in case the river started to flow again, as it is at present.

Figure 17 shows the typical dry season movement patterns of the zebra around the Boteti River, where zebra were recorded moving up to 31km from the riverbed in search of preferred resources and going without access to water for up to 7 days (Brooks, 2005). This map demonstrates pre-fence behaviour, but pots fence behaviour will be similar, i.e. restricted central place movement from both Xhumaga and Meno-a-Kwena to search for grazing resources. This map depicts the movement of zebra west from the Boteti River prior to the development of the fence. This movement was undertaken by almost a third of the population, but only 4% of preferred foraging patches were selected by zebra in this region. This may have been due to disturbance in the area by cattle and farmers. Exclusion of this area by the fence was therefore not expected to have a significant impact upon the zebra population (Brooks, 2005).

Figure 17: Typical movement patterns of zebra out from the confined water resources of the Boteti riverbed



d. Research and monitoring within the Makgadikgadi region

There has been extensive research conducted on the zebra population within the Makgadikgadi by Dr Chris Brooks. His work gathered information on pre-fence conditions prior to 2004.

Following on from his work, James Bradley is conducting his PhD research project on quantifying the impact of the fence on the zebra population. Harriet Bartlam-Brooks has also observed the movement of zebra from the Okavango down to and back from the Makgadikgadi region and is in the process of continuing this research.

Further aerial census work is however required. It is believed that the population is in the stages of recovery, following on from many decades of decline. To help quantify this further aerial census are required to help survey the population.

e. Current threats to the population within the Makgadikgadi region

Historical records clearly show that the population is vulnerable to stochastic variation in ecological conditions. The fencing of the system reduces the resilience of the system to such stochastic variation and requires improved management.

The area is vulnerable to fires which sweep in from the east. Future fires could either trap zebra herds against the fence, or exhaust all foraging resources in close proximity to the limited water supplies. The fence simplifies predation strategies for lions along the Boteti and while such activity will not threaten the viability of the population adjustments in the fence alignment away from water points would help mitigate this problem.

Before the erection of the fence, Brooks recorded a rate of poaching on zebra of close to 6%. If such rates are continuing then they will affect any potential for the population to increase and stabilise at a higher level.

There have been proposals made to fence the southern boundary of NG49 to reduce human-wildlife conflict within the region. Such an alignment would cut off the re-emerging migratory link between the Makgadikgadi and the Okavango. This migratory pathway is not only used by zebra. It is believed that a similar route was used by two rhinos which moved from the Delta to the Makgadikgadi in 2006, while buffalo are also known to move into the system from the north along a similar route. This route provides a vital corridor of inter-ecosystem connectivity and could be vital for genetic flow between these above mention species and many different predator species that may also disperse through these areas.

The Department of Roads has proposed for the fencing of the Gweta-Makalamabedi road. This fence would have the same repercussions as the above mentioned fence and must not be permitted.

f. Current threats caused by the population to the rest of the Makgadikgadi region

African horse sickness is endemic within zebra and they therefore pose a risk to domestic livestock.

g. Conservation actions recommended:

1. The alignment of the fence should be adjusted away from areas close to water points;
2. There must be no fence developed along the southern boundary of NG49. This fence was proposed as a conflict mitigation strategy for this region, but its development would cut of the important migratory corridor between the Okavango and the Makgadikgadi. This corridor is not only used by zebra, but also by species such as, elephant, rhino, buffalo and giraffe;

3. The Dept. of Roads should not be permitted to develop fencing along the Gweta-Makalamabedi main tar road which bisects the park. This fence would have the same impact as the proposed conflict mitigation fence;
4. Firebreaks should be placed within the National Park, running North-to-South 20km to the east of Xhumaga. These will help to protect the forage along the Boteti River. Protection of these dry season forage reserves is vital now that the zebra and wildebeest are unable to move over to the west of the Boteti River to graze as they used to during periods of fire;
5. The new water points provided for wildlife should have all surrounding bush cleared for a distance of up to 50m to encourage use;
6. To improve the spread of the population during the dry season and reduce their reliance upon foraging resources around the Xhumaga area additional water points should be installed. The development of water points in NG49 would attract zebra into this key foraging area. A preference for this area has been demonstrated by zebra, while an increase in wildlife density in the region would help facilitate tourism objectives for the area. More crucially the extension of the dry season home range would reduce the population's vulnerability to the effects of fire, which could denude the foraging resources around Xhumaga;
7. The alignment of the western fence along the Boteti River should be adjusted. Improving the number of access points to the riverbed would be the best initial method of improving the spread of the population along the length of the river. Access to ground water is also better in this region and when the river runs dry again pumped supplies can be provided;
8. The proposed fence to be erected to the east of the Makgadikgadi Pans National Park must include the CT11 area. This is a vital part of the wet season migratory range and its exclusion would be of significant detrimental impact to the population.

3.1.4 Carnivores

Brown Hyaena

a. Ecology, habitat and food preferences

Across much of its range within Botswana, it is the largest and most dominant carnivore, due to the lack of other predators in the region. The cause for this is its adaptability, opportunistic nature and ability to survive without surface water. It is primarily a scavenger, but also eats Tsama melons to gain water and has been recorded hunting springhares. It is nocturnal, lives in a clan social system, but spends the majority of its time as a solitary individual searching for dispersed resources across a large home range of up to 500km^2. It is cryptic in nature and has no audible load call. The fact that it is primarily a scavenger and is cryptic has enabled it to survive in close approximation with people, hence its widespread distribution across much of Botswana (Estes, 1992).

b. Population estimate within the Makgadikgadi region

The population estimate within the Makgadikgadi Pans National Park (excluding the Nxai Pan National Park) has been tentatively set at around 98 adults in 7 – 10 clans. An unknown number of nomadic males occur in the area. There are thought to be 3-4 clans with an estimated 25 adults in CT 11. Population estimates for the rest of the Makgadikgadi region are unknown (G. Maude pers. com.).

c. Spatial distribution within the Makgadikgadi region

It is believed that the population is widespread throughout the Makgadikgadi. The species is cryptic and nocturnal and is known to live around people, especially around low densities of people living within a cattle post system, such as across most of the Makgadikgadi.

d. Research and monitoring within the Makgadikgadi region

Glyn Maude is completing his PhD on the Brown Hyaena within the Makgadikgadi. Mr. Maude's PhD project is the first to study the brown hyaena within Botswana since the Owen's in the 1970s and focuses on the ecology of brown Hyaena in association with cattle posts and farmers. There are at present two clans located in the eastern Makgadikgadi Pans National Park and several more within CT11 which are being studied under this project.

e. Current threats to the population within the Makgadikgadi region

The status of the brown hyaena is presently listed as Lower Risk: Near Threatened (98 IUCN Hyaena Status Survey, Mills, Hofer) with a minimum worldwide population estimated at between 4,825-7,800. Botswana is a stronghold for the population, but increased risk from antagonistic farmers is having localised impacts on the population. While primarily a scavenger, the brown hyaena is often blamed for the loss of livestock, when it may be leopards or even spotted hyaena. As there is no compensation available for the loss of livestock from hyaena kills, people often kill them in response.

f. Current threats caused by the population to the rest of the Makgadikgadi region

Across the whole Makgadikgadi hyaenas form the 5th most important problem animal, although in certain areas they form the 2nd most important problem animal, when assessed through economic terms. However, due to recent changes in the compensation regulations these damages are not compensated. Therefore many incidents of damages caused by hyaenas are not reported, with hyaenas persecuted as a result. The uncompensated loss of livestock therefore poses a significant cause for concern for both the local residents of the MWS and the species themselves.

g. Conservation actions recommended:

Compensation for the loss of livestock from hyaena kills should be paid. The lack of compensation compels farmers to shoot hyaenas to solve the problem.

Lion

a. Ecology, habitat and food preferences

The largest African carnivore that while adept at scavenging food is ideally suited to the predation of large ungulates. They are a gregarious and territorial species that is visibly and audibly conspicuous. They generally hunt cooperatively in prides up to twenty-five strong in areas with high prey densities, but more usually only two females within semi-arid areas with lower prey densities. Home range is related to prey density (Estes, 1992).

b. Population estimate within the Makgadikgadi region

The Makgadikgadi National Park supports a small population of lions that was estimated at between 28-59 individuals in 2002, which occurred at a low density of one lion per 125 sq/km (adult and sub-adult, Hemson, 2001). Dr. Graham Hemson's PhD project on the lion population within the Makgadikgadi Pans National Park was focused on general lion ecology and the

relative prey selection of lions between seasons in relation to the movement of the zebra and wildebeest population. His study area focused on the region in the park between Xhumaga and CT11. Within this study area, there were 12 adults, 8 sub-adults and 22 cubs. The sex ratio in cubs over 6 months was estimated at 1:1.75 males to females, 1.1.71 in sub-adults and .38:1 for adults and was similar to other Southern African lion populations.

c. Spatial distribution within the Makgadikgadi region

The spatial distribution of lions within the MFMP area is limited to the Makgadikgadi and Nxai Pan National Park and surrounding WMAs. There is no evidence of lions in the south of the area or around Sua Pan. Detailed knowledge of the spatial distribution patterns of lions within the park is reliant upon the PhD research of Dr Graham Hemson, who collared lions with both GPS and VHF collars. There is no information on distribution patterns elsewhere in the park, or within the WMAs.

d. Research and monitoring within the Makgadikgadi region

Dr Graham Hemson conducted the only lion research within the Makgadikgadi system between 2000 and 2003. Further research is required to help assess the current population dynamics of the lion population and assess how the reaction of the conflict fence has affected their behaviour and their viability within the system as a whole.

e. Current threats to the population within the Makgadikgadi region

Lion conflict with farmers remains a large management problem in the area both in terms of lion population viability and economic loss to farmers. In the 1999-2000 wet season, 10 lions alone were killed (Hemson, 2001), while further extensive mortalities have been recorded in more recent years, with 6 lions reported killed in 2009 along the Boteti.

f. Current threats caused by the population to the rest of the Makgadikgadi region

Lions are related to more than twice the economic damage to people property within the MWS than all other problem animals put together. Between 1998 and 2008 lions were responsible for more than P700, 000 worth of damage to livestock (as paid out by DWNP as a direct form of compensation to farmers). Farmers living within close proximity to the MPNP suffer the greatest burden, with those farmers surrounding Rakops and Xhumaga suffering the greatest impact of all with P270, 000 and P180, 000 worth of damage to livestock respectively.

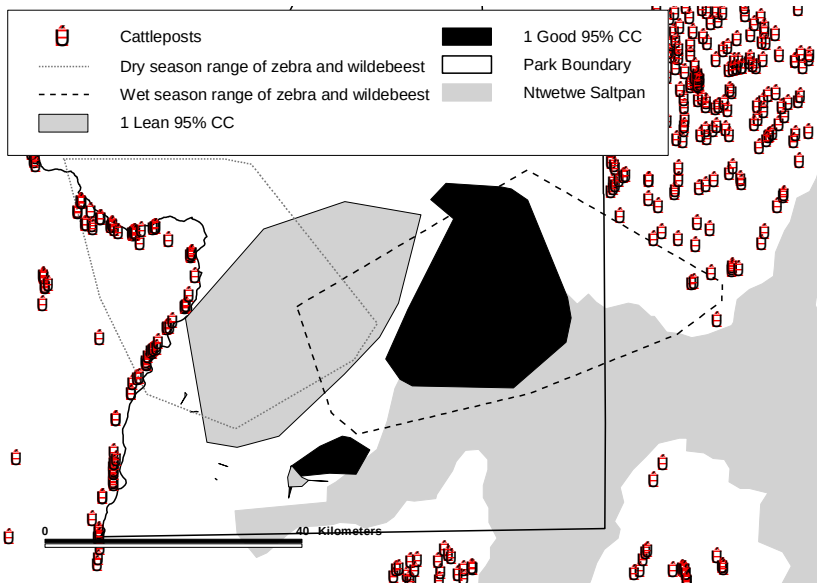
g. Conservation actions recommended

It is essential that a detailed predator survey is undertaken within the Makgadikgadi region. There are no viable baseline data for the population of leopard within the system and it is therefore impossible to define appropriate management strategies, or to assess how development scenarios impact the predator guild.

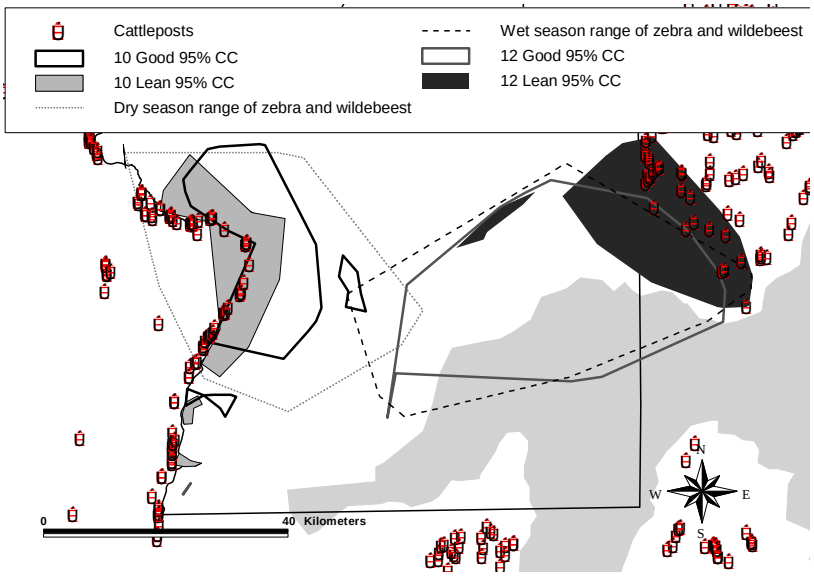
Figures 18(a) and (b) indicate various lion home ranges within the Makgadikgadi Pans National Park (Hemson, 2004**)**. *The maps cover the central part of the park, showing cattlepost distribution along the Boteti to the west and within CT11 and CT7 to the east.*

Figure 18: Lion home ranges within the MPNP

a) Some lions preferred to remain within the national park and did not kill cattle around the park boundary, but instead predated on wild species such as zebra, wildebeest, kudu, gemsbok and hartebeest.



b) Some lions left the park to kill cattle either during the wet season along the Boteti (when the migration was in the east of the park), or during the dry season in CT11 (when the migration was along the Boteti).



3.2 Mammal core ranges used to help define the biodiversity hotspots

All of the key mammal home ranges defined during this study and not just the key species represented within this report formed a crucial part of the Biodiversity Hotspot assessment within the ecology and hydrology component. The Biodiversity Hotspots were spatially defined and then evaluated to help rank them in order of importance for conservation, with the spatial definition originating from a) the core areas of the mammal kernel home ranges (Figure 19), and b) the hydrological wetspots (Figure 20), i.e. those areas of the pan surface that retain their water for on average longer than any other locality due to slight variations in topography and hydrological flow. The wet spots were identified as those areas key for the birdlife, while the cores areas of the mammal home ranges were assumed to be the most productive, diverse and important habitats, which would also support a wider range of wildlife, bird and plant species. Plant and biodiversity hotspots as defined by the Botswana Biodiversity Index were also used to help identify further Biodiversity Hotspots (Figure 21) within the system.

Figure 19: Mammal core home ranges, used to help define the Biodiversity Hotspots

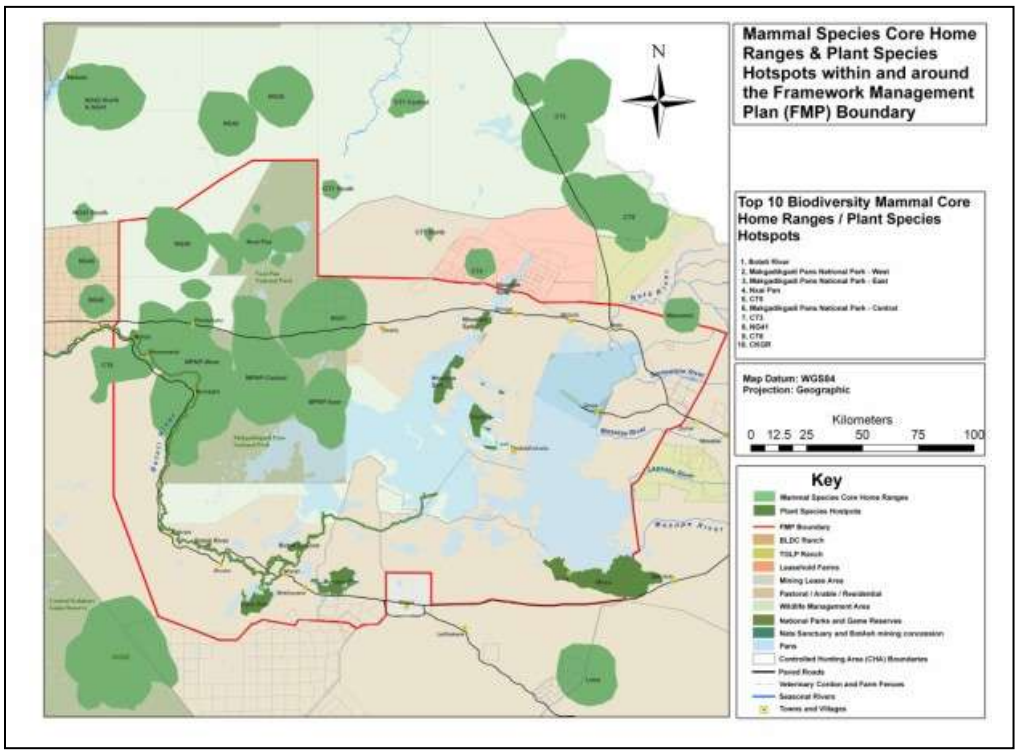


Figure 20: Hydrological Wet spots, used to help define the most important waterbird habitats as well as biodiversity hotspots within the system

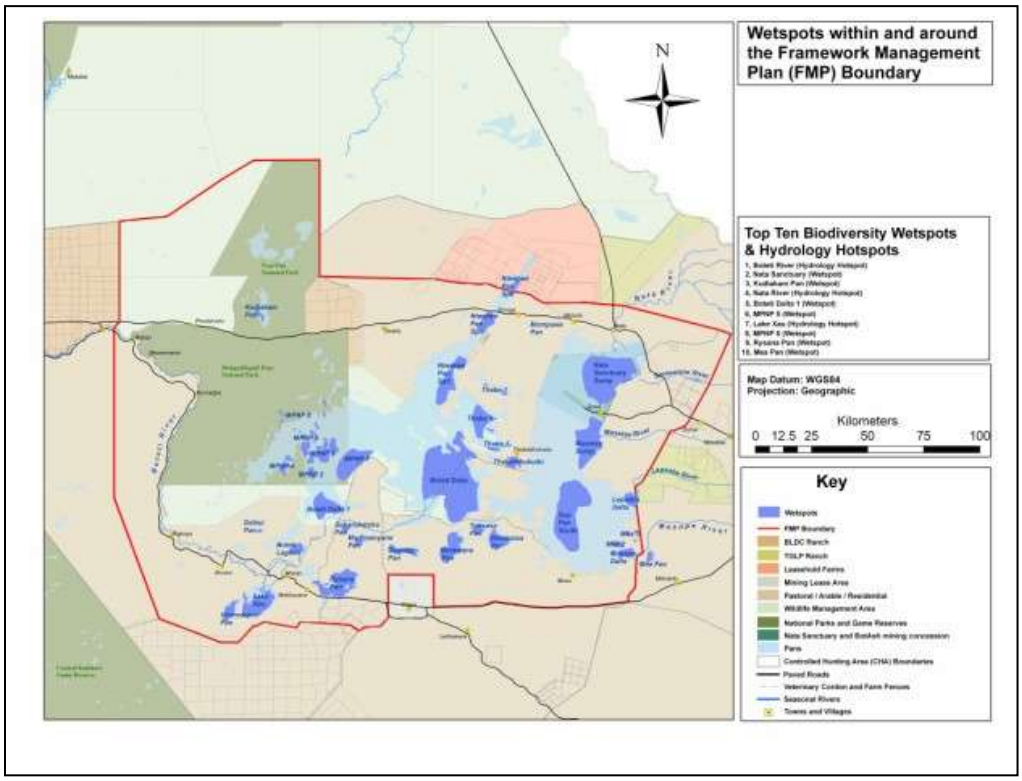
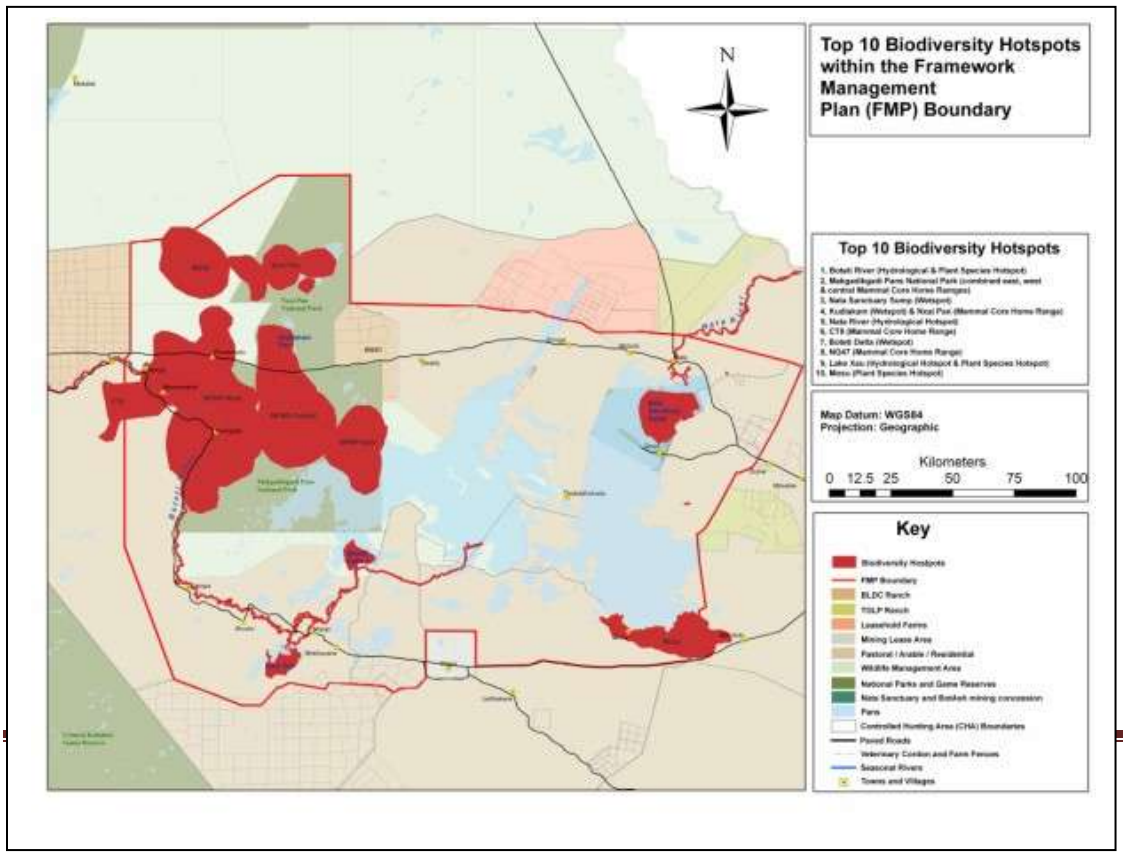


Figure 21: Biodiversity Hotspots defined for the Ecology & Hydrology Component of the MFMP



3.3 Amphibian, Reptile, Fish and Invertebrate Inventory and Species Status for the Makgadikgadi Wetlands

3.3.1 Amphibians, Reptiles and Fish

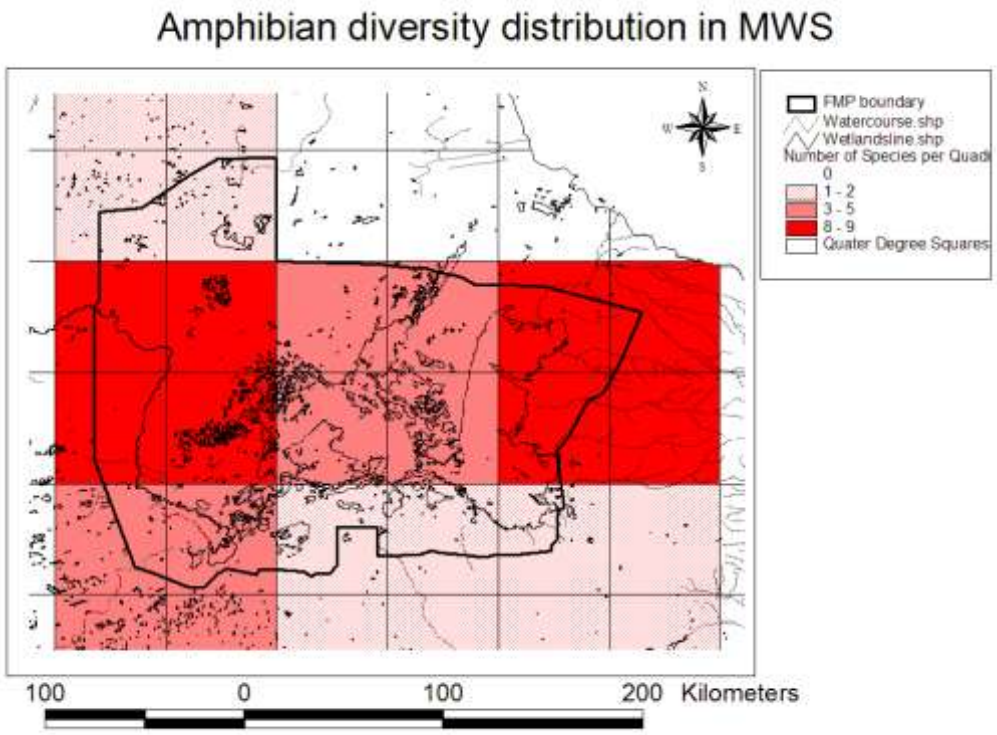
Reptiles and amphibians are important components of the ecosystem and are of value to the remote-area communities in Botswana. For instance, land tortoises, turtles, monitor lizards and their eggs, pythons and a variety of small lizards are used as food, or their by-products are fashioned into curios. Similarly, many reptiles and amphibian derivatives are valued greatly by herbalists and traditional healers. However, the role these reptiles and amphibians play in the Pans ecosystem is relatively unknown. Reports of endemic frog species in the MWS could not be confirmed. There is need for studies aimed at gaining more knowledge about the reptiles and amphibians of the Pans.

Amphibians

The most recent frog species accounts and their general distributions have been gathered from Channing (2001) and Carruthers (2001), in which eighteen species of amphibian have been identified to occur in the MWS. None of these species are currently listed on the IUCN Red List of threatened species. Other historical records were also reviewed and some contained species for the MWS with spatial distributions. A summary of amphibian species accounts and their locations, recorded during annual expeditions to the area by the Peter House institution in Zimbabwe, in the 60's (Ginn, 1971), revealed a total of six species from four different sites: 5 species were found in Xhumaga (the Guttural Toad, Western Olive Toad, Tropical platanna, Speckled bellied Grass Frog, and the Mascarene Grass Frog), 1 in Nthane (Foam Nest Frog), and 1 in Sukwane (Western Olive Toad). Cumming (2001) recorded the distribution of 15 species in the MWS area.

A spatial distribution analysis of amphibian diversity in the MFMP area, identified in both Cumming (2001) and Ginn (1971), reveals that species diversity is highest in the Xhumaga/Boteti River area and the Nata Sanctuary/eastern side of Sua Pan area, with eight to nine species in each area, followed by Ntwetwe Pan and the south western Boteti/Lake Xau areas, with three to five species (Figure 22). Generally, species diversity follows aquatic habitat diversity, with more species found along the main rivers and their associated permanent pools and floodplains, decreasing as one moves to temporarily flooded pan and grassland habitat.

Figure 22: Spatial distribution map of amphibian diversity among quarter degree squares in the MWS



Reptiles

Fourteen families and seventy-one species of reptiles have been recorded in the Pans area, according to species distributions in Auerbach, (1987) and Clauss & Clauss, (2002).

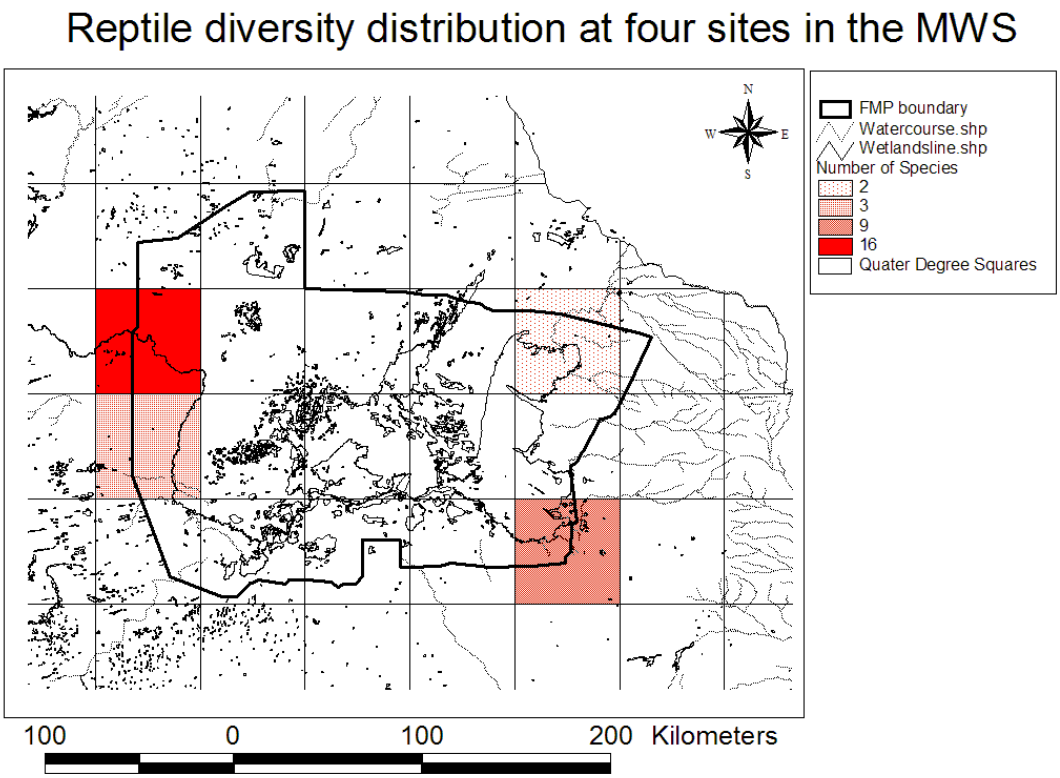
A summary of reptile accounts and their locations, during annual expeditions to the area in the 60's by the Peter House institution in Zimbabwe (Ginn, 1971), recorded a total of twenty eight species. Among the four sites that were visited during these expeditions, Xhumaga had the greatest species diversity, with a total of sixteen species identified there, followed by Nthane with nine, Sukwane with three, and Nata with only two species of reptiles recorded as identified there (Figure 23).

Two species of reptile in the area are listed as protected:

1. Protected in Botswana, on the basis of vulnerability (Botswana Wildlife Conservation and National Parks Act, 2002):
   Southern African Rock Python, *Python sebae natalensis* (Smith).

2. Protected under Appendix 1 of the CITES Convention:
   Nile Crocodile**,** *Crocodylus niloticus*

Figure 23: Spatial distribution map of reptile diversity in the MWS, taken from historical records at four sites in the area



Fish

No official collections have been taken from Nata River or Sua pan, but according to Department of Fisheries' officers, confiscated fish that were from people fishing in the Nata River included three species, Bream, Barbel and Tilapia (Eco-Logic Support Services, 2003). They also said that a ban on fishing in the Nata River is largely ignored by the local communities. Fish do, also, occur and breed on Sua Pan during years of exceptional flooding (McCulloch, 2003). It is thought that they are brought onto Sua pan via Nata River, from Dams and pools upstream in Zimbabwe. The most common fish species: the Barbel (*Clarius qariepinus*), can, however, aestivate (lay dormant) in order to survive the dry season, and is reported to do so in the sand and clay beds of the dry Nata River. It occurs in great numbers at the beginning of the flood. A species of Tilapia, or Cichilid, not yet identified, also occurs in Sua Pan's floodwaters and breeds very well on the pan. It tends to be more tolerant of, and survive for longer periods during increasing salinities, as the pan dries up (McCulloch, 2003). During these exceptional flood years, both species play a very important role in the breeding success of fish eating birds like cormorants, herons and Great White Pelicans, that breed in large numbers along the Nata River and estuary. In addition, unconfirmed reports suggest that the pans may also contain Killifish (*Nothobranchius sp*.) and maybe even lungfish (*Protopterus* sp.), but no sightings have been recorded.

There have been no fish studies carried out on the Boteti according to a Senior Fisheries officer from the Ministry of Agriculture (Eco-Logic Support Services, 2003). Records of fish species caught in the Boteti River, when in flood, suggested that all species found in the Delta have, due to the flooding regime, been caught in the Boteti. A species list for the

Okavango Delta, taken from Skelton *et al*. (1985) provides a comprehensive list of those species that could be found in the Boteti River.

3.3.2 Invertebrates

Invertebrates comprise a critical food source for many vertebrates, especially insectivorous birds, herpetofauna and small mammals. Furthermore, it must be remembered that invertebrates are the ecological dynamos for many ecosystems, in particular recycling nutrients and pollinating plants. Recent evidence from Namibia, for example, has shown that termites can lift to the surface scarce nutrients such as copper, iodine and selenium from depths of 80 m under the soil surface. The cocktail of nutrients supplies plants, which, in turn, attracts mega herbivores.

There are surprisingly good taxonomic records for the major groups of insects for the country as a whole, but so little on the distribution of these species within the country, owing to lack of inventories and research. Inevitably, this dearth of knowledge also means that there are quite likely many species still not described, especially of the lesser-known taxa. Interestingly, there are as yet no truly threatened (i.e. globally threatened on the IUCN Red List as Vulnerable, Endangered or Critically Endangered) invertebrates in Botswana.

Ascertaining what all these species do in the ecological scheme of things is then the next step in ecological understanding of this important group. The large population size of some species, which in some cases equates to very large biomass, indicates that they are indeed playing an important, as yet unknown, functional role. This knowledge of function is indeed a special issue that needs addressing in the MWS.

Odonata (Dragonflies)

In 2000, Kipping (2006) started a series of several odonatological study trips to Botswana, which lead to an updated checklist of the *Odonata* of Botswana (Kipping, 2006). An apparent species diversity gradient roughly correlates with the country's rainfall gradient; from NE to SW, and with the number of freshwater wetlands (prime habitat) in the north of the country. According to Kipping, in Anonymous (2007), twenty one species from five families have been recorded to occur in the Makgadikgadi and Nxai Pan NP (Table 9). It is likely to hold more species, with most of these additional species likely to be widespread pan-African species. The Boteti River is mostly responsible for the *Odonata* records that have be made in the area, with species like *Olpogastra lugubris* occasionally found there, far from any permanent water. MPNP has, however, been poorly sampled for *Odonata*. Most of the historic records derive from the Boteti River occurred in a much wetter period than the last ten years. Some of the records provided by Pinhey (1976) from 1967, which are absent today, may, however, soon be repeated owing to the recurrence of river flow this in the last few years, e.g. *Phyllomacromia contumax, Pseudagrion deningi* or *P. sjoestedti*.

Table 9: Species checklist for the MWS

	Accuracy[a]	Status[a]	Notes
Family: Lestidae			
Lestes pallidus Rambur, 1842	3	LC	
Family: Coenagrionidae			
Agriocnemis exilis Selys, 1872	3	LC	
Ceriagrion glabrum (Burmeister, 1839)	3	LC	
Ischnura senegalensis (Rambur, 1842)	3	LC	
Pseudagrion coeleste Longfield, 1947	3	LC	
Pseudagrion deningi Pinhey, 1961	3	LC	
Pseudagrion hamoni Fraser, 1955	0	LC	expected to occur, syn. *Pseudagrion whellani*
Pseudagrion massaicum Sjöstedt, 1909	0	LC	expected to occur
Pseudagrion sjoestedti jacksoni Förster, 1906	1	LC	only one historical record from Boteti River in 1967, probably absent today
Family: Gomphidae			
Paragomphus genei (Selys, 1841)	0	LC	expected to occur
Family: Aeshnidae			
Anax ephippiger (Burmeister, 1839)	3	LC	
Anax imperator Leach, 1815	0	LC	expected to occur
Anax tristis Hagen, 1867	0	LC	expected to occur, certainly present
Family: Macromiidae			
Phyllomacromia contumax Selys, 1879	3	LC	only one historical record, syn. *Macromia bifasciata*
Family: Libellulidae			
Brachythemis leucosticta (Burmeister, 1839)	0	LC	expected to occur, certainly present
Brachythemis wilsoni	1	DD	only one historical record

Pinhey, 1952			from Boteti River in 1967, probably absent today
Crocothemis erythraea (Brullé, 1832)	3	LC	
Diplacodes lefebvrii (Rambur, 1842)	0	LC	expected to occur, certainly present
Diplacodes luminans (Karsch, 1893)	3	LC	syn. *Philonomon luminans*
Olpogastra lugubris (Karsch, 1895)	3	LC	one recent record, probably migrating individual, not regularly part of the inventory
Orthetrum brachiale (Palisot de Beauvois, 1805)	3	LC	
Orthetrum chrysostigma (Burmeister, 1839)	3	LC	
Orthetrum trinacria (Selys, 1841)	3	LC	
Pantala flavescens (Fabricius, 1798)	3	LC	
Rhyothemis semihyalina (Desjardins, 1832)	3	LC	
Sympetrum fonscolombii (Selys, 1840)	3	LC	
Tramea basilaris (Palisot de Beauvois, 1805)	3	LC	
Trithemis annulata (Palisot de Beauvois, 1805)	3	LC	
Trithemis arteriosa (Burmeister, 1839)	0	LC	expected to occur
Trithemis kirbyi ardens Selys, 1891	0	LC	expected to occur
Totals:	**21**		
+ spp. expected :	**9**		

0 – No spatial data; 1 – Locality described; 2 – Quarter degree grid square reference; 3 – Precise Lat-Long coordinates.
BW – Botswana endemic; SA – Southern African endemic; EX - Extinct; NT - Near Threatened; EW - Extinct in the Wild; LC - Least Concern; CR - Critically Endangered; DD - Data Deficient; EN – Endangered; VU - Vulnerable.
Source: Kipping (2006) and Kipping in Anonymous (2007).

Odonata in general are useful indicators of freshwater ecosystem health. Habitat selection is more or less strong and varies among different species, e.g. there are well-defined groups living in lotic or lentic water bodies. In general, the habitat must meet the ecological needs of all stages in the life cycle of a species to make it suitable. There is, therefore, a strong correlation between diversity of vegetation and structure and *Odonata* biodiversity. This shows the suitability of dragonflies as bio-indicators both from the aquatic and terrestrial point of view (Kipping, in Anonymous, 2007).

Butterflies

Butterflies have been fairly well-collected in Botswana (Henning *et al*., 1994), but very little data is available on species distribution. Table 8, Appendix 1 of the Site Inventory Report lists the species from Henning *et al.* (1994) that mentions distribution to include the Makgadikgadi area, known sites in the MWS, or those with a range throughout Botswana.

Scorpions

Scorpions have been surveyed to some extent by Leeming (2003), and seven species (Table 10) in total fall within the Makgadikgadi area (Anonymous 2007). Prendini (2005) suggests that the lack of endemic scorpions to Botswana is due to sampling effort.

Table 10: ***List of Scorpion species in the MWS***

Species
Family Hottentotta
Parabuthus granulatus
Parabuthus raudus
Uroplectes planimanus
Uroplectes carinatus
Uroplectes vittatus
Family Scorpionidae
Opistophthalmus carinatus
Opistophthalmus wahlbergii

Source: *Leeming (2003).*

Grasshoppers and other insects

Orthoptera, from the order *Acridoidea*, the grasshoppers, have also been surveyed to some extent, with the excellent monographs of Johnsen (1990; 1991a; 1991b). To date, 152 grasshopper species have been recorded from Botswana, of which 26 species are recorded occurring in the MWS (Anonymous, 2007). Other *Orthoptera*, particularly the *Tetiigoniidae*, are very poorly known in the country, despite their very important contribution to ecosystem processes. Other flagship taxa such as the moths and mantids have been collected, but very few species have found their way into formal databases.

There are 10 genera and 40 species of bees recorded to occur in Botswana. Given the species specificity in pollination habits and the role they play in plant propagation, high priority should be given to identifying the species distribution and status of *Apidae* in Botswana. The best information on *Apidae* was provided from Dr. Connal Eardley from the Agricultural Research Council, Plant Protection Research Institute. She reviewed the Apidae species found in Botswana and information on collection locality. Eight species of Apidae were identified from collections in the MWS area: *Amegilla kaimosica*, a *Halictus sp*., *Anthophora ferripicta*, *Anthophora pygmaea*, *Thyreus plumifer*, *Chalicodoma marchalli*, a *Nomia* sp., *Amegilla calens*, *Anthophora xanthostoma*, and *Anthidium abdominale*.

Aquatic Invertebrates

When flooded, the MWS hosts an extremely important population of aquatic invertebrates, particularly crustaceans, e.g. Clam shrimps (*Concostracans*) Fairy Shrimps (*Anostracans*), *Copopods* and Seed shrimp (*Ostracods*) that provide a food source for many wetland birds that migrate to the MWS each year. The table below (Table 11) lists those species found in

the north basin of Sua Pan during a three year PhD study on the pan between 1998 and 2001 (McCulloch *et al*., 2007).

Table 11: Taxonomic species list of crustaceans and other small invertebrates found on Sua Pan between November 1999 and June 2001.

Class	Order	Species	Basin	Reference
Crustacean				
Branchiopoda	Anostraca	*Branchinella spinosa*	N,M,S	(Milne-Edwards 1840)
		Branchinella ornata	N,M,S	(Daday 1910)
	Spinicaudata	*Leptestheria striatoconcha*	N	(Barnard 1924)
	Anomopoda	*Moina belli*	N,M,S	(Gurney 1904)
		Daphnia barbata	N	(Weltner 1897)
Copepoda	Calanoida	*Lovenula africana*	N,M	(Daday 1908)
	Cyclopoida	*Metadiaptomus transvaalensis*	N	(Methuen 1910)
Ostracoda	Podocopida	*Limnocythere tudoranceai*	N,M,S	(Martens 1990)
		Sclerocypris exserta makarikarensis	N,M	(Martens 1988)
		Potamocypris	N	(Martens pers comm.)
		Plesiocypridopsis aldabrae	N	(Meisch 1988)
Others				
		Coryxid hemiptera of *Sigara* and *Notonecta* genus		
		Dytiscus species of beetle		
		Beetle larvae, *Cybister*		
		Dragonfly larvae, Libellulidae		
		Nematode worms		

Note: N, M and S represent the presence of species in the north, middle and south basins, respectively\

Source: McCulloch *et al*., 2007.

The dominant species of crustaceans include *Branchinella spinosa, Moina belli, Lovenula africana* and *Limnocythere tudoranceai* (McCulloch *et al*., 2007). Two of these: *B. spinosa* and *L. africana*, have not been found elsewhere in southern Africa, while others, *M. belli* and *L. tudoranceai* have been found in only a few temporary waters in Namibia. The ostracod *Sclerocypris exserta makarikarensis* is endemic to the Makgadikgadi Pans. McCulloch found a striking reduction in crustacean species richness, from 11 to 4, among the basins as salinity increased along a north–south gradient, and over time as the pan dried up. This was most noticeable in the north basin, where the number of species was reduced from 11 to 3 during a two year flood period.

Some species tolerated large variations in salinity and pH. These species-specific salinity tolerances among the crustacean community highlight the potential for their use as bio-indicators in identifying changes in the surface water chemistry of Sua Pan and other flood waters around the MWS.

Crustacean biomass and production rates among the crustacean community were among the highest of any tropical African lake and contributes greatly to the success of their

consumer species, including Greater Flamingo, Chestnut-banded plovers, Spoonbills, Avocets, Black-winged Pratincoles and Godwits.

3.4 Bird Inventory and Species Status for the Makgadikgadi Wetlands

An important wetland, worthy of Ramsar designation, may be designated so on the basis of its importance to birdlife: if it supports >20,000 waterbirds on a regular basis, or if a high proportion of the entire global population (>1%) of a, or a number of waterbird species regularly occurs there. The Makgadikgadi Wetland System (MWS) satisfies both these key birdlife a criterion as a RAMSAR site and, for similar reasons, has been designated as an IBA, criteria A1 by Birdlife Botswana (Tyler 2001).

When flooded, the Makgadikgadi Wetlands System (MWS) attracts a wide variety of waterbirds, including several Globally Threatened Birds, e.g. Wattled Crane and Lesser Flamingo. Many waterbird species migrate to the MWS each year owing to an abundance of food and owing to its importance in providing ideal breeding sites for colonies of Greater and Lesser Flamingos, Great White Pelicans, as well as Chestnut-banded Plovers. During the wet season (the austral summer), many thousands of Palearctic migrant waders also migrate to its shores to take advantage of an abundance of food (Tyler, 2001).

The surrounding grasslands and woodlands of the MWS also support important populations of terrestrial species, including Kori Bustard, Southern Ground Hornbill, Ostrich, Secretary bird, Red-necked Falcon, Bronze-winged Courser and Orange-river Francolin (Tyler and Bishop 1998). Indeed, Nxai Pan is one of the main strongholds of the Kori Bustard, where its population density is among the highest found anywhere. Indeed, Tyler (2005) suggested that Kori Bustards in Botswana have retreated into protected areas like Nxai Pan to escape disturbance and hunting.

A recent species list, compiled by McCulloch & Tyler, records a total of three hundred and eighty five bird species in the MWS. One hundred and four of these species are waterbird species, and thirty two of these waterbird species breed in the MWS. The list also indicates those species that are rare: thirty nine species are listed as B rarities (uncommon to rare) and seven are listed as A rarities (very rare), The MWS supports a considerable number of threatened species too: seven species are listed as 'Vulnerable' and eleven are listed as 'Near Threatened' in the IUCN Red Data List (IUCN Red Data List Website; 2009). In an attempt to help focus/prioritise bird related research and conservation efforts, Birdlife Botswana has identifying twenty species of national concern, requiring special attention because of their population status and/or the importance of the Botswana in sustaining the total global population. The MWS supports nineteen of these species (Table 12). These and other bird groups are also listed as protected under the Wildlife and National Park Act, 2002.

3.4.1 Waterbird numbers and trends in the MWS

Large numbers of birds migrate to the pans each year, with numbers varying from year to year depending on the extent of annual flooding and corresponding habitat availability. Tyler (2001) provides a review of a decade of bi-annual waterbird counts (between 1991 and 2000), conducted in January and July each year at wetlands throughout Botswana for Wetlands International. This report includes quantitative data for each species from site surveys recorded from seven areas around the MWS: Mea Pan, Mokobilo Pan, Tlapana Pan, Nata Sanctuary, Nata-Gweta small pans, Rysana Pan, and Sua Spit Conservancy. A summary

of the annual average number of birds recorded regularly during this period highlights the importance of this wetland to waterbirds.

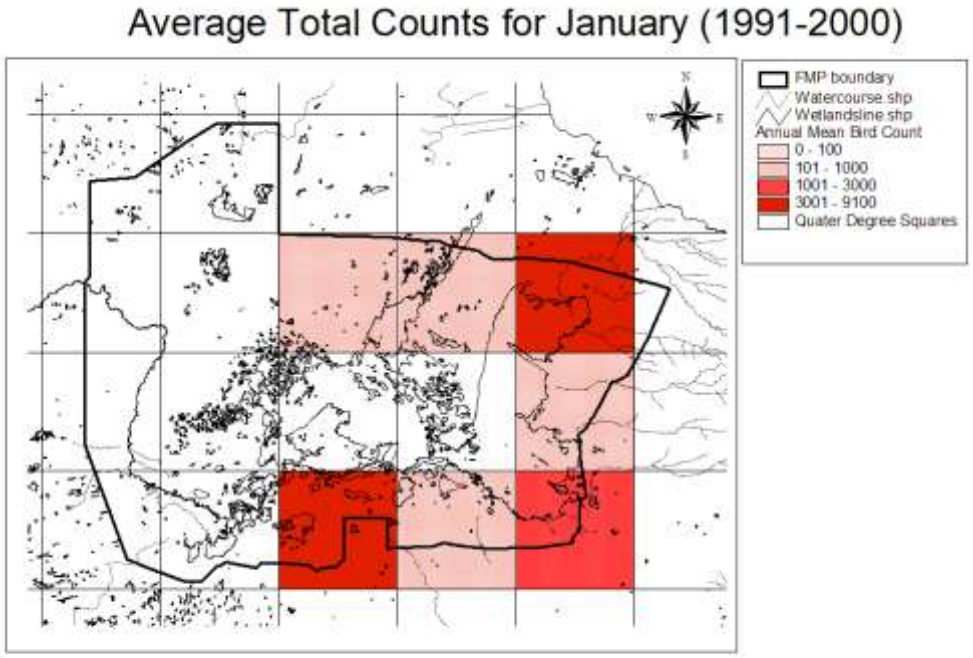
Average total counts for July at each site were generally and, on some occasions, significantly higher than counts in January owing to decreased dispersal and corresponding higher population densities at each site as the extent of the flood area diminished during the dry season. Those species most numerous in the area include flamingo, teals, plovers, sandpipers, Ruffs, pratincoles, avocets, pelicans and Black-winged stilts.

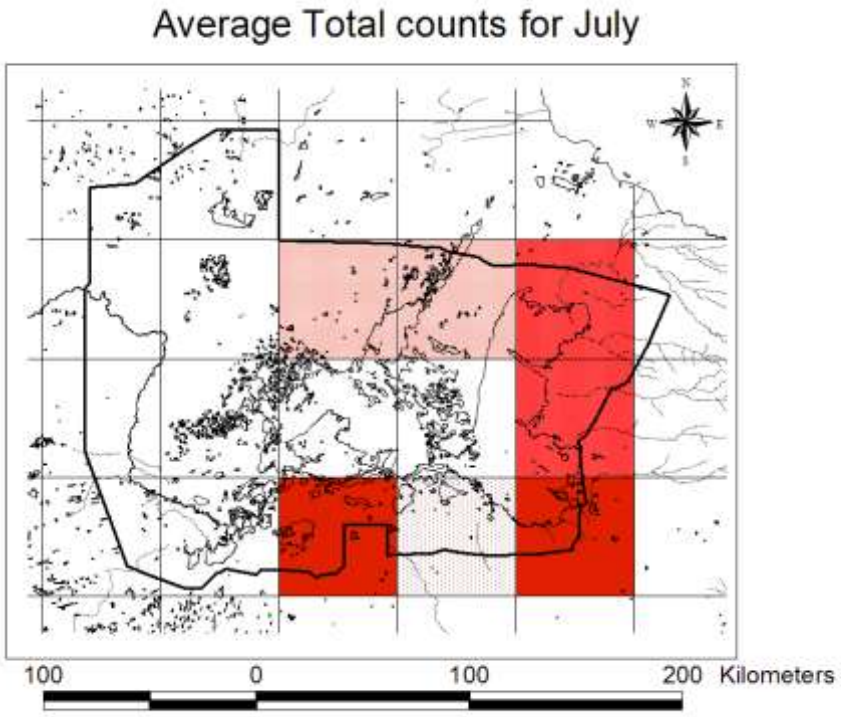
A spatial representation of the mean annual total January and July waterbird counts for each site, illustrated using equivalent quarter degree squares for their respective areas, highlights the areas where the largest numbers of waterbirds are counted on a regular basis (Figure 24). Large numbers of birds were regularly counted at Nata Sanctuary, Mea Pan, the Sua spit area and at Rysana Pan, with mean annual total numbers recorded during the January counts of, respectively, 9,075, 1,858, 973 and 5,110. Mean total numbers recorded for the same sites during the July counts were, respectively, 1,923, 3,362, 2,365 and 8,389. There were, however, large variations in annual total counts at each site. Fluctuations in the extent of flood/habitat area impact both the number of birds arriving each year and the degree of concentration or dispersal of the birds throughout the MWS. Extreme variation in annual flooding, among and within seasons, therefore, makes it very difficult to identify trends in the waterbird populations. More in-depth statistical analysis of these bi-annual count data sets may, however, shed more light on the impact of flooding on population numbers.

Assuming the annual mean total counts for each site represent the annual mean population for the area covered by each, respective, quarter degree square, which is a gross underestimate in many cases, the mean annual population estimates per quarter degree square for January and July are, respectively, 2,578 and 2,539. This equates to a mean annual total count for the MWS for the January and July counts of, respectively, 30,934 and 30,473 waterbirds, assuming that the wetland habitat of the MWS is approximately covered by a total of twelve QDS.

Bi-annual counts have been sparse since January 2001, by comparison, and include the drought years of 2002 and 2003, when the pan was completely dry for much of the year and very few birds were counted. A record high during this period of 203,577 birds was, however, counted in July 2001, at the end of a two-year continuous flood period, when total numbers were confined to the last remaining floodwater in the Nata Sanctuary. Most of these birds comprised flamingos (170,000 Lesser Flamingo and 30,000 Greater Flamingo) counted by McCulloch (Simmons *et al*., 2001, McCulloch, 2003) during an aerial survey of the species that month. It also included 1,700 Great White Pelicans.

Figure 24: Waterbird densities at seven sites in the MWS





These are taken from the mean annual total counted at each site in January and July each year, between 1991-2000 (Tyler, 2001). Spatial representation is given using the equivalent Quarter degree squares for the area around each site.

3.4.2 Game bird numbers and trends in the MWS

Detailed analysis of distribution and status of terrestrial game birds in Botswana has not been done. A review of the literature on game birds in Botswana reveals scant records with the exception of the work conducted by L. Rutina (1995). Rutina reviews the status of three terrestrial game bird orders: *Gruiformes* (bustards, korhaan and buttonquails), *Galliformes* (francolins, guinea fowl and quail) and *Pterocliformes* in three land use and four vegetation types in Botswana and provides estimates of breeding success in the Makgadikgadi system. His findings indicate that *Gruiformes* were restricted to the grasslands with the exception of the Korhaan, which preferred the Northern Kalahari tree and shrub savanna. All of the *Gruiformes* observed were restricted to protected and semi-protected areas. *Galliformes* were mostly confined to the riparian acacia woodlands along the Boteti, in the woodlands of the Kalahari sands and throughout protected areas. No correlations between for land use or vegetation type and *Pterocliformes* distribution were identified in the study.

Galliformes and *Gruiformes* appeared to breed well in the study area, while *Pterocliformes* appeared to experience low breeding success in the study area. The author concluded that habitat destruction and excessive land use practices accounted for less game bird numbers in the community areas. Monitoring of terrestrial game bird breeding success, distribution, habitat preference and species abundance was recommended.

In his study, Rutina (1995) also recommended that a review of bag limits and breeding season hunting bans per species should be considered essential. A number of game birds are available for citizen and non-citizen hunting by license access. Bag limits are generous although not based on any ecological analysis of sustainable off take. According to some preliminary analysis of issued hunting licence records, game birds provide and important source of wildlife utilization with preference in descending order of francolin, guinea fowls, geese and ducks (Rutina, 1995).

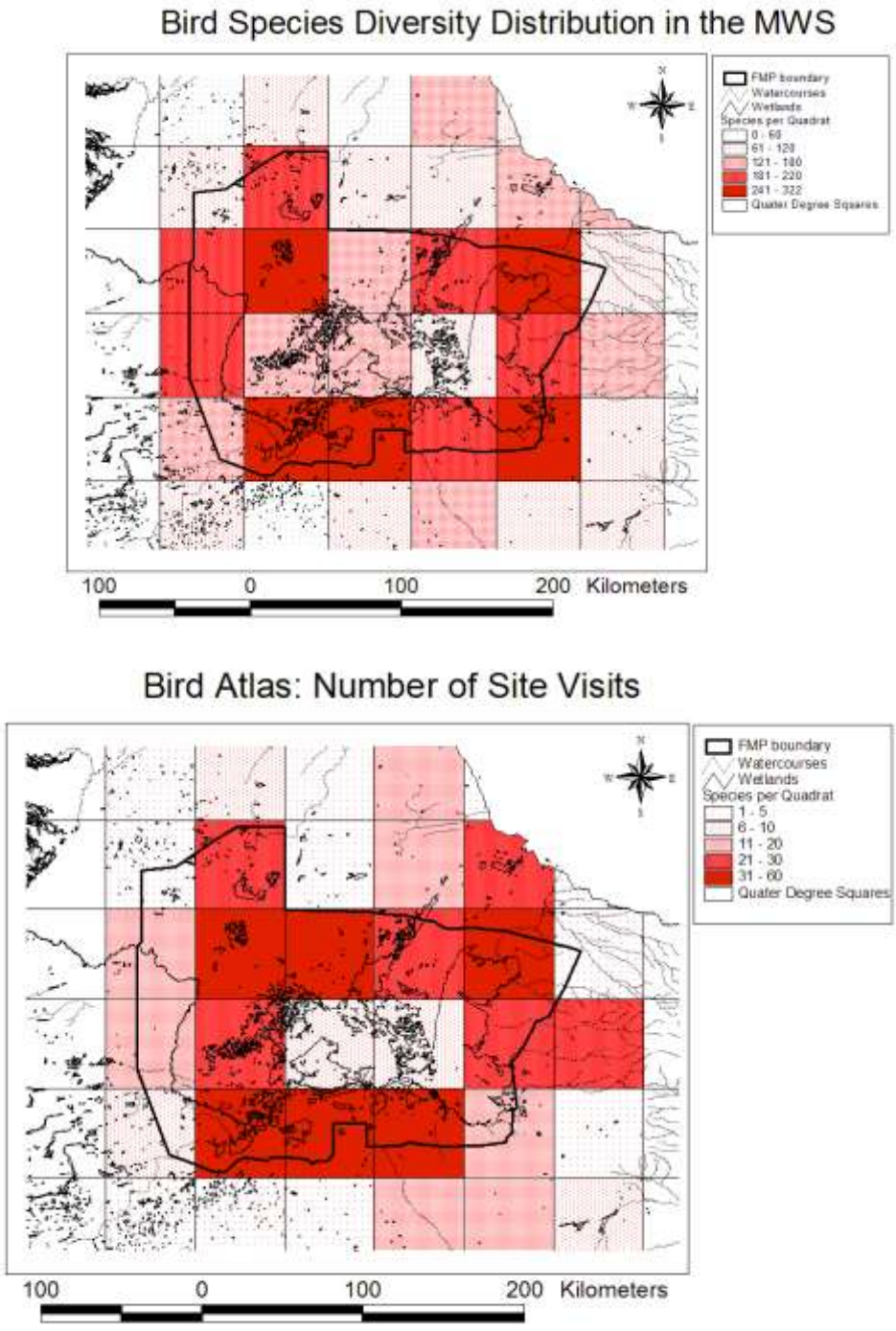
3.4.3 Bird species diversity in MWS

Overall, the MWS supports a large number of species, some 385 species in total. Species diversity does, however, vary considerably within the MWS. The avifauna of Botswana is relatively well known due to an atlas project in 1980–90 organised by Huw Penry established the distribution of birds' species in Botswana. Penry subsequently produced the Bird Atlas of Botswana with distribution maps based on 30' × 30' squares or quarter degree square (QDS) (Penry, 1994). Spatial representation of species diversity distribution in the MWS, adapted from the Bird Atlas of Botswana, illustrate the variation and highlight areas of importance for maintaining species diversity (Figure 25). For qualitative purposes, this data is coupled with the number of sites visits to each area/QDS that was made in order to calculate total respective species diversity Figures.

Most of the diversity hotspots for birdlife within the MWS occur on and around the major water bodies, e.g. Nata River Delta and the north basin of Sua Pan, the Boteti River, Lake Xau, the lower Boteti and Mopipi's surrounding pans, Rysana Pan and nearby pans, and Mea Pan and its surrounding pans, where the number of species recorded were, respectively, 322, 242, 271, 294, and 243. High species diversity at these sites could be attributed to wetland bird species augmenting the large numbers of woodland and grassland species adjacent to them, particularly where wetland occurs adjacent to a diverse number of

terrestrial vegetative habitats, e.g. the diverse woodland and nearby grassland habitats on the edge of the Nata and Boteti Rivers.

Figure 25: Spatial distribution maps of species diversity per quarter degree square, and the corresponding site visits per quadrate



Source: (Penry, 1994).

Table 12: List of threatened birdlife and rare species known to utilise the Makgadikgadi wetlands

Species, New names: Roberts 7	Latin name	Threatened (IUCN List)	Botswana A & B rarities	Waterbirds. Spp breeding in MWS (Br)	Vagrants
Great Crested Grebe	*Podiceps cristatus*		B	x	
Black-necked Grebe	*Podiceps nigricollis*		B	x, Br	
Yellow-billed Egret	*Egretta intermedia*		B	x	
Black Heron#	*Egretta ardesiaca*		B	x	
Slaty Egret	*Egretta vinaceigula*	VU	B	x	x
White-backed Night-Heron	*Gorsachius leuconotus*		B	x	
Little Bittern	*Ixobrychus minutus*		B	x	
Black Stork	*Ciconia nigra*		B	x	
Woolly-necked Stork	*Ciconia episcopus*		B	x	
Saddle-billed Stork	*Ephippiorhynchus senegalensis*		B	x	
Lesser Flamingo	*Phoenicopnaias minor*	NT	B	x, Br	
Fulvous Duck	*Dendrocygna bicolor*		B	x	
White-backed Duck	*Thalassornis leuconotus*		B	x	
Maccoa Duck	*Oxyura maccoa*	NT	B	x	x
Egyptian Vulture	*Neophron percnopterus*		A		
Hooded Vulture	*Necrosyrtes monachus*		B		
Cape Vulture	*Gyps coprotheres*	VU	B		
White-backed Vulture	*Gyps africanus*	NT			
Lappet-faced Vulture	*Aegypius tracheliotus*	VU			
White-headed Vulture	*Trigonoceps occipitalis*	VU	B		
Steppe Eagle	*Aquila nipalensis*		B		
Lesser Spotted Eagle	*Aquila pomarina*		B		
Booted Eagle	*Aquila pennatus*		B		
Ayres's Hawk Eagle	*Aquila ayresii*		B		
Black Sparrowhawk	*Accipiter melanoleucus*		B		
Western Marsh-Harrier	*Circus aeruginosus*		B		
African Marsh-Harrier	*Circus ranivorous*		B	x	
Montagu's Harrier	*Circus pygargus*		B		
Pallid Harrier	*Circus macrourus*	NT	B		
Osprey	*Pandion haliaetus*		B	x	
Peregrine Falcon	*Falco peregrinus*		B		
Eurasian Hobby	*Falco subbuteo*		B		x
Red-footed Falcon	*Falco vespertinus*	NT	B		
Amur Falcon	*Falco amurensis*		B		x
Lesser Kestrel	*Falco naumanni*	VU	B		
Wattled Crane	*Bugeranus carunculatus*	VU	B	x	
Blue Crane	*Anthropoides paradiseus*	VU	A		
Grey Crowned Crane	*Balearica regulorum*		B		
African Rail	*Rallus caerulescens*		B	x	
African Crake	*Crecopsis egregia*		B	x	
Spotted Crake	*Prozana prozana*		B	x	x
Baillon's Crake	*Prozana pusilla*		A	x	x
Allen's Gallinule	*Porphyrio alleni*		B	x	x

Denham's Bustard	*Neotis denhami*	NT	B		x
White-fronted Plover	*Charadrius marginatus*		B	x	
Chestnut-banded Plover	*Charadrius pallidus*	NT	B	x, Br	
Grey (Black-bellied) Plover	*Pluvialis sqautarola*		B	x	x
Ruddy Turnstone	*Arenaria interpres*		B	x	x
Terek Sandpiper	*Xenus cinereus*		A	x	x
Common Redshank	*Tringa totanus*		A		
Sanderling	*Calidris alba*		B	x	
Black-tailed Godwit	*Limosa limosa*	NT	B	x	
Bar-tailed Godwit	*Limosa lapponica*		A		
Eurasian Curlew	*Numenius arquata*	NT	B	x	
Common Whimbrel	*Numenius phaopus*		B	x	
Red Phalarope	*Phalarodus fulicarius*		A		x
Black-winged Pratincole	*Glareola nordmanni*	NT	B	x	
Lesser Black-backed Gull	*Larus fuscus*		A		
Caspian Tern	*Sterna caspia*		B	x, Br	
Common Cuckoo	*Cuculus canorus*		B		
African Black Swift	*Apus barbatus*		B		
Giant Kingfisher	*Megaceryle maximus*		B	x	
Grey-headed Kingfisher	*Halcyon leucocephala*		B		
European Roller	*Coracias garrulus*	NT			
Pearl-breasted Swallow	*Hirundo dimidiata*		B		
Garden Warbler	*Sylvia borin*		B		

3.4.4 Breeding by waterbirds in the MWS

The wetlands of the Makgadikgadi are not only an important feeding ground for thousands of waterbirds; they also provide key breeding sites for some important species where, occasionally, almost the entire regional population of these species breed. Of special interest are the breeding sites for some of these threatened and/or protected species. The Nata River delta is lined with a riparian woodland dominated by *Acacia kirkii* and, during exceptional flood years (every 3-5 years), these trees provide nesting platforms for numerous waterbirds including Grey and Goliath Herons, Pink-backed Pelicans, Reed and White-breasted cormorants, Sacred and Glossy ibises, and Cattle egrets (Ken Oak pers comms, Tim Liversedge pers comms, McCulloch). Nata River flows onto Sua Pan at Nata Sanctuary, and as it does so it deposits sediment that forms sand bars at the mouths of its distributaries. During years of exceptional floods, Great White Pelicans gather here in large numbers, scrape rudimentary nests in the bare ground and raise their chicks in relative safety from terrestrial predators. Indeed, it is one of only a handful of recorded breeding sites in southern Africa (McCulloch & Hancock, 2008). McCulloch counted 1,700 pelicans breeding here in 2001, and over 3,200 in January 2007 (McCulloch & Hancock, 2008).

Other waterbird species, most notably Spoonbills and Avocets have also been observed nesting on small islands and sand spits in the middle of Sua Pan. Caspian Terns occasionally breed successfully on small protruding calcrete rocks and brine well point platforms in the Botswana Ash concession area during exceptional flooding. Sua Pan is also one of only four sites in the whole of Africa where the Lesser Flamingo consistently breeds successfully in large numbers. It does so in the south basin of Sua Pan, alongside Greater Flamingos, and together the colonies can contain in excess of 150,000 birds in years of exceptional rainfall (McCulloch & Irvine, 2004, McCulloch *et al*., in press). This is one of the reasons why so many

flamingos migrate to Sua Pan. It is for this reason, that the Department of Wildlife and National Parks have initiated the setting up of a Flamingo sanctuary in the south basin of Sua Pan in order to protect the flamingo breeding colonies and their chicks. Flamingos are, in fact, the only waterbird species in the MWS, for which there are consistent long-term breeding records that allow us to identify when and how often they breed, what determines good breeding conditions, and how successful are they when they breed.

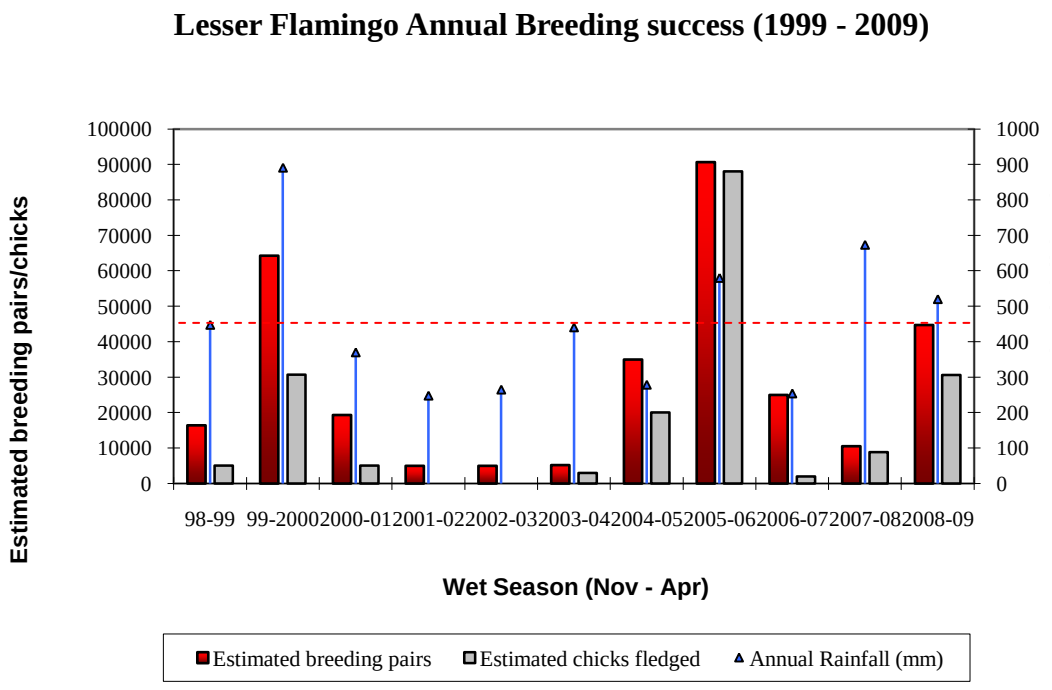
Flamingo breeding success on Sua Pan: a decade of monitoring

The flamingo research project on Sua Pan, coordinated by McCulloch, has been conducting annual surveys of the Flamingo breeding sites on Sua Pan for over ten years now and the corresponding breeding records for this period provide a very valuable monitoring data set for Greater and Lesser flamingo: both important indicator species for the MWS, targeted as such by Birdlife Botswana for the Makgadikgadi IBA site. Breeding success during annual monitoring is quantified by estimating two parameters:

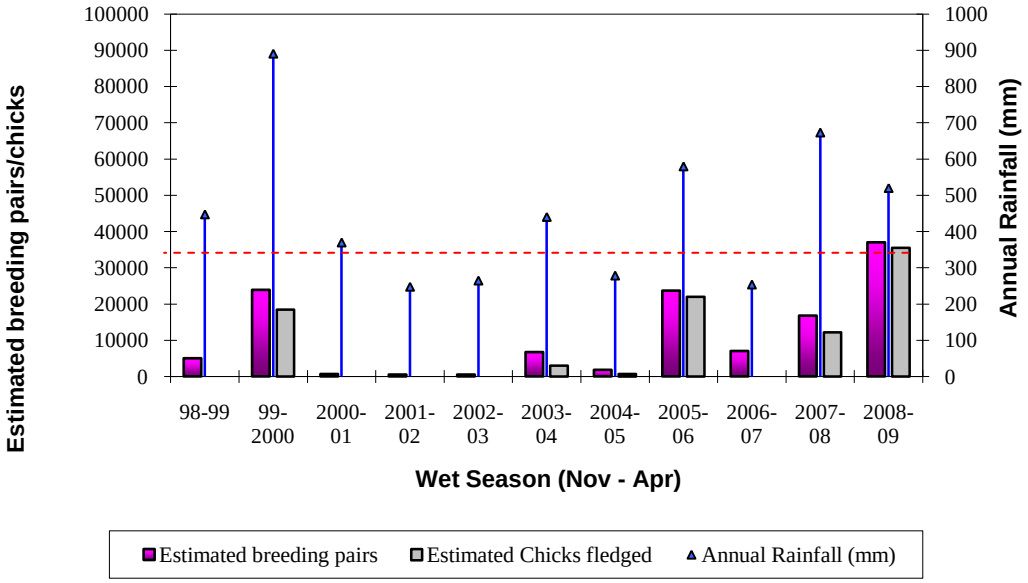
1. the annual total number of breeding pairs, estimated by summing the total number of active nests and the number of chicks in the nearby crèches; and
2. the annual number of chicks fledged, estimated from the total number of chicks counted in the crèches.

Large variation in annual breeding attempts and success for both species was observed, and, in general, was dependent upon good rainfall (Figure 26). Although breeding may occur on an annual basis, the success of the chicks fledging depends on the period of flooding on the pan and this closely correlates with rainfall. Estimates for the number of fledged chicks each year assumed that all those chicks counted in the crèches fledged and made it to the feeding grounds. This number, of course, although hard to quantify varies from year to year according to flooding in the south basin of Sua Pan and the associated variation in predator pressure and mortalities as a result of physiological stress. McCulloch & Irvine, (2004) estimated that fledging success rate was very high during exceptional rainfall years (like the year 2000) owing to high floods providing a predator free refuge for the chicks during the three-month period before they fledged.

Figure 26: Annual estimated breeding numbers (nesting pairs) and success (chicks fledged) for Lesser and Greater Flamingo during an eleven year period, between 1999 and 2009.



Greater Flamingo Annual Breeding success (1999 - 2009)



Source: (McCulloch et al., in press).

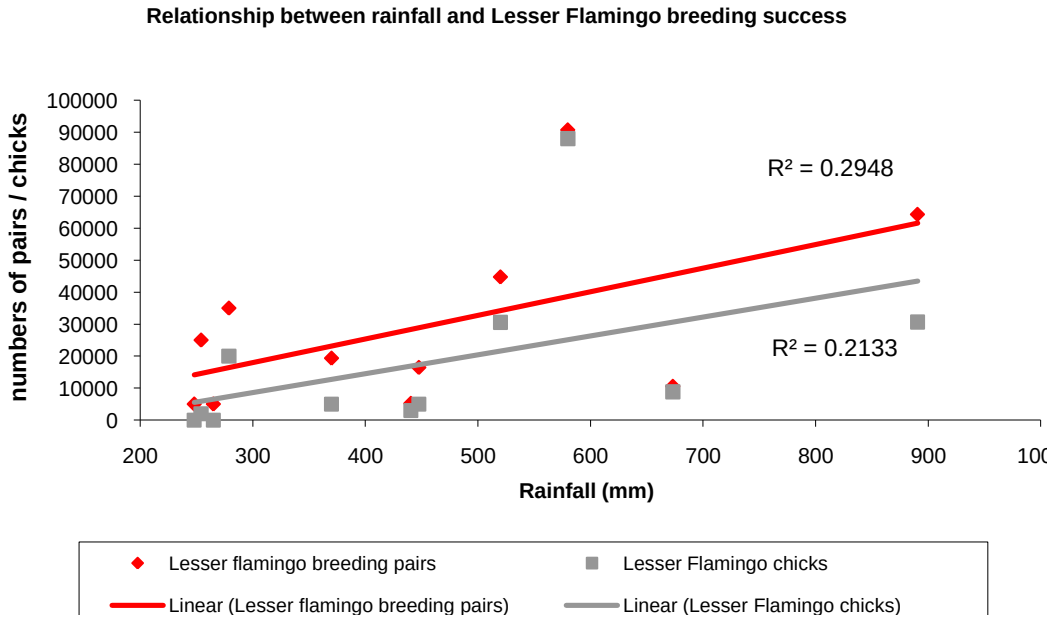
On closer analysis of the data, there appears to be a rainfall threshold of approximately 450mm (the annual average rainfall for Sua Pan), below which the pan dries up before the chicks fledge and dramatically reduces overall breeding success (Figure 27) (McCulloch, in prep). There are, however, some exceptions to this rule when extremes in flooding (amount and period) account for nest flooding and egg loss in some years, as was the case in 2000, and success during low rainfall years that experience continuous flooding from the previous wet season rainfall, as was the case in the 2004-05 wet season, when 278mm fell, but the pan still held flood water from heavy rains the previous March (McCulloch et al. in press). Low numbers of breeding Lesser Flamingos during the 2007-08 breeding season, when breeding conditions were good, may have been attributed to the construction of a new breeding island on Kamfers Dam, where many of the breeding population from Sua Pan spend the non-breeding season and where over 10,000 breeding pairs nested for the first time that year.

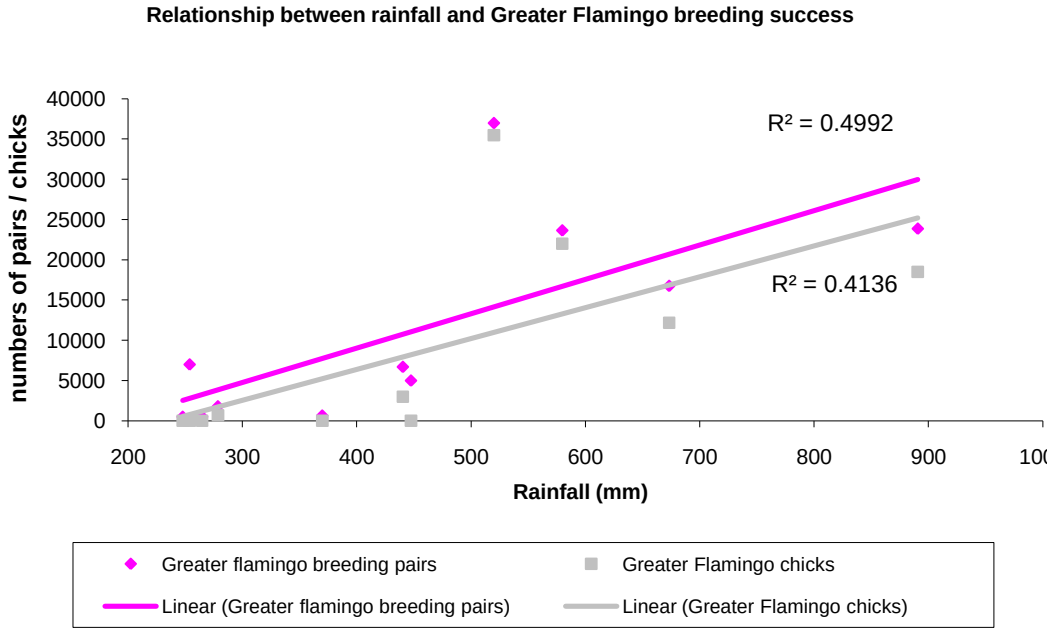
No counts were conducted during the drought years of 2002 and 2003 and so chick estimates for these years are absent. Breeding was attempted, but the pan dried up completely in February/March of each season, forcing the adults to migrate elsewhere and abandoning young unfledged chicks with little chance of survival.

Also evident from the graphs is the difference in breeding attempt frequency and numbers, when comparing both species breeding success. Greater Flamingo prefer to breed on small calcrete islands and sand spits in the middle of Sua Pan, which only become suitable when they are surrounded by water during good rainfall years. Greater flamingos, therefore, tend to breed much better in high rainfall years and very little attempt is made during low rainfall years. As a result, their breeding success rate, measured by the average ratio of chicks raised per breeding attempt, is great than that of Lesser Flamingo, which exhibits a different breeding strategy, appearing to breed early every year, almost in anticipation of the rainfall

(McCulloch, in prep). Linear regression analysis of the data suggests a general positive relationship between annual rainfall and breeding success for both species. The relationship is, however, statistically more significant/stronger for Greater Flamingo as a result of their breeding strategies.

Figure 27: Linear regression relationships between rainfall and breeding success, quantified as both the number of pairs breeding and the number of chicks fledged, for Lesser and Greater Flamingo.





3.4.5 Bird Migration in the MWS

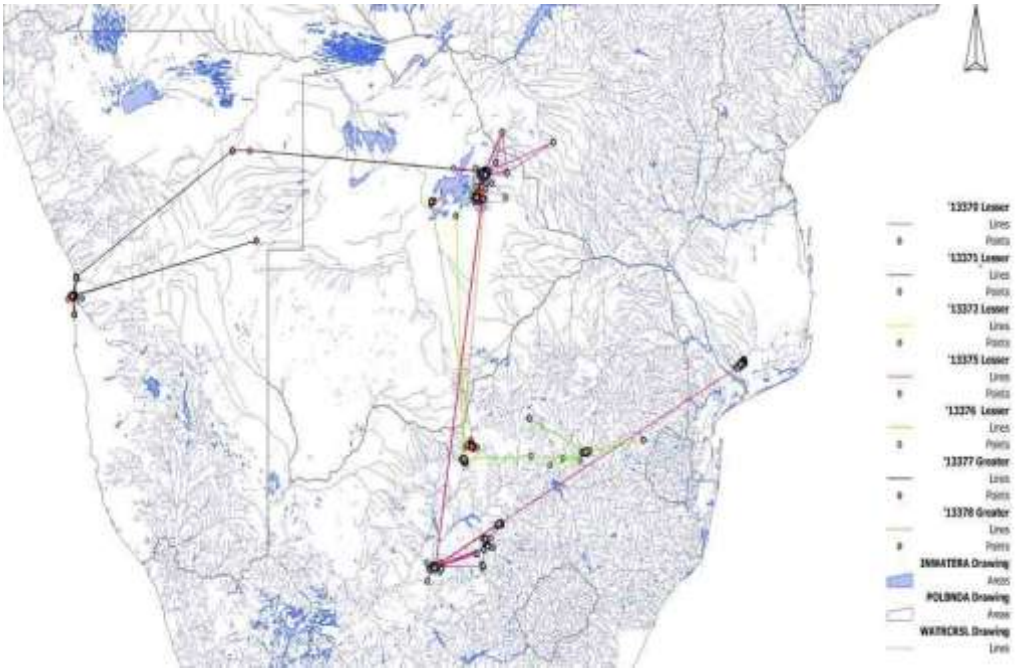
Little is known about the movement patterns and seasonal migration of the many waterbird species that visit Makgadikgadi. Some studies, conducted by the Max Plank Institute of ornithology, have identified some of the flyways followed by White Stork from their

breeding grounds in northern Europe (Max Plank Institute). Important regional movements and identification of wetland networks that linked to the MWS and are crucial for sustaining the regional populations of these birds, is however scanty.

In 2001, the first satellite tracking project on flamingos in Africa was carried out at Sua Pan in an attempt to find out where Greater and Lesser flamingos go after leaving Makgadikgadi (McCulloch *et al*., 2003). Of the 5 birds that were tracked leaving Makgadikgadi when the pans finally dried up, one of the Greater flamingos flew west to the coast of Namibia and the other south to a small wetland in South Africa (Figure 28). One bird provided reliable estimates of an approximate ground speed of 65 km/hr during its migration. The Lesser flamingos moved SE from Makgadikgadi to South Africa and Mozambique, with a maximum flight speed, over ground, of an estimated 60km/hr. Movement by both species was nocturnal, with flights between sites recorded only during transmissions at night.

This work shows that flamingos migrate from all over southern Africa to the Makgadikgadi, to breed. It also shows that, during the non-breeding season, movement is widely dispersed and nomadic among a network of wetlands around the sub-continent. Small wetlands, often unrecognised as important for conservation, provide valuable feeding sites and migration staging posts along flamingo migration routes. This highlights the need for the conservation of the network of small wetlands around southern Africa that are often under threat from anthropogenic activities in order to protect two high profile bird species in decline.

Figure 28: Movements of two Greater Flamingo and three Lesser Flamingo after leaving the MWS during a satellite tracking project in 2001 (McCulloch, 2003).



3.4.6 Species Accounts

The MWS supports populations of some important nationally and globally threatened and protected species and these deserve special attention. This list below includes some of these species, for which the MWS and its surrounding habitats play an important role in sustaining their national and global populations. The status, distributions, and threats of these species represent a good example of the main areas and issues of importance and conservation concerns for birdlife in the MWS. Accounts of these species in Hancock (2008) have been adapted below to include some additional data and distribution maps.

Lesser Flamingo Phoeniconaias minor (Geoffroy Saint-Hilaire, 1798): Near Threatened

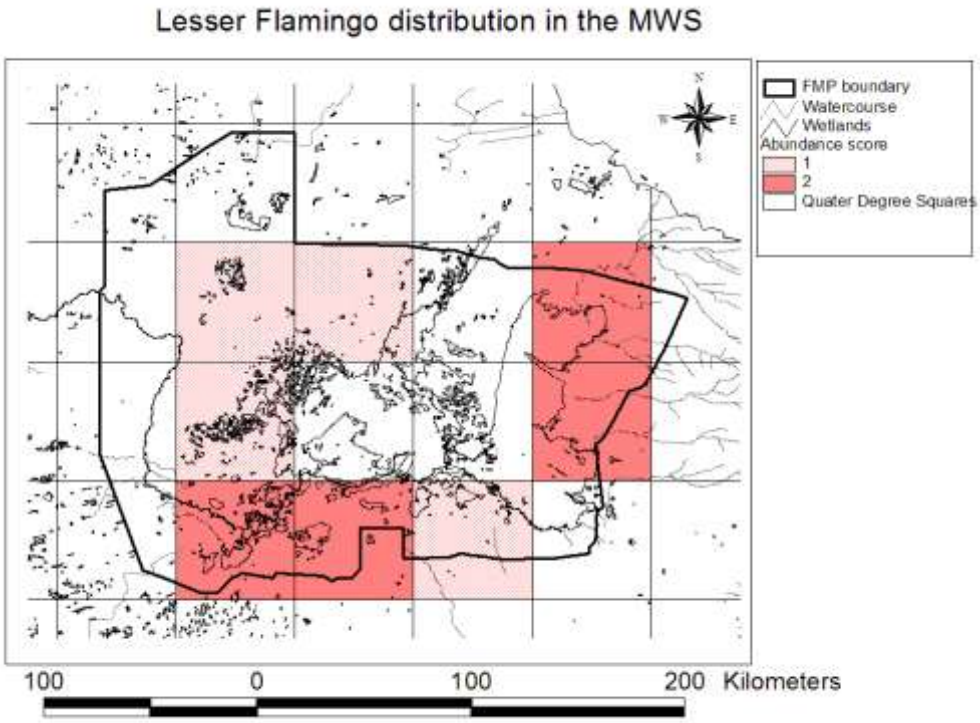
a. Status and distribution

Although the most numerous of the world's flamingos, the Lesser Flamingo is classified "Near Threatened" in the 2008 IUCN Red List of Threatened Species, listed in Columns A and B of the Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA) Action Plan, Appendix II of the Bonn Convention and Appendix II of the CITES convention, owing to unpredictable and sensitive breeding regime at only a few sites throughout their range (Brooks *et al*., 2007). Confirmed regular breeding is confined to just five sites: Makgadikgadi Pans in Botswana, Etosha Pan in Namibia, Lake Natron in Tanzania, and Zinzuwada and Purabcheria salt pans in India.

Four separate populations are recognised for conservation purposes: the Indian, East African, West African and southern African populations, although it is assumed that some interchanges probably occur among them. The population of southern Africa is estimated to be 55,000 - 65,000, where historical declines have been suggested (Simmons, 1996, Simmons *et al*., 2001), but are difficult to clarify owing to wide scale and frequent movements within, and quite possibly outside the sub-continent, and the associated difficulties in assessing long-term population trends (Brooks *et al.*, 2007).

The most important area for Lesser Flamingos in Botswana is the MWS, where large numbers feed and, in suitable years, breed in the south basin of Sua Pan (see McCulloch, 2003; McCulloch and Irvine, 2004; McCulloch *et al*., in press). The major feeding areas are in the north of Sua Pan, where some protection is provided by the Botswana Ash concession and the Nata Sanctuary, and in the main shallow flooded basins of Sua and Ntwetwe Pans, where the algae they eat grows in abundance. However, their distribution in the MWS is widespread, including many of the smaller pans. Indeed, historical records from the Bird Atlas of Botswana (Penry, 1994) indicate their common occurrence at a number of these smaller pans, while data for some of the basins in larger pans are absent owing to inaccessibility (Figure 29). According to the Atlas, abundance is indicated by numbers: 1 equates to its observation on 10% or less of visits to the area (sparse or rare), 2 equates to observations on 10.1 – 49.9% of visits (uncommon to common), and 3 means it was seen on 50% or more of the visits (very common).

Figure 29: Spatial distribution map of Lesser Flamingo in the MWS, adapted from the Botswana Bird Atlas



b. Ongoing monitoring

Total population counts were conducted by McCulloch in July 2001, when numbers of a large breeding population of approximately 120,000 individuals was augmented by tens of thousands of juveniles that were successfully raised during the previous breeding season, and the total population was estimated to exceed 170,000 birds (McCulloch 2003). In July 2008, the entire population was counted again by McCulloch as part of co-ordinated regional count by the regional Species Specialist Group (Hancock, 2008). A total of 77,491 Lesser Flamingos were counted on this occasion, again outnumbering the total estimate for Southern Africa (~65,000).

Monitoring of the Flamingo breeding colonies over the past eleven years has revealed a general correlation in breeding success with rainfall and a threshold of approximately 450mm, below which breeding was unsuccessful or poor (McCulloch *et al*., in press, and see the section on Waterbird Breeding in the MWS above).

c. Threats

The International Single Species Action Plan for the Conservation of the Lesser Flamingo, compiled by Childress *et al*., (2007) makes the following generalisations about threats to the species across its range:

"*… the most critical threat to the survival of the Lesser Flamingo (a factor causing or likely to cause very rapid declines) is the loss and/or the degradation of its specialised habitat through altered hydrology and water quality*".

Threats of high importance were determined to include poisoning (particularly by cyanobacteria toxins), diseases and the disruption of its few breeding colonies by human

activities (particularly from nearby settlements). All other threats, including human disturbance of non-breeding sites, collision with man-made structures, predation, competition with other species for food and breeding sites, harvesting of eggs and live birds were perceived as being threats of local importance.

Tyler and Bishop (1998) list several threats specific to the Makgadikgadi Important Bird Areas, and McCulloch *et al*. (2007) highlight those that are still applicable to the Lesser Flamingo in particular:

- Disturbance from tourist activities e.g. motorbike safaris;
- Veterinary cordon fences protruding onto the Pan and overhead powerlines near the pan, which flamingos collide into at night;
- A soda ash factory operates on the northeast edge of Sua Pan and there is concern about the effect on breeding flamingos of abstraction of water from the pans by the soda ash company; and
- Waste disposal by the company may also be a problem if access by Pied Crows and Marabou Storks to rubbish dumps is allowed; proliferation of these species could result in flamingo egg depredation at the breeding site.

d) Conservation action

The International Single Species Action Plan for the Conservation of the Lesser Flamingo (Childress *et al*., 2007) has not been 'customised' for Botswana, and this is an important step in detailing priority conservation actions for the species. The International Action Plan provides detailed guidelines for conservation actions applicable to range states, including Botswana, and these need to be tabulated in a National Action Plan to inform priorities for the near future. The International Action Plan needs to be 'customised' for Botswana, with buy-in from all relevant stakeholders.

A huge step in the conservation of the species in Botswana was the recent establishment of a flamingo sanctuary in the south basin of Sua Pan to protect the breeding colonies and their chicks. Part of the process, initiated by the DWNP, was consultations and with the communities and other stakeholders and a management plan for the area, to outline the management and regulations of the area, is planned for the very near future.

Greater Flamingo Phoenicopterus ruber: Nationally Protected

a. Status and distribution

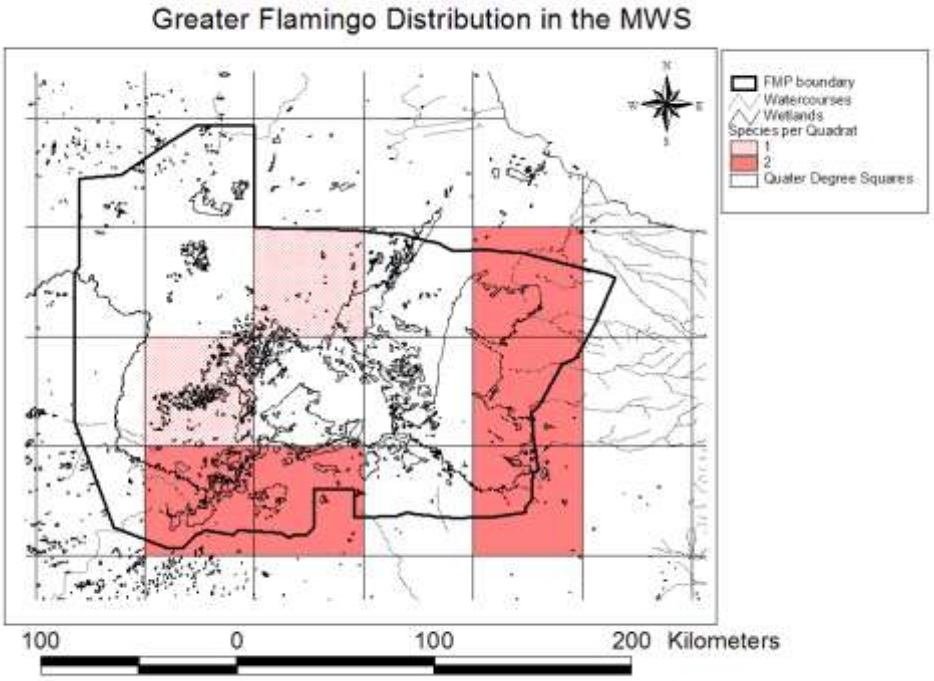
Although not listed as threatened in the IUCN Red Data List, Greater Flamingo are considered near threatened throughout southern Africa, and vulnerable in Namibia owing primarily to the lack of breeding sites and the vulnerability of breeding to both natural and anthropogenic disturbance (Brook, 1984; Simmons, 1996; Anderson, 2000a; b). Simmons (1996; 2000) has suggested that a lack of successful breeding at the large wetland sites of Etosha Pan in Namibia and Sua pan in Botswana may have caused greater than a 30% decline of flamingo numbers in two decades, from 165 000 estimated in 1975 (Kahl 1975) to 115 000 birds in 2001 (Simmons et al 2001; Simmons, 1996). Since that assessment Botswana birds have bred more frequently (McCulloch and Irvine 2004), Etosha birds have bred successfully twice (2000 and 2004) since 1996, non-breeding populations at Kamfers Dam have increased (Anderson 2000c), and southern African populations have stabilised at about 115 000 birds present day (Simmons *et al.,* 2001).

The Greater Flamingo prefers deeper less saline habitat than Lesser Flamingo where, like many waders found in similar habitat, it filters crustaceans such as fairy shrimps (e.g. Branchinella spp) and other small invertebrates like brine flies (Ephydra spp.) from the water column and mud surface (Berry, 1972, Anderson, 2000b, McCulloch, 2003). The MWS provides plenty of deeper water habitats on Sua Pan and some of the deeper outlying pans surrounding it and Ntwetwe pan, and historical observations (Penry, 1994) have, indeed, identified it occurring most frequently in these areas (Figure 30).

b. Ongoing monitoring

Total population counts were conducted in July 2001, when numbers recorded exceeded 30,000 individuals (Simmons *et al*., 2001; McCulloch 2003). In July 2008, the entire population was counted again by McCulloch as part of co-ordinated regional count by the regional Species Specialist Group. A total of 14,800 Greater Flamingos were counted on this occasion. Annual monitoring of the breeding colonies over the past eleven years have, however, resulted in estimated numbers of breeding adults that far exceed population counts: approximately 48,000 breeding adults in 2000 and 2006, and 80,000 breeding pairs in 2009, suggesting that the MWS, during good rainfall years, is the prime breeding site for the regions total population (McCulloch *et al*., in press).

Figure 30: Spatial distribution map of Greater Flamingo in the MWS



Monitoring of the Flamingo breeding colonies over the past eleven years has revealed a general correlation in breeding success with rainfall and a threshold of approximately 450mm, below which breeding was unsuccessful or poor (McCulloch et al., in press, and see the section on Breeding of Waterbirds in the MWS above).

c. Threats

Generalisations about the main threats to the species across its range are similar to those of the Lesser Flamingo, i.e. the loss and/or the degradation of its specialised habitat through altered hydrology and water quality. Other threats include disruption of its few breeding colonies by human activities, collision with man-made structures, predation, competition with other species for food and breeding sites, harvesting of eggs and live birds.

Tyler and Bishop (1998) list several threats specific to the Makgadikgadi IBAs, and McCulloch *et al*. (2007) highlights those that are still applicable to the Greater Flamingo in particular:

- Disturbance from tourist activities e.g. motorbike safaris;
- Veterinary cordon fences protruding onto the Pan and overhead powerlines near the pan, which flamingos collide into at night;
- A soda ash factory operates on the northeast edge of Sua Pan and there is concern about the effect on breeding flamingos of abstraction of water from the pans by the soda ash company;
- Waste disposal by the company may also be a problem if access by Pied Crows and Marabou Storks to rubbish dumps is allowed; proliferation of these species could result in flamingo egg depredation at the breeding site.

d. Conservation action

The International Single Species Action Plan for the Conservation of the Lesser Flamingo provides detailed guidelines for conservation actions applicable to Lesser Flamingo and

many of these can also be applied to Greater Flamingo, as they occupy very similar habitat and breed near or at the same colonies. These actions need to be tabulated in a national Action Plan to inform priorities for the near future.

A huge step in the conservation of the species in Botswana was the recent establishment of a flamingo sanctuary in the south basin of Sua Pan to protect the breeding colonies and their chicks. Part of the process, initiated by the DWNP, was consultations and with the communities and other stakeholders and a management plan for the area, to outline the management and regulations of the area, is planned for the very near future.

Wattled Crane Bugeranus carunculatu: Vulnerable

a. Status and distribution

The numbers and distribution of Wattled Cranes in Botswana is relatively well known in the Okavango Delta due to comprehensive, systematic aerial surveys by BirdLife Botswana and the Department of Wildlife and National Parks in 2001, 2002 and 2003. These surveys consistently showed a population of approximately 1,300 individuals and supporting the largest single population of Wattled Cranes remaining in the world. While the Okavango Delta is a key feeding and breeding habitat for Wattled Cranes, they do disperse from this stronghold to other key areas during the summer months. Hancock and Maude (2006) have documented these areas, mostly ephemeral wetlands within Botswana and the Makgadikgadi one of the most important of these sites.

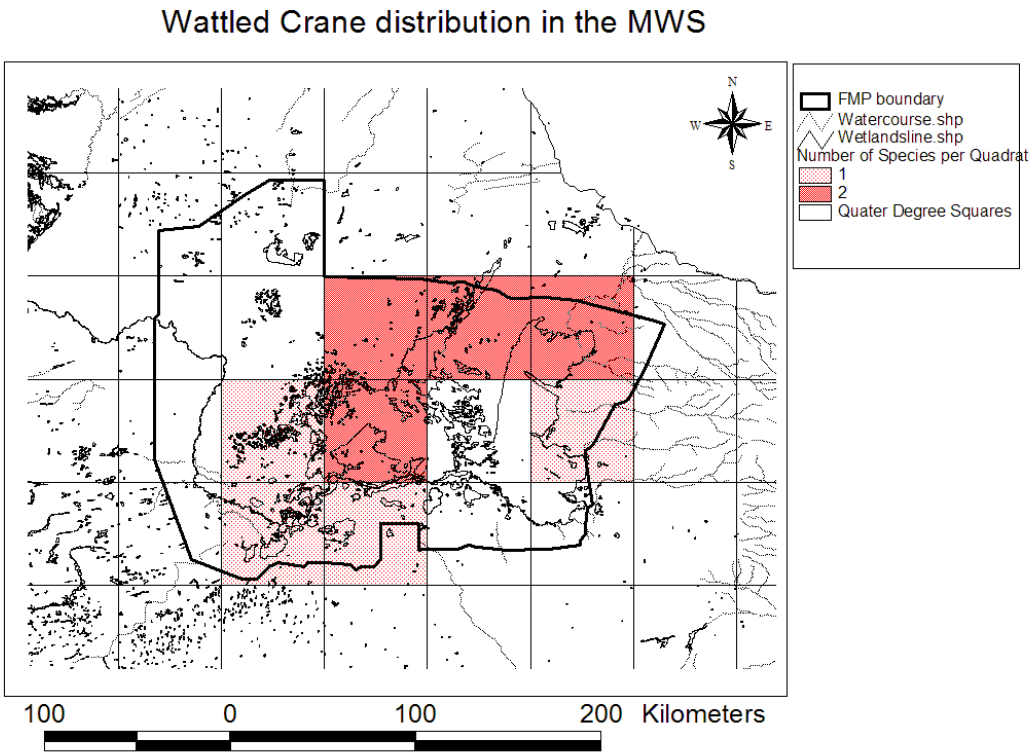
b. Ongoing monitoring

The Botswana Bird Atlas recorded a number of sitings in some key areas of the Makgadikgadi, mainly the seasonally flooded grasslands and pans on the periphery of the two main pans: Sua and Ntwetwe Pans. They have been seen here feeding in flooded grasslands and roosting on pans near Jacks Camp and on Mompswe Pan in large numbers, sometimes exceeding 90 individuals (Hancock and Maude, 2006).

Figure 31 indicates the spatial distribution of the Wattled Cranes in the MFMP area (Penry, 1994). Abundance is indicated by numbers according to the Atlas: 1 equates to its observation on 10% or less of the visits (sparse or rare), 2 equates to observations on 10.1 – 49.9% of visits (uncommon to common), and 3 means it was seen on 50% or more of the visits (very common).

Wattled Crane Action Plan (Motsumi et al., 2003). In many cases, there is a paucity of information about the threats – however, hydrological changes that in any way diminish the floodplains that are key feeding and breeding areas in the Okavango are undoubtedly the most serious threat.

Figure 31: Spatial distribution map of Wattled crane in the MWS



c. Conservation action

The Botswana Wattled Crane Action Plan recommends four major actions to achieve the objective of "maintaining the size of Botswana's Wattled Crane population within natural cycles" and these are still largely valid:

1. Knowledge of factors affecting biology and ecological requirements of the Wattled Crane obtained;
2. Laws, regulations and plans better implemented and enforced by responsible agencies;
3. The awareness and knowledge of wetland dynamics, and the role of Wattled Cranes, improved amongst planners, developers, communities, the tourism sector and policymakers so that Wattled Crane habitat requirements are maintained in the long run;
4. Funds and human resources for the implementation of the Wattled Crane Species Action Plan are secured.

Aspects of some of these objectives have been achieved since the plan was drafted e.g. the development of the ODMP. Also, the alignment of the eastern Makgadikgadi veterinary fence provides some additional protection to the most important Wattled Crane summer area.

d. Priorities for further research and conservation

One of BirdLife Botswana (BLB)'s priority activities is to determine the regional movements of the Wattled Crane population by using satellite tracking devices (PTTs). Finally, BirdLife

Botswana has a vast amount of detailed information on Wattled Crane distribution, with precise GPS co-ordinates of each sighting, and these data should be analysed to look at local movements and habitat preferences.

Grey Crowned Crane Balearica regulorum: Conservation Concern

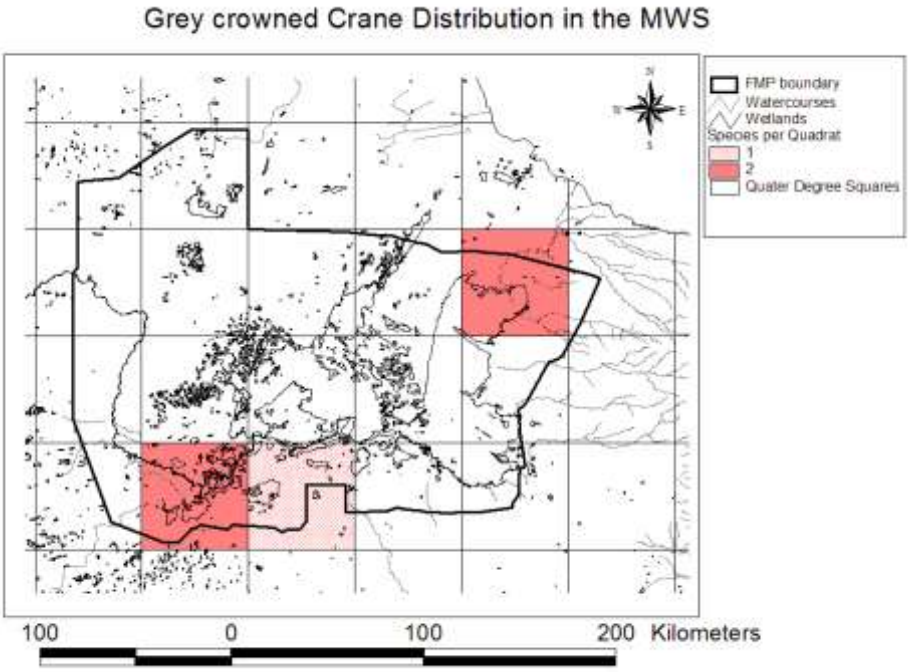
a. Status and distribution

The Grey Crowned Crane is a Category B Rarity and a bird of Conservation Concern in Botswana. All recorded observations of this species in the two databases (Category B Rarity database and Birds of Conservation Concern database) were analysed by Tyler and Hancock (2005) who found that 68.5% of the sightings were from the Makgadikgadi Pans area, particularly the Nata Sanctuary where the species has also been recorded breeding. Surprisingly, it is seldom recorded in the Okavango Delta, and there are no clear reasons for this apparent anomaly. Historical records of the bird in the MWS area suggest rather scattered distribution of the species (Figure 32).

b. Threats

The species is not under any obvious threat in Botswana but pressures experienced in most other parts of its range include habitat destruction, collision with powerlines and especially illegal bird trade.

Figure 32: Spatial distribution map of Grey Crowned Crane in the MWS



c. Conservation action

In Botswana, the Grey Crowned Crane is a Protected Animal under the Wildlife Conservation and National Parks Act of 1992; trade is also regulated by the Convention on Trade in Endangered Species of Wild Fauna and Flora (CITES), to which Botswana is a signatory. This is a low priority species for research and conservation action in Botswana.

Chestnut-banded Plover Charadrius pallidus: Near Threatened

a. Status and distribution

The Makgadikgadi Pans, specifically the Nata River Delta, Mea and Rysana Pans, are the most important area in Botswana for this recently uplisted, Near Threatened species, according to Simmons *et al*. (2007). This is also reflected in the historical species accounts and distribution records from the Bird Atlas of Botswana (Penry, 1994) (Figure 33). Of these sites, the Nata Delta/sanctuary has been recorded to host, on average, over 1% or more of the world population i.e. > 178 birds, on a regular basis, but Tyler (2001) predicted that surveys throughout the Makgadikgadi system would be likely to regularly reveal >200 Chestnut-banded Plovers. This prompted Dunbar-Irwin and McCulloch (2008) to conduct further counts in northern Sua Pan during 2007, and these produced a population estimate ranging from a minimum of 508 to 1,016 birds.

b. Ongoing monitoring

No monitoring of this species has been undertaken recently, but Dunbar-Irwin and McCulloch (2008) recommend that regular counts be conducted along standardised transects at the end of the dry season when water levels are lowest and the birds are most concentrated to prioritise and gain maximum benefit out of further monitoring.

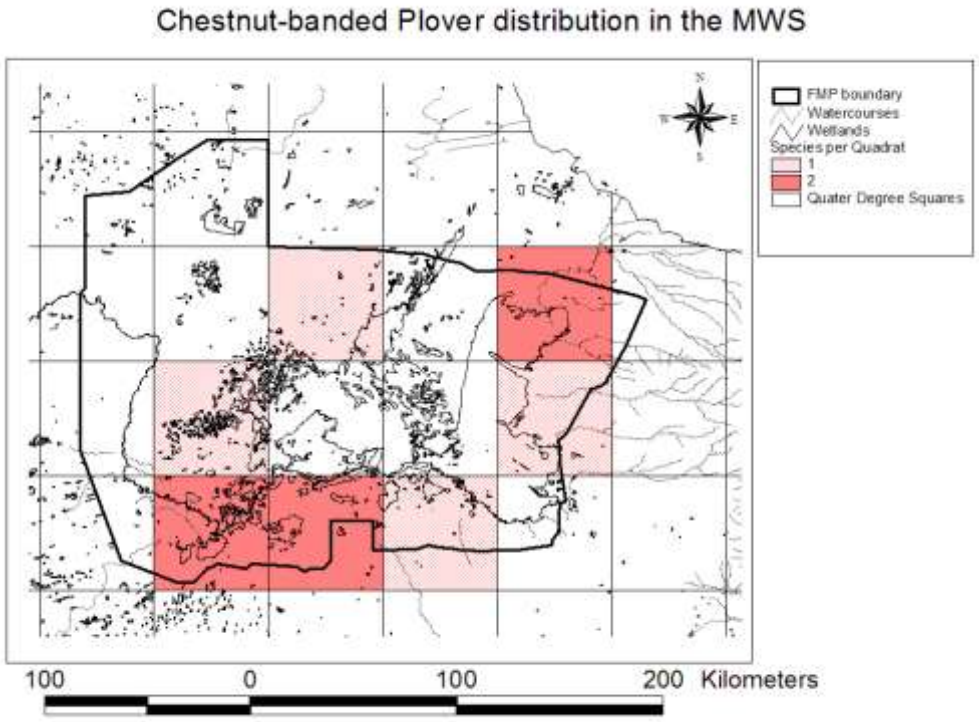
c. Threats

Threats to Chestnut-banded Plovers in Botswana are not well documented but are probably similar to those described for Lesser Flamingos since the two species occupy the same specialised habitat i.e. hydrological changes due to water abstraction by the soda ash factory, and possibly pollution from mining and other activities in the catchment.

d. Conservation action

More information is needed on the Chestnut-banded Plover, both in terms of its numbers and population dynamics, and potential and real threats. Monitoring of the species at Sua Pan, along the transect established by Dunbar-Irwin and McCulloch should be undertaken as a high priority since this would provide population data as well as the opportunity for identifying threats and causes of mortality. The Chestnut-banded Plover should also be declared a Protected Animal in Botswana in accordance with the wildlife legislation.

Figure 33: Spatial distribution map of Chestnut-banded Plover in the MWS



Lappet-faced Vulture Aegypius tracheliotus: Vulnerable

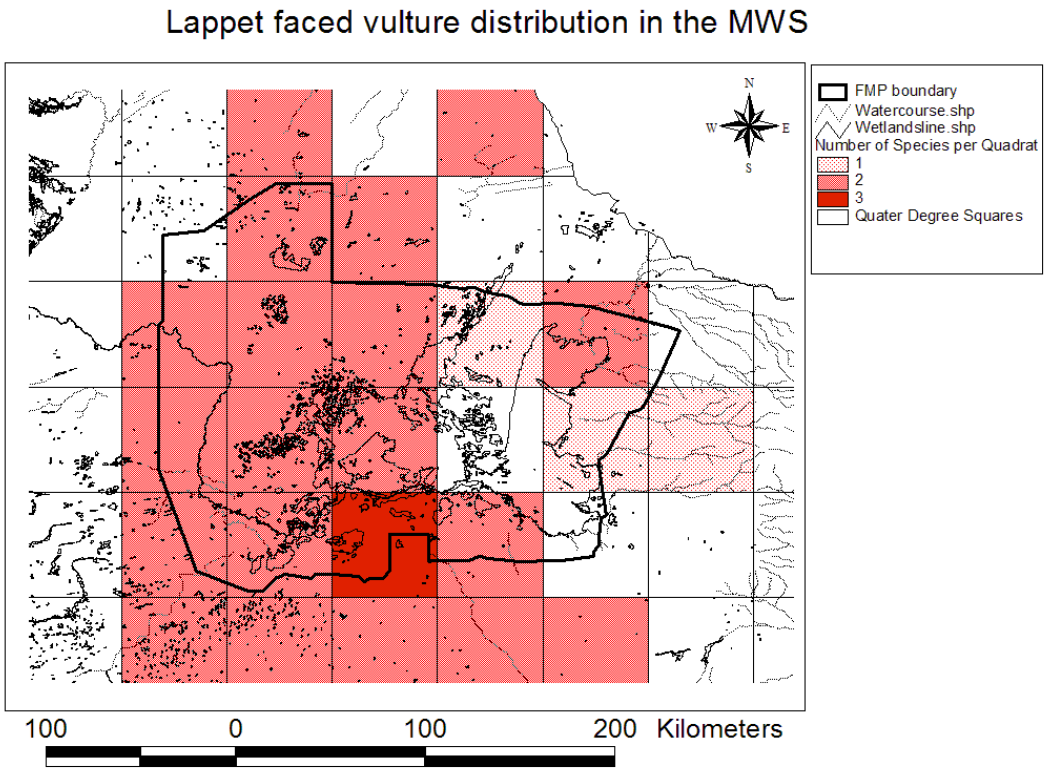
a. Status and distribution

There are no data on the size of the Botswana Lappet-faced Vulture population (Boshoff et al., 1997) even though a decade has elapsed since these authors highlighted this shortcoming. Penry (1994) shows that this species is widely distributed throughout the MWS, where there is one of the highest reporting rates in the country (Figure. 34).

b. Ongoing monitoring

During 2008, several parts of Botswana were surveyed for breeding Lappet- faced Vultures as part of a project to determine the size of the breeding population in the country. The survey areas included most of the Linyanti and Makgadikgadi Important Bird Areas and a significant portion of the Okavango Delta Important Bird Area (IBA). The Makgadikgadi appears to be the favoured nesting area for this species, with 23 active nests being located and monitored during 2008, compared to 14 during 2006 and 14 in 2007 (Hancock, in press). This increase in 2008 is thought to be mainly the result of longer and more efficient searching time spent in this area. Since nests were checked early in the breeding season, and then later, just before the chicks fledged, a measure of breeding success was obtained, and the results indicated that there was a 57% success rate in 2006 and 2007 and a 35% success rate in 2008.

Figure 34: Spatial distribution map of Lappet-faced vulture in the MWS



Low breeding success in 2008 may be reason for concern – two chicks were found dead in nests, but cause of death was unknown. It is believed Makgadikgadi is an important breeding area for this species due to its remoteness, coupled with the fact that large numbers of Burchell's Zebra foal in early summer just as the Lappet- faced Vulture chicks fledge – there is thus an abundant source of food at this critical stage in the Lappet- faced Vulture lifecycle. Lapped-faced vultures have also been observed to scavenge and hunt flamingo chicks and eggs on Sua Pan at this time of the year, forming gatherings of over 40 individuals on the dry pan when the flamingo chicks are most vulnerable to predation (McCulloch, 2004). Key ecological food chain links like these are vital to the long-term survival of the species. It is noteworthy that the zebra numbers have diminished over the past few decades and this may be impacting Lappet-faced Vulture chick survival.

Concurrently with the breeding bird surveys, BirdLife Botswana has been conducting road counts for all large raptors, including the Lappet- faced Vulture, throughout Botswana during 2008. These data have not yet been computerised or analysed, but in time, will provide useful information on population trends, under different land use practices.

c. Threats

During 2008, the following direct causes of mortality to Lappet- faced Vultures were noted:

- Road traffic mortalities: One adult Lappet- faced Vulture was killed by a vehicle on the Gweta-Maun road on 13/11/08. Since there are records of other vulture species being killed

by vehicles while scavenging at roadkills, it is quite likely that this is a small but regular source of mortalities for Lappet- faced Vultures.

Poisoning: On 1/11/08, one Lappet-faced Vulture was found poisoned in the Xudum Concession (NG 30) together with about 50 White-backed Vultures. The Lappet- faced Vulture was bearing a yellow wing tag numbered E052 which had been affixed to the bird's wing by Wilferd Versfeld during September 2007, in the Etosha National Park. This vulture had travelled over 720 kilometres from its natal area, highlighting the importance of regional migration by this species and the importance of the Makgadikgadi breeding sites for the regional population as a whole. There were other reported incidents of vultures being poisoned during 2008 (mainly White-backed Vultures, in large numbers) so it is likely that poisoning of Lappet-faced Vultures is a serious threat to the continued survival of this species in Botswana.

d. Conservation action

BirdLife Botswana is still in the data gathering phase as far as the Lappet- faced Vulture is concerned, and conservation action for the species has not commenced in earnest yet.
However it is apparent that poisoning of vultures is a serious threat that needs to be addressed as a matter of urgency (see below).
The only other advocacy work undertaken on behalf of the Lappet- faced Vulture during 2008 was to approach the Veterinary Department to find out about the use in Botswana of the Non-Steroidal Anti-Inflammatory Drug (NSAID) Diclofenac. This drug has been responsible for the virtual extinction of three species of Asian vultures, and is currently in limited use in Botswana. Members of the Veterinary Department were amenable to the suggestion of banning its use in Botswana, but this still needs to be actioned.

e. Priorities for further research and conservation

In order to put Lappet- faced Vulture research and conservation on a sound footing in Botswana, funds are urgently required. A funding proposal entitled "The Lappet-faced Vulture – a flagship for threatened raptors in Botswana" has been proposed. This project will form the basis for developing a national Lappet-faced Vulture Action Plan, in line with the International Species Action Plan for the Lappet-faced Vulture, Torgos tracheliotus (Shimelis *et al*., 2005).

This proposed BirdLife Botswana project also includes research and monitoring of other vulture species, including the declining White-headed Vulture, which occurs in small numbers around the MWS, particularly in the Boteti River area. In view of the apparently precarious status of the White-headed Vulture in Botswana, securing funds for this project assumes an even greater priority. The project will also help the formulation of a Species Action Plan for the White- headed Vulture, which will detail priority conservation actions that are desperately needed.

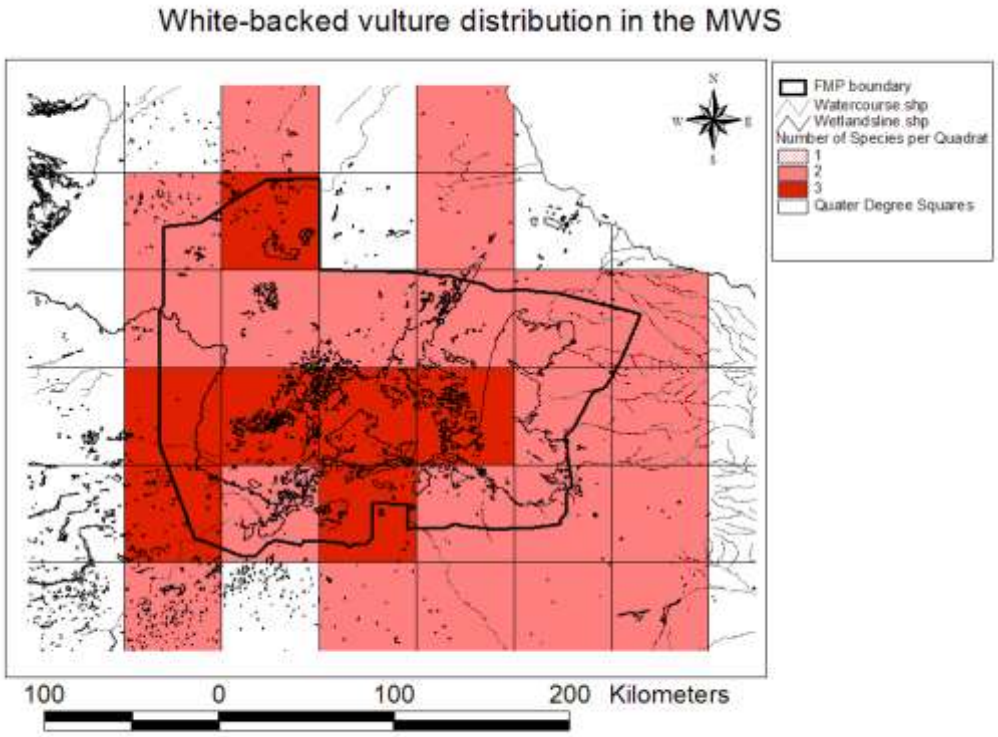
White-backed Vulture Gyps africanus: Near Threatened

a. Status and distribution

The White-backed Vulture is currently Botswana's most numerous and widespread vulture species, which can be seen virtually anywhere throughout the country. Aggregations of 50 to 100 birds can be seen at a single carcase, and although this seems a very satisfactory situation in terms of the number of birds, it also means that the species is highly susceptible to poisoning (see below – Threats). The Makgadikgadi is an important area for this species and its historical occurrence in the area (Penry, 1994) testifies to this (Figure 35).

The species is a loosely colonial breeder, and relatively large colonies are known in the northern part of the country, in particular. Some complete colonies are outside protected areas, in stark contrast to the situation in Swaziland, for example, where there is a strong correlation between nest sites and protected areas (Bamford *et al*., 2009).

Figure 35: Spatial distribution map of White-backed vulture in the MWS



b. Ongoing monitoring

Surveys of White-backed Vulture nests in northern Botswana, done concurrently with the Lappet- faced Vulture nest monitoring, identified Makgadikgadi as one of the most important areas in the country for breeding by this species, revealing the highest number of nests: 87, with the Okavango and Linyanti areas revealing, respectively 77 and 62 nests (Hancock, 2008). Other potentially suitable areas such as the Central Kalahari Game Reserve and Gemsbok National Park have not yet been surveyed for vulture nests.

In 2007 breeding success at the Linyanti colonies was 64% and 79% for the Makgadikgadi colonies, both within the range of 43 to 87% recorded for this species by Mundy et al. (1992). It is, therefore, suggested that there is a healthy breeding population of this species

in Botswana. The raptor road counts being undertaken by BirdLife Botswana include this species, and will continue to form an important part of White-backed Vulture monitoring.

c. Threats

There were three poisoning incidents reported during 2008, which killed over 100 Whitebacked Vultures in total, details of which are given by Hancock (2008). Since it is unlikely that all vulture poisoning incidents were brought to the attention of BirdLife Botswana, the magnitude of this problem is regarded as serious, more so than other documented threats such as destruction of nesting trees by the high density of Elephants in some areas, and the occasional vulture killed by vehicles on the national roads.

d. Conservation action

Although poisoning of vultures is a serious threat that needs to be addressed as a matter of urgency, no strategy has yet been developed – this remains a priority (see below). The only other advocacy work undertaken on behalf of the White-backed and other vulture species during 2008 was to approach the Veterinary Department about the use in Botswana of the Non-Steroidal Anti-Inflammatory Drug (NSAID) Diclofenac. This drug has been responsible for the virtual extinction of three species of Asian vultures, and is currently in limited use in Botswana. Members of the Veterinary Department were amenable to the suggestion of banning its use in Botswana, but this still needs to be actioned.

e. Priorities for further research and conservation

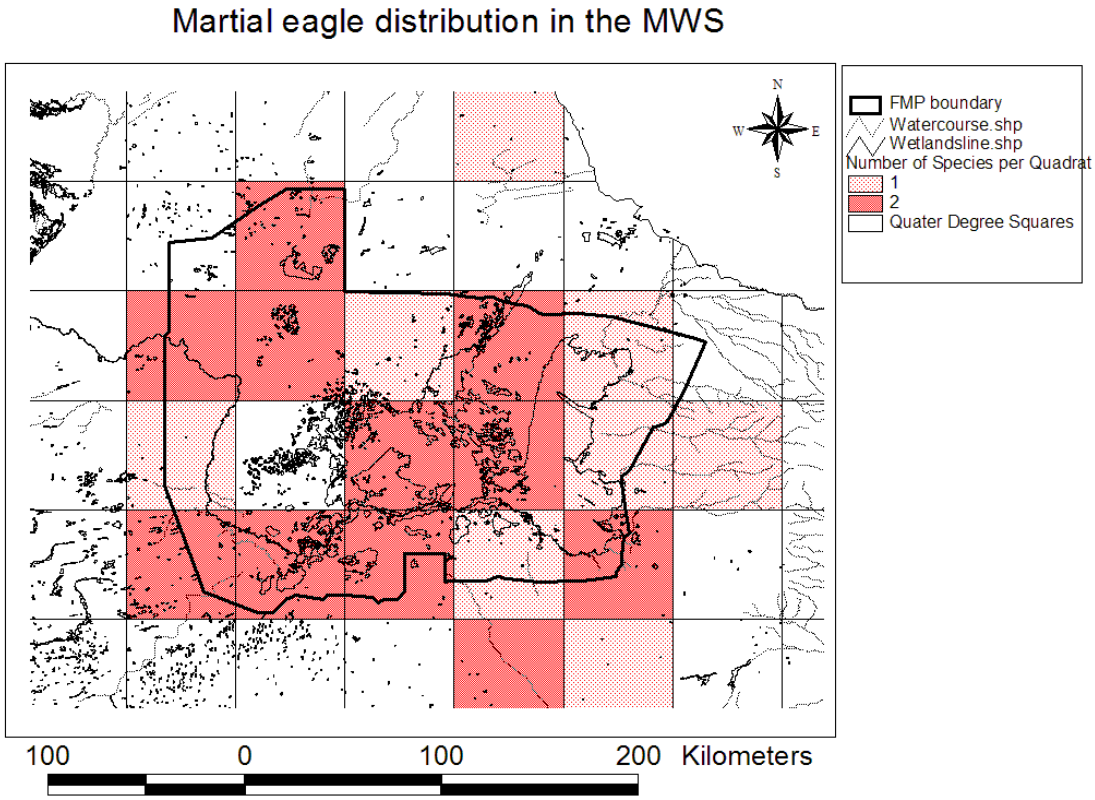
It is most important to develop a strategy to address the issue of poisoning of vultures, and to secure the necessary resources to facilitate its implementation. The banning of the veterinary use of the drug Diclofenac in Botswana is also regarded as a priority – this is also in line with the priorities for the BirdLife Africa Partnership for 2009.

Martial Eagle Polemaetus bellicosus: Conservation Concern

a. Status and distribution

The Martial Eagle has apparently declined throughout its range in Africa, and in Botswana, is becoming increasingly confined to protected areas. According to data collected by Herremans and Herremans-Tonnoery (2000), in unprotected areas it occurs at less than half the densities of numbers found in protected areas, suggesting the extent of the impacts of human activities on the species. It represents many large eagle species, whereby the current population size and trends for are not known, nor are their potential threats. Historical records from Penry (1994), however, indicate that the species is relatively common in the MWS, suggesting the importance of the wetland to the national population (Figure. 36). Determining these, and threats to the species, is a priority for research.

Figure 36: Spatial distribution map of Martial eagle in the MWS.



Great White Pelican Pelecanus onocrotalus: Nationally Protected

a. Status and Distribution

In Botswana, the Great White Pelican is relatively common, but is nevertheless regarded as a potential candidate for inclusion in the Botswana Red Data Book for Birds (Hancock, pers comms). The reason for the concern for the species in the country is because it breeds at only one locality, and it does so here only rarely. Breeding at Lake Ngami has not been observed since the early 70's, and breeding on Sua Pan, part of the great Makgadikgadi Salt Pans complex in northern Botswana, happens only after exceptional rains and that happens once in every 3 to 5 years.

Originating from dams on tributaries of the Nata River, or from aestivation pockets in the usually dry Nata River bed, fish emerge at the onset of flooding and mark the migration of many fish-eating bird species to Sua Pan. Great White Pelicans arrive in their thousands when the fish populations have reached their peak. At the mouth of the Nata River Delta, small, flat, low-lying islands are created and some provide ideal locations for Pelican breeding colonies. Here they make rudimentary nests and raise their young in relative safety from land predators. Conditions here can be highly favourable, so much so that as many as 6000 individuals (observed in 1989) have been observed utilizing the site in the past (McCulloch & Hancock, 2007).

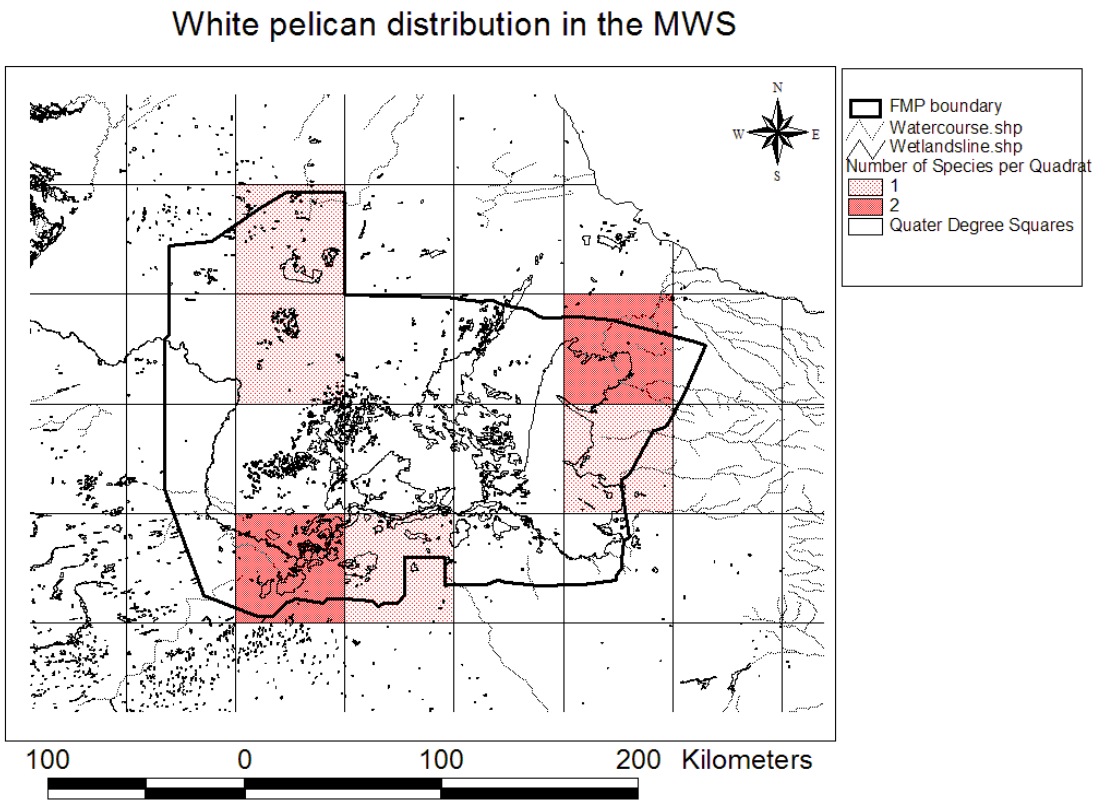
Historical records (Penry, 1994) identify their main areas of occurrence as being Nata Sanctuary and the Lake Xau-Mopipi Dam area, with some observations made at some of the smaller peripheral pans (Figure 37).

A chance sighting of a colour-ringed pelican at Lake Ngami during 2004 provided an insight into the birds' ability to locate optimal fishing localities: the bird had been ringed as a chick on Dassen Island near Cape Town in South Africa several months earlier. Lake Ngami is approximately 2,000 kilometres from Dassen Island 'as the pelican flies' if they follow the west coast as is suspected on their regional migrations.

b. Threats and Conservation action

Only five or six suitable places exist in the whole of Southern Africa provide the right prerequisite conditions to enable these birds to breed successfully, Dassen Island and Lake St. Lucia in South Africa, Walvis Bay Hardap Dam and Etosha Pan in Namibia, and Sua Pan and Lake Ngami in Botswana. Threats to the breeding site on the Nata River as a result of altering the river hydrology, increased human activity/disturbance at the site, and a decrease in their food abundance through over-fishing or poisoning/pollution pose the most serious threats to this species in Botswana and the region. In addition, when the pans dry up before the chicks fledge, huge daily trips of >300km are made to the Okavango in order to sustain the chicks until they fledge. Before they have returned to the colony, some of the adults have been observed colliding with nearby power lines around Nata village, suggesting the susceptibility of these and other large nomadic waterbirds to overhead obstacles.

Figure 37: Spatial distribution map of Great White Pelican in the MWS



Kori Bustard Ardeotis kori: Conservation Concern

a. Status and distribution

Botswana is the stronghold of the Kori Bustard in Southern Africa; elsewhere in the region it has apparently decreased markedly outside protected areas. It is currently widespread in Botswana, but one of its key areas of abundance and importance to the country's breeding population is Nxai Pan. Other areas where it is abundant include Savuti, the Nossop Valley and Deception Valley, all of which are within national parks and game reserves. Tyler (2005) suggested that Kori Bustards in Botswana have retreated into protected areas.

b. Ongoing monitoring

A detailed PhD study of the Kori Bustard, entitled "Ecology and conservation of the Kori Bustard Ardeotis kori in Botswana" is being undertaken at present to identify movements, population dynamics and threats to the population, and it is hoped that the study will produce recommendations for the long-term conservation of the species (Senyatso pers comms).

c. Threats

The documented threats to the species are habitat destruction (through transformation of formerly suitable areas to crop farming, and/or bush encroachment due to rangeland overgrazing), hunting pressure, human disturbance, collision with overhead transmission lines, poisoning, stray dogs and entanglement in fences – of these, illegal hunting in Botswana is definitely important (Senyatso, 2006).

d. Conservation action and future priorities

Apart from the applied research being undertaken (as described above), there was no conservation action undertaken for this species during 2008. It is important to establish quantifiable, measurable trends for this species both inside and outside protected areas, and to ascertain which of the general threats mentioned above are operative in Botswana, so that if the species is at risk, a Species Action Plan can be developed.

In the short-term, it may be constructive to repeat Ritter's unpublished Kori Bustard counts from Nxai Pan from the early 1990s. The existence of these historical data will make it possible to get an indication of whether or not this sub-population (which is protected) has increased, remained stable or decreased – it can then provide a benchmark for other subpopulations.

Black-winged Pratincole Glareola nordmanni: Near Threatened

a. Status and distribution

The Black-winged Pratincole is a Palearctic non-breeding migrant to Botswana. Its global population declined precipitously during the twentieth century, although in recent years, unexpectedly high numbers have been recorded in parts of its range e.g. 20,000 in the Stavropol region, Russia (see World Birdwatch, 2006).

Botswana is one of three countries that support the largest migratory population. The MWS plays an important role in providing some of this important habitat, and, as such, is important for the species. An International Single Species Action Plan has been produced for this species (Belik and Lebedava, 2004), and this outlines some of the threats to the species and potential solutions. The Action Plan makes some recommendations about the

conservation of the Black-winged Pratincole, but the most important for Botswana is the development, endorsement and implementation of a National Action Plan for the species.

b. Threats

Threats faced by the birds when they are in Botswana are unknown, so it is important to monitor all the areas they utilise and identify any potential threats. Black-winged Pratincoles are counted during the biannual African Waterbird Census, and this activity should continue; observed threats need to be reported and the information documented. The Black-winged Pratincole should also be included as a Protected Animal under the Wildlife Conservation and National Parks Act.

European Roller Coracias garrulous: Near Threatened

a. Status and distribution

Despite an influx of European Rollers into Botswana during the summer of 2001 (Tyler, 2002), and observations of scores of them together on numerous occasions in the MWS since (Tyler, pers comms, McCulloch), this species was recently up listed to Near Threatened as it has declined markedly in the northern hemisphere. Habitat destruction in Europe, where hedgerows have been destroyed to make way for monocultures, has been the blame of the decline in this species. The use of pesticides in Europe has also undoubtedly had a negative impact on the species, since it is mainly insectivorous.

b. Ongoing monitoring

At present, little is known about this species in Botswana, and there are no studies or monitoring being undertaken in the country let alone in the MWS. It may be adversely affected by the marked increase in bird shooting using unregulated air rifles (or pellet guns) that has been a noticeable feature of the past few years. The use of pesticides in commercial farming areas in Botswana may also be taking its toll on the species. The Bird Population Monitoring to be initiated during 2009 should provide a means of determining population trends, since it will be undertaken during the summer months when the birds are present in Botswana; however, a concerted effort will be needed to identify real and potential threats to the species so that they can be addressed.

c. Threats

The European Roller represents a number of terrestrial insectivorous species that migrate to the MWS each summer and are facing ever-increasing threats and consequential declines in Europe and should be recognised as a Protected Animal in Botswana under the wildlife legislation.

Black-tailed Godwit Limosa limosa: Near Threatened

a. Status and distribution

This is another Category B Rarity, for which more information is needed. It occurs sparsely in Botswana, and it is unlikely that conservation action here will contribute greatly to improving the global status of the species, but it has been seen in the MWS during bi-annual waterfowl counts for Wetlands International on numerous occasions suggesting the wetland is an important site for the species. An International Single Species Action Plan has been compiled for this species, and was adopted at the Meeting of Parties of the African-Eurasian Waterbird Agreement in September, 2008.

b. Threats

In Botswana, the current wildlife legislation does not afford any protection to this species and it, therefore, needs to be classified as a Protected Animal. This was proposed at the review of the wildlife legislation that took place during early 2008.

3.5 Assessment of Human Wildlife Conflict Issues and Mitigation Strategies

3.5.1 Causes of Human Wildlife Conflict

Human wildlife conflict occurs when the requirements of wildlife populations for land and resources overlap with those of human populations, creating costs to both the human residents and the wild animals (IUCN World Park Congress, 2003; Lamarque et al. 2008).

Habitat & resource induced factors in the Makgadikgadi

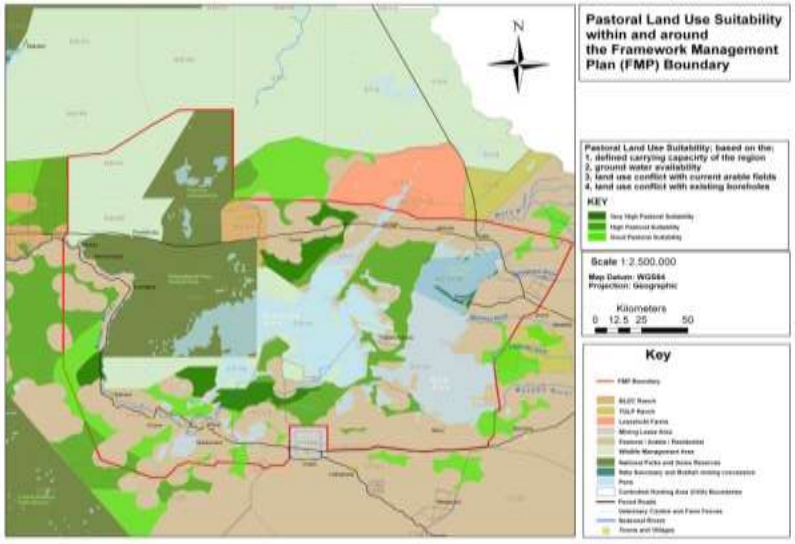
Drought of any form leads to increased pressure for resources by both people and wildlife around remaining available water sources, so that rivers and other water bodies can form the focus of conflict. This is clearly evident within the Makgadikgadi along the Boteti River. Levels of conflict across the rest of the region will be affected by changes in the availability of surface water bodies, as well as by changes in resource availability as primary productivity is affected by declining precipitation. Climate change could threaten to place even greater constraints on access to water resources, which could lead to increases in the levels of human-wildlife conflict across much of Botswana.

A) Limited good grazing potential

Most of the Makgadikgadi region lacks good perennial grazing. The lacustrine soils around the main salt pans are very fertile, supporting high quality grazing during the wet season, but water availability is otherwise poor, so that a natural system of high intensity use by wildlife in the wet season and limited activity in the dry season enables the fragile, fine, soils to escape intensive year round use. Developing boreholes and expanding cattle grazing into these areas has exposed the pan fringe to excessive rangeland degradation. Poor quality grazing elsewhere in the system requires cattle herds to move across large areas in search of optimal grazing. This has lead to direct competition for grazing resources between livestock and wildlife.

The literature review of past management plans and the land use suitability assessment within the Land Use Component of the MFMP helped to identify those areas with the best potential for cattle grazing (Figure 38). The pastoral land suitability map as defined in the Land Use Component Report uses key resource factors and current development constraints to identify those areas most suitable for future cattle development in the future.

Figure 38: Pastoral Land Use Suitability map



Previously identified areas were defined west of the Nata state ranches, north of Phuduhudu around bushman pits, east of Sua Pan and south of Mosu / Mmatshumo (Land Use Plan for the Ngamiland Statelands, 1987; Land Use Plan for the Makgadikgadi Region, 1989). These opinions were based on rangeland estimates during the late 1980s and to some extent are supported by the assessment of soil fertility within the region by the Department of Agriculture, suggesting that grazing quality should be good (depending upon annual rainfall) within similar areas, as well as around Rakops, north of Mmatshumo, around Mea Pan to the southeast of Sua Pan and south of Zoroga.

B) Competition for Grazing Resources

One of the most common conflicts described from previous land use plans is the competition for grazing resources between wildlife and livestock. It is well noted that the Makgadikgadi region does not provide perennial grass resources of high biomass and high quality. The increasing cattle herd in the region from around 80,000 in the late 1980s to over 200,000 in the early 2000s has continuously been blamed for overgrazing these fragile resources, resulting in rangeland degradation (Land Use Plan for the Makgadikgadi Region, 1989; Ministry of Agriculture, 2010).

Competition for grazing resources has been cited as one of the principal causes for the decline of the zebra and wildebeest populations within the Makgadikgadi (Brooks, 2005). The drying of the Boteti River in 1991 stopped the river forming a natural barrier along the western boundary of the Makgadikgadi Pans National Park enabling cattle to transgress the park boundary and graze within the Park. Denudation of resources by cattle close to the river (within 5km) forced zebra to graze up to 32km from water points in the riverbed, while wildebeest were out competed for their preferred resources. Significant declines in both these wildlife populations were evident from 1991.

Land use induced factors in the Makgadikgadi

The size and functionality of the northern conservation area, which covers the north and western parts of the FMP area, helps reduce the relative levels of conflicts between people and wildlife. Across the rest of Africa, a rapidly expanding human population has eliminated and fragmented wilderness regions through, primarily, an expanding intensification of

agriculture and associated settlements. Roads, pathways and power lines connecting these settlements increase the footprint of human activity yet further and separate areas of resource importance for wildlife. Loss of habitat through land use change is now one of the greatest concerns for wildlife conservation with Africa and one of the main protagonists in the escalation of human-wildlife conflict in the continent. In the Makgadikgadi region land use conflicts and human-wildlife conflicts are concentrated around the periphery of the PAs of the Makgadikgadi Pans National Park and the Nata Bird Sanctuary. The lack of viable buffer zones around these PAs and the increasing human pressure for access to resources close to the PAs increases the relative level of conflict.

Table 13: Land Use changes and human-induced changes that have occurred over the past 30 years that have affected human-wildlife conflict in the Makgadikgadi region

Land Use change	Impact +ve and -ve to human-wildlife conflict
Tarring the Maun-Nata road in the early 1990s	1) Increased traffic volume and disturbance to wildlife, with high levels of road kill incidents **(-ve).** 2) Increased tourism volume and associated financial benefits for Gov. and communities and thereby indirect benefits of wildlife to local communities **(+ve).**
Tarring the Motopi – Rakops Rd in the late 1990s	1) Increased traffic volume and initial disturbance to wildlife before the erection of the Makgadikgadi fence **(-ve).** 2) Increased tourism volume and associated financial benefits for Gov. and communities and thereby indirect benefits of wildlife to local communities **(+ve).**
Expansion of the MPNP to the southwest and to the east in 1992	1) Created hostility of local communities towards the Park that is still evident today, even though the land was always stateland **(-ve).** 2) Conserved important resource areas for wildlife **(+ve).** 3) Improved buffer between high densities of people/livestock and wildlife **(+ve).**
Expansion of the Nxai Pan NP to the south and joining with the MPNP in 1992	1) Conserved important resource areas for wildlife and protected migration route between Nxai Pan and Makgadikgadi **(+ve).**
Creation of the Gazetted WMAs (NG47 and NG49) to the west of Nxai Pan in 1992	1) Improved buffer protection to Nxai Pan NP **(+ve).** 2) Allocation of land user rights and management of NG49 to local communities (Phuduhudu), enabling distribution of indirect benefits from wildlife **(+ve).**
Creation of the Ungazetted WMAs (CT10 and CT11) around the MPNP in 1992	1) Improved buffer protection to MPNP **(+ve).** 2) No allocation of land user rights and management of either area to local communities (Gweta / Rakops / Mopipi), restricting distribution of indirect benefits from wildlife and creating hostility of local people towards Gov. and wildlife **(-ve).**
Illegal expansion of pastoral and arable agriculture into CT10 and CT11	1) CT10 and CT11 are both stateland and there is limited ground level management. The areas have therefore seen significant disputed encroachment of pastoral and some arable activity. Increased human activity reduces the effectiveness of the WMAs as buffer zones, with the people subject to high levels of conflict **(-ve).**

Land Use change	Impact +ve and -ve to human-wildlife conflict
A mean population increase of 15% in Botswana in the past 10 years with, for example, Phuduhudu having increased from 274 in the late 1980s to 455 in 2001, while over 48,000 people now live in the Boteti region of Central District	1) As the size of each settlement increases there is a greater demand for the use of surrounding natural resources which brings people into competition with wildlife **(-ve).** 2) Increased population size requires additional municipal services, increasing levels of development, which unless it occurs sustainably can increase negative impacts for wildlife **(-ve).**
Increase cattle herd within the Makgadikgadi region from 80,000 in 1980s to over 200,000 at present	1) The spatial distribution of cattle across the region has increased over the past 30 years, widening the zone of interaction with wildlife and increasing the spread of human wildlife conflict **(-ve).** 2) Increased numbers of cattle are having a detrimental effect on rangeland condition, with evidence of rangeland degradation across those areas with the highest cattle density **(-ve).**
Expansion of dryland farming across communal areas in response to population growth	1) As the population of the region increases, the food demands also increase. People in the region are very poor and reliant upon dry land farming to survive. The area of land fenced and ploughed for agriculture has therefore increased **(-ve).** 2) There has been no control over the development of farms in the region, resulting in a scattered spatial distribution and increasing the relative exposure to conflict **(-ve).**
Development of fenced BLDC Ranches in close proximity to and adjoining PAs	1) The BLDC ranches were developed on stateland and, as with the stateland WMAs, there has been a lack of management, with fences in disrepair allowing wildlife to move into many of the ranches **(-ve).**
Fencing of the CKGR with the Phefodiafoka fence in 1996	1) The communities requested the development of the fence to reduce the impact of human-predator conflict and the loss of livestock. The fence has had some success at achieving this aim **(+ve).** 2) The fence is not predator proof and predators move under the fence to predate on livestock before returning to the Reserve **(-ve).**
Development of fences across Ntwetwe Pan and into Sua Pan as part of the Dept. of Veterinary zoning policy	1) The fences in the middle of the pan form no functional purpose in stopping the movement of cattle, as there are no cattle in the middle of the pan **(-ve).** 2) The fences trap and kill birdlife, especially flamingos which fly low over the pan **(-ve).**
Fencing the Nata Bird Sanctuary	1) Restricts cattle movement into the sanctuary and helps conserve this important area **(+ve).** 2) The management of the sanctuary has been poor, the fence has fallen into disrepair and cattle now enter the area **(-ve).** 3) The Sanctuary is very small and close to a high density of people. The wildlife species are therefore vulnerable to extreme edge effects **(-ve).**
Decommissioning of the northern Nxai Pan Fence in 2001	1) The fence was declared as serving no functional basis by Gov. in 1997 and decommissioned in 2001 **(+ve).**

Land Use change	Impact +ve and -ve to human-wildlife conflict
Development of the Makgadikgadi conflict fence in 2004	1) The communities requested the development of the fence to reduce the impact of human-predator conflict and the loss of livestock. The fence has not been successful at achieving this aim **(-ve).** 2) The fence is not predator proof and predators move under the fence to predate on livestock before returning to the Reserve **(-ve).** 3) The fence restricts movement of cattle into the NP and has increased resource availability for wildlife **(+ve).** 4) Cattle can now no longer graze inside the park and the cattle population is degrading the resources outside of the park. Local communities are, in some places, therefore bitter about the development of the fence **(-ve).** 5) The fence can be re-aligned if requested by the communities, enabling the developing of CBNRM tourism ventures and indirect benefits to communities **(+ve).** 6) The fence controls access into the park and may have helped reduce the incidence of poaching **(+ve).** 7) The fence was only maintained south of the Maun-Nata Rd, but this contract has since expired and there is no longer any fence maintenance. There is a significant risk that wildlife, such as buffalo, could leave the park. This endangers the upgrading of the CT8 area as a FMD Free zone **(-ve).**
Development of the Soda BotAsh mine	1) The mine extracts large amounts of brine form the system, which is having an unknown impact on the integrity of the system. This could affect resource availability and quality for wetland birdlife **(-ve).** 2) The mine is surrounded by a large, fenced area to the East, in which introduced wildlife numbers have increased that can provide benefit to local communities through tourism, if the area is connected to the Nata Bird Sanctuary **(+ve).**
Development of the Damtshaa Diamond mine	1) Damtshaa diamond mine was developed in a low sensitive area in the south of the FMP study area. It is operated as a satellite of Orapa diamond mine and has limited impact **(neither +ve or -ve).**
Development of tourism facilities across the region from 1980s	1) Several tourism camps and facilities have been developed across the region in the past 30 years. Some of these in sensitive areas. The management of most is good, ensuring limited environmental impact. The provision of jobs and Gov. based revenue provides positive benefit from wildlife in the region **(+ve).** 2) Very few of the tourism facilities have a strong community link, and indirect benefits from tourism for local communities are still low **(-ve).**

Human induced factors in the Makgadikgadi

The Makgadikgadi region is characterised by poor rural communities, whose prime livelihood is rain-fed arable agriculture and livestock. People receive little benefit from wildlife within the region and absorb most of the consequences of the conflict. There is a negative attitude towards wildlife, while poaching is evident. There is a desperate need to improve the wildlife associated benefits for the Makgadikgadi's rural communities, while regional and national strategies are required to ensure potential conflict is mitigated through effective land use planning.

A) Management of communal grazing areas

Calls have also been made to improve the management of the communal pastoral areas across the country, with CT7, CT8 and CT21 being relevant areas within the FMP study area.

There is a need to define a concept between the extremes of open access communal grazing and fenced ranches in exclusive occupation. The use of communal areas is an issue of national importance with dual grazing rights one of the biggest points of concern that results in extensive rangeland degradation, while fenced ranches exclude the majority of people from some of the best potential grazing (Review of National Land Use Map, 2009).

There is also a significant lack of any tourism development across many of these communal areas (Ngamiland District Land Use Plan, 2009). A lack of tourism growth has restricted the potential for any in-direct benefits to accrue to the local population. Many of these conflicts are expected to increase as the local human and livestock population increases. The human population has increased by 15% in the last 10 years and is expected to continue to increase over the next 10 years.

B) Management of Stateland WMAs

Recent disputed settlement of CT10 and CT11 has highlighted the poor localised management of the statelands. The lack of day-to-day management has permitted disputed borehole development and the subsequent spread of cattle into the WMAs (Land Use Plan for the Ngamiland Statelands, 1987; Central District Land Use Plan, 2009). The current state of affairs has resulted in a recent Cabinet directive to reassess land use activities within these areas. Following area specific management plans for both CHAs, individual land use applications will be assessed and land appropriately allocated.

An area also of concern within the MWAs is Phuduhudu. The settlement has been associated with extensive land use conflict since the 1980s, with a significant rise in the human and cattle population leading to an increase in relative conflict. In 1987 there were 274 people living in Phuduhudu with 627 cattle, while early district records clearly state that only 400 cattle were permitted in the settlement (Land Use Plan for the Ngamiland Statelands, 1987).

The 'Mafisa' system of distant livestock owners aggravates the problem of unregulated cattle increases and not only within Phuduhudu. Across the whole of the Makgadikgadi, absentee landlords and cattle owners constitute a vast proportion of the cattle owners in the region. This system does not assist good animal husbandry practices and can lead to over stocking and subsequent rangeland degradation (Land Use Plan for the Ngamiland Statelands, 1987). There is a need to improve the management of the WMAs and it is hoped that the recent Cabinet directive will facilitate this.

C) Livestock & arable conflict

In 1987, the main conflicts that were observed by rural communities identified livestock as a primary concern when considering arable development with 36% of farmers stating livestock were their biggest problem, with only 23% stating wildlife. Poor available grazing was also a problem (9%), especially along the pan edge, along with drought (17%); also stating that arable development is encroaching into grazing land. Areas of greatest concern for farmers included;

- Pan fringes – over grazing
- CT11 and CT10 – over grazing
- Mosu escarpment – gully erosion
- Thabatsakudu – over grazing

The development of the drift fences around the southeast of the MFMP area has done much to alleviate the conflict between arable and pastoral farmers in this region, with the Mmatshumo farmers stating the benefits of drift fences in the recent FGDs.

3.5.2 Summary of the principal causes of human-wildlife conflict within the MFMP area

1. Habitat and resource induced factors
    a. **Limited good grazing potential** – poor quality sandy soils and fragile saline soils dominate the region, while the area is susceptible to variable rainfall patterns. While carrying capacity is quite good on the saline soils (5-8 ha/lsu) the soils are fragile and susceptible to erosion and rangeland degradation. Poor grazing leads to a spatially expanding cattle population and an extension of the conflict zone.
    b. **Competition for the limited grazing between livestock and wildlife** – permeable PA boundaries leads to extensive movement of both wildlife and livestock across the region searching for optimal grazing, with severe competition for grazing resources around the MPNP.
    c. **Expanding elephant population** – Increased rainfall over the past 5 years, plus an expanding elephant population in Chobe District is causing movement of more elephants down into the Makgadikgadi region, intensifying levels of human-elephant conflict.

2. Land use induced factors
    a. **Lack of Land Use Buffer** - The drying of the Boteti River in the early 1990s created a hard edge between wildlife within the MPNP and cattle and people in CT8, ensuring that the highest levels of conflict within the region occur along the Boteti region.

3. Human induced factors
    a. **Poor management of the communal grazing areas** – An expanding livestock population and evidence of rangeland degradation in the region has highlighted issues of poor management of communal land. The situation is only expected to get worse with an increasing human and cattle population.
    b. **Disputed use and settlement of the WMA wildlife buffer zones** – the statelands of CT10 and CT11 have limited on-the-ground management, enabling disputed settlement of people and use of the area for cattle. These areas are designated as buffer zones to help reduce conflict and illegal settlement if aggregating, not mitigating the conflict.
    c. **Livestock and arable conflict** – The poor soil quality and variable rainfall patters limit the potential areas for good arable land. The areas with the best soils are also utilised by pastoral farmers with limited zoning between pastoral and arable farming, apart from in CT21 where drift fences have been effective
    d. **Depredation of Livestock** – Large seasonal movements of wildlife and permeable PA boundaries have resulted in extensive human-predator conflict, especially with lions along the Boteti River and in CT11. However there are also severe problems associated with smaller predators such as black-backed jackals and hyaenas, with over one third of the perceived loss of livestock to predators caused by these smaller species. The biggest issue associated with this problem is that damage caused by these species is not compensated for.
    e. **Small mammal conflict** – While larger species such as elephants are blamed for a lot of the conflict problems, many households also suffer from the

impacts of smaller species such as honey badgers and porcupines which eat crops. Retaliation against these smaller species could lead to local eradication if problems are not addressed.

3.5.3 Consequences of Human Wildlife Conflict

Socio-economic impact of HWC

A) Crop Raiding in the Makgadikgadi

In the Makgadikgadi region, the incidence of crop raiding by elephants has increased significantly over the past 10 years. The increased level of conflict might be associated with increased rainfall in the region, or the expanding national elephant population. Either way, human-elephant conflict is becoming an increasing issue for concern, with no signs of abating. There is limited assistance for farmers, who have not been trained in modern mitigation strategies, while there is no planning in field development.

B) Predation on Domestic Stock in the Makgadikgadi

The majority of the farmers within the Makgadikgadi area are small stock holders with anywhere between 5 and 100 cattle per family, so that the relative impact of livestock predation is high. Hemson (2005) estimated that each cattlepost within the vicinity of the Makgadikgadi Pans National Park lost $168 per annum to lions alone, with Meynell & Parry, (2002) suggesting that lions were responsible for 50% of wildlife associated damage. The cost of human wildlife conflict at the household level in the vicinity of the Makgadikgadi Pans National Park is therefore estimated at $336 per annum. This forms a significant portion of an individual's annual income within this part of the Makgadikgadi.

Several species of carnivore have been identified by subsistence farmers living east of the MPNP, in the CT11 region, as carnivores that predate on their livestock (Maude 2005). These are lion, leopard, spotted hyaena, brown hyaena, cheetah, black-backed jackal, wild dog, caracal and African wild cat. Five of these carnivore species were identified by the subsistence farmers as the main predators of their livestock (Figure 39a). Each cattlepost had a perceived mean value of approximately $744 worth of livestock killed by predators over a 12 month period, with black-backed jackals perceived to have killed the most animals, while lions were associated with the biggest negative economic impact (Figure. 39b).

Immediately west of the MPNP in the Xhumaga region of the Boteti River, The Department of Wildlife and National Park's Problem Animal Control (PAC) division records show that between 1998 and 2008, government compensation paid for the predation of livestock, were primarily associated with depredation by lion (Figure 39; Tables 14 & 15). Lions cause more than 4 times more damage (P710,240) to personal property within the FMP region than all of the other problem animals combined (P163,483).

However, by 2005 and 2006, the impact of wild dogs killing livestock had begun to significantly increase. What is clear from the PAC data is the lack of any recorded impact from black-backed jackals, which differentiates significantly from the data collected by Maude to the east of the Park. This is more than likely an artifact of the compensation system, rather than a difference in the form of conflict between each area, as damages caused by black-backed jackal are not compensated by DWNP. The differential impact of

hyaenas to the east of the park versus the west is again more than likely an artifact of the compensation records, with damages caused by hyaenas also not compensated.

Figure 39: The five principal problem carnivore species to the east of the MPNP

a) Represents the percentage of the average number of livestock perceived to be killed per cattlepost over a 12-month period;
***b) Shows the percentage of the average cost of livestock perceived to be lost per cattlepost over a 12-month period*.**

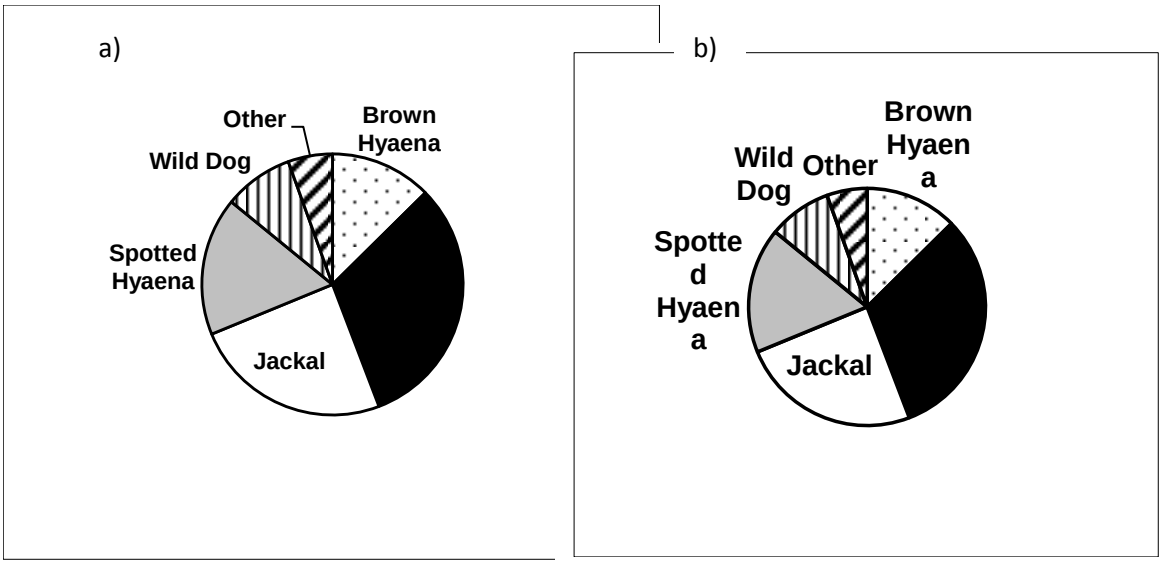


Table 14: Impact of conflict with lions within the MFMP area

Villages	Lions	Leopards	Wild dog	Cheetah	Hyaenas	Crocodile	Elephants	hippo	Jackal	crops	fence	boreholes	poles	well
Letlhakane	23,385	26,560	15,950										1	
Mosu	700	2,340												
Mmatshumo														
Mopipi	14,630	1,080		600	3,800									
Xhumo	1,760	2,090	700											
Kedia	2,800													
Rakops	271,085	16,880		5,560	1,870		1,440	1,400	360	1	1	1		
Toromoja	900													
Moreomaoto	99,230	10,020	1,870	240	1,400	120				2				1
Makalamabedi	96,410	20,680	17,331	840	1,250		380			3				
Khwee	120													
Xhumaga	187,600	2,360		4,970	1,050	3,910	307							
Motopi	5,230	9,390					271			2				
Mmadikola										2				
Maitengwe	2,100													
Nata		350	900						120					
Nkange											1			
Senete											2			
Tutume											1			
Matsitama	1,140						624			1				
Tonota		350												
Shashe-Mooke			1,400											
Gweta			720				700							
Zoroga										1				1

Villages	Lions	Leopards	Wild dog	Cheetah	Hyaenas	Crocodile	Elephants	hippo	Jackal	crops	fence	boreholes	poles	well
Sepako	1,750	350												
Makutla											1			
Maposa		710					120							
Matsiloje	1,400	120												
Totals	**710,240**	**93,280**	**38,871**	**12,210**	**9,370**	**4,030**	**3,842**	**1,400**	**480**	**12**	**6**	**1**	**1**	**2**

Table 15: Settlements and their surrounding associated settlements, most affected by impact of the human conflict animal within the MFMP area

Villages	Amount paid in compensation from 1998-2008	Damage to crops
Rakops	311,935	crops
Xhumaga	200,197	
Makalamabedi	136,890	crops
Moreomaoto	112,880	crops
Letlhakane	65,895	
Mopipi	20,110	
Motopi	14,891	crops
Xhumo	4,450	
Mosu	3,390	
Kedia	2,800	
Maitengwe	2,100	
Sepako	2,100	
Matsitama	1,764	
Matsiloje	1,520	
Gweta	1,420	
Shashe-Mooke	1,400	
Nata	1,370	
Toromoja	900	
Maposa	830	
Tonota	350	
Khwee	120	
Mmatshumo		crops
Mmadikola		crops
Nkange		crops
Senete		fence
Tutume		fence
Zoroga		crops
Makutla		fence

The change in relative impact of problem animals from lions to wild dog may be related to three things: One, the erection of the Makgadikgadi fence initially reducing the movement of lions out of the park into community areas: Two; the removal of the ban on shooting lions in 2004, with farmers retaliating against lions dramatically in subsequent years and thereby reducing the lion population: Three; a significant drop in the lion population would have facilitated an increase in the local wild dog population.

To the south west of the MFMP area in the Rakops region from 2000 to 2004, lions were again associated with the majority of PAC compensation (Figures 40 and 41). As with the Xhumaga region, the impact of wild dogs also increased in 2005 and 2006, while the relative impact of lions decreased, following the same pattern of change found in Xhumaga. The

cause and effect of these changes need to be interpreted along a greater time line to make firmer conclusions. The PAC data to be made available to the consultants is from 2000 to 2010 and the results from these analyses will be made available in the final draft of this report.

Figure 40: Level of government compensation for livetock animals killed by each predator type in the Xhumaga area in Pula by year, from 2001 to 2006.

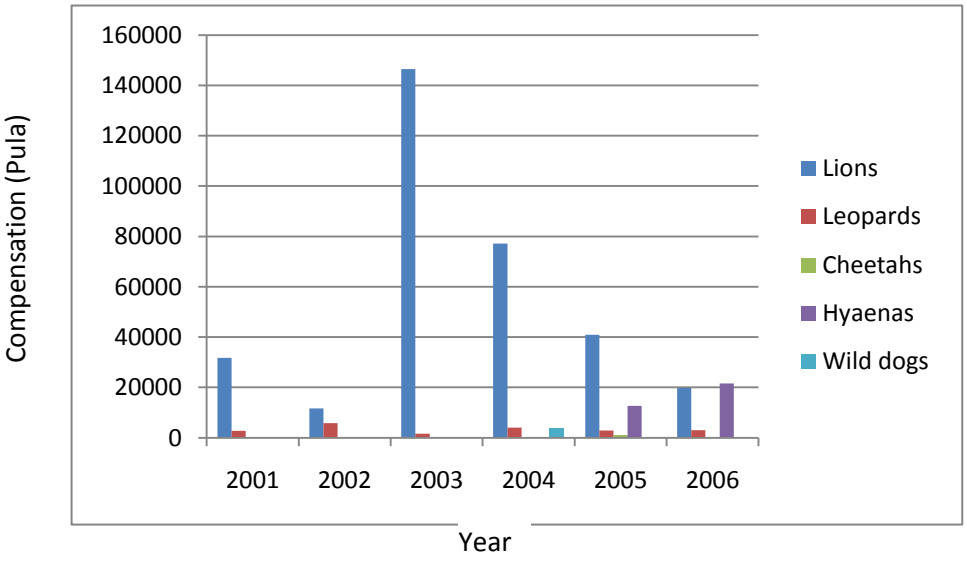
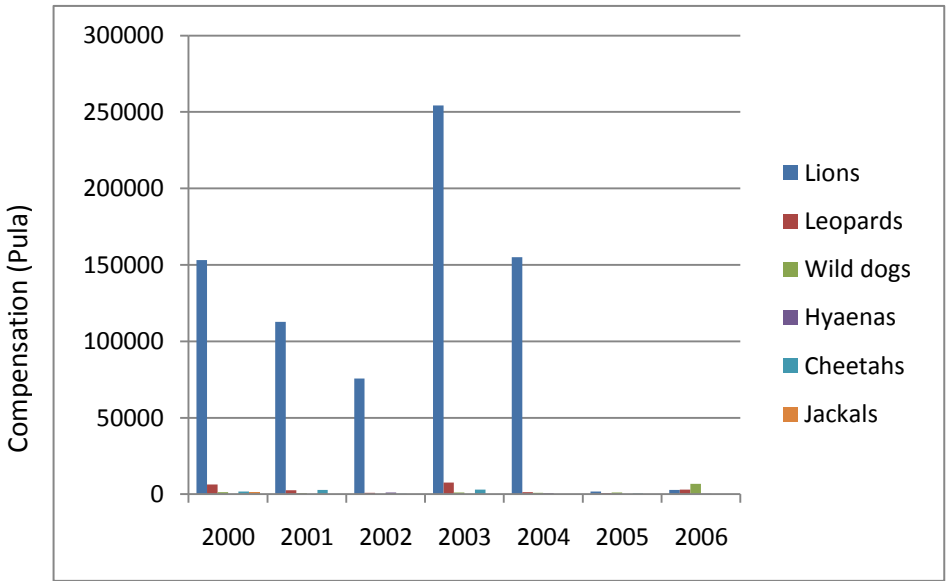


Figure 41: Level of government compensation for livetock animals killed by each predator type in the Rakops area in Pula by year, from 2001 to 2006.



In the Letlhakane area to the south of PNP, compensations were again mostly paid out for lion, leopard and wild dog kills on livestock from 2003 to 2006. There were a few compensation payments for livestock killed by hyaenas although it is not specified as to which type of hyaena, brown or spotted hyaena. As many of the kills compensated for were for cows and donkeys, it is likely most of these were killed by spotted hyaenas due to their size. It is possible that some of the goats and calves killed may have been by brown hyaena but again, most are likely to have been from spotted hyaenas (Maude 2005).

As livestock killed by black-backed jackals are not compensated for there are no records from the PAC department for this species. The recent removal of hyaenas from the compensation list does suggest that people around the Makgadikgadi will suffer from the change in policy due to the relatively high percentage of depredation of livestock by hyaenas in some regions.

Predation of livestock is not the only cause of human wildlife conflict from carnivores. The eating of melons by brown hyaenas and black-backed jackals also causes much bad feeling of farmers towards brown hyaenas and jackals and thus persecution of them (Maude 2005).

Although the economic value of melons is low, the effort involved in cultivating them is significant and their nutritional value as a food highly valued. Thus farmers highly resented and targeted animals for persecution that were believed to eat their melons. In the Phuduhudu and Rakops areas both brown hyaenas and porcupines eating melons, antagonizing arable farmers (FGDs; Makgadikgadi FMP consultations, 2010).

C) Disease Transmission in the Makgadikgadi

There have been no outbreaks of FMD within the Makgadikgadi region since 1980. The last outbreaks in close vicinity to the Makgadikgadi were in Chobe District in 2005 and in Francistown in 2001. The FMP study area incorporates and bisects many of the different levels of FMD zones, as delineated by the Veterinary Department. These zones have important economic implications. Those cattle within the FMD free zone can be exported and sold on the international market, i.e. either to the European Union, or other separate countries, such as Norway and Reunion, where prices are often better (IRIN, 2004). The EU market is still however the leading destination for beef exports from Botswana.

Loss of Human Life / health and safety concerns – Internationally and in the Makgadikgadi

Injuries to people mostly occur as a result of chance contact between man and elephant, buffalo, hippo, leopard and lion, usually along paths to and from dwellings and water. While the intensity of human wildlife conflict within the Makgadikgadi is one of the highest within Botswana, there is not a correspondingly high incidence rate of human fatalities or injuries. This may be a result of the relatively low densities of problem animals in the region or a high level of awareness within local communities of the danger of wildlife. This compares with other countries where extensive numbers of fatalities are recorded. In Kenya over 200 people were killed by elephants between 2001 and 2008 alone (WWF, 2007), while in less than a period of 18 months within one province (Cabo Delgado) of Mozambique 70 people were killed by lions (FAO, 2005), with almost 30 people killed by crocodiles in a 500km^2 area north of Selous Game Reserve in Tanzania in less than 5 years (Baldus, 2005).

Impact to Wildlife from conflict

A) Decline in wildlife populations through retaliation in the Makgadikgadi

The loss of wildlife species through retaliation is of specific concern to predators, who are accused of predating upon livestock. In the Makgadikgadi the decline in the lion population can be directly attributed to their killing by rural communities. Most lions are shot by individuals tracking the lions from spoor, or trapped, but incidence of poisoning are also believed to have occurred (Hemson pers. comms), with, for example, 8 lions killed during the 2000 wet season along the Boteti alone (Hemson, 2005). Hemson (2005) reported that 12% of people from all backgrounds along the boundaries of the Makgadikgadi Pans National

Park admitted to attempting to kill lions. Illegal persecution of predators, including poisoning, shooting and trapping, has been stated as the greatest threat to lions (Muruthi, 2005).

One of principal problems driving this issue is the attitude that government compensation does not cover the costs associated with the conflict, so that it is easier to solve the conflict personally through retaliation than rely upon government mitigation strategies and receive government compensation. Hemson (2005) reported that each cattlepost in the vicinity of the Makgadikgadi Pans National Park lost on average $289 worth of cattle per annum, with only 42% of this loss recouped through compensation. As loses were not homogeneous across the area, some families lost more and others less.

Problem animals are also shot to alleviate conflict. Problem lions in Botswana are, where possible, captured and released away from conflict areas, but according to the Predator Management Strategy (DWNP, 2009), up to 2% of the local population of predators can be shot through lethal control of problem animals. The DWNP now however prioritise translocation over lethal control, but extensive and uncontrolled lethal control by local communities is a significant cause for concern (see predator management section later in this report). Problem elephants are shot, due to obvious problems associated with translocation. There is no limit set within the Elephant Management Strategy (DWNP, 2009) to control the extent of this off-take. The loss of these problem elephants is not however believed to impact wildlife at the population level at present.

B) Decline in wildlife populations through resource conflict in the Makgadikgadi

One of the most detrimental effects of the drying of the Boteti River in the late 1980s was the loss of any physical barrier between livestock to the west of the Makgadikgadi Pans National Park and wildlife within the park. Transgression by both wildlife and livestock across the dry river bed led these species to compete for the same limited resources close. The situation was aggravated by limited surface water availability, concentrating activity around Xhumaga. The result was competition for grazing resources, with a negative outcome for wildlife. Wildebeest dues to their physiology preferred the exact same resources as cattle and were out-competed. This may have been the cause for their significant decline from over 25,000 in the late 1980s to less than 5,000 in the late 1990s (DWNP aerial survey data). Zebra prefer taller, more bulky grass and travelled longer distances away from the water holes to access food. While they escaped direct competition with cattle, they were exposed to significant physiological constraint and the population also declined from around 25,000 to around 18,000 over the same period. The development of the Makgadikgadi conflict fence along the Boteti River separates wildlife from livestock and it is hoped that the wildlife populations will stabilise and recover.

C) Decline in wildlife populations through disease transmission in the Makgadikgadi

Rinderpest was known to have impacted the wildlife populations of Botswana and the eradication of the disease in the early 1900s may have been associated with an increase in the wildebeest population across the Makgadikgadi region. There has been no evidence of canine distemper in the region.

3.5.4 Spatial Impact of Human Wildlife Conflict within the Makgadikgadi

Geographically the areas within the Makgadikgadi FMP that have the highest human-predator conflict are on the western and southern boundaries of the MPNP in the Boteti region, on the eastern boundary of the MPNP, in the Phuduhudu region and on the game

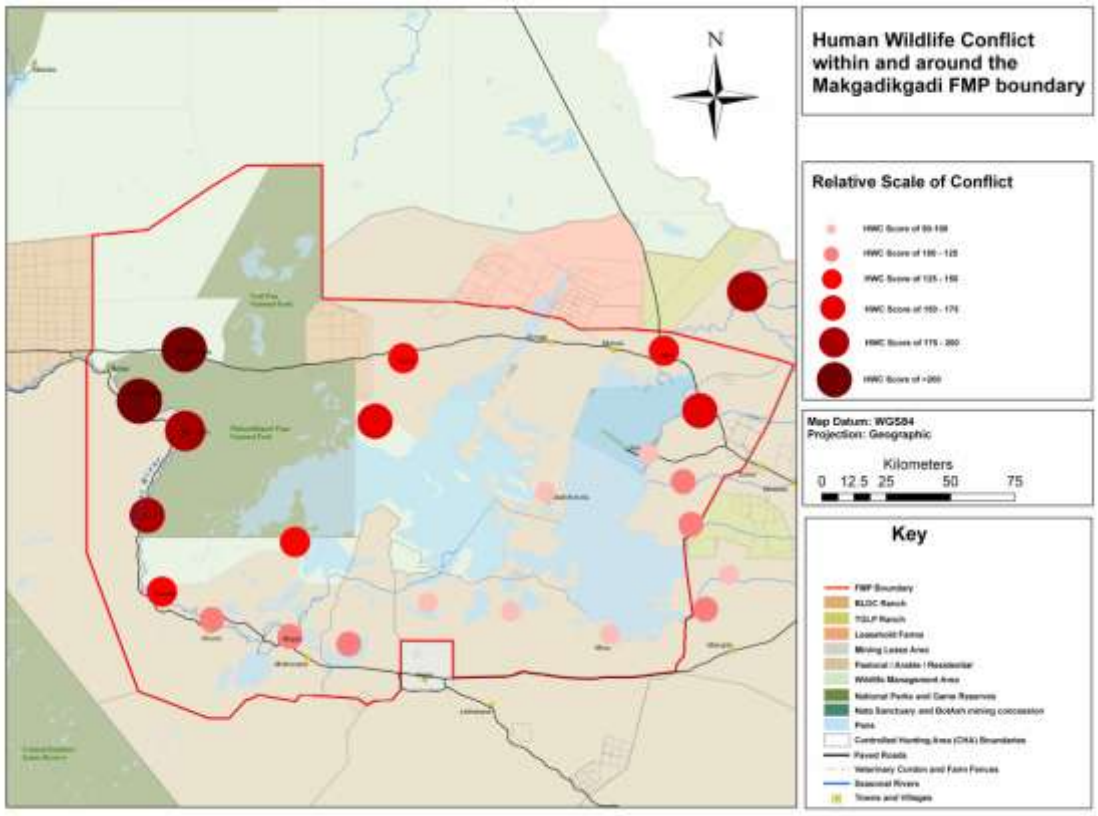
farms located to the east of the Makalambedi veterinary fence and north of the main Maun-Gweta road. The MPNP acts as a reservoir, or source of predators within the region, from which the move into surrounding community areas. Predators also descend from the northern WMAs and from as far as Chobe and Moremi into the region, so that areas such as Phuduhudu and the northern ranches suffer from the movement of predators from both directions. The cause of movement of predators out of the protected areas and into conflict with people is varied, and depends upon the geographical location of the point of conflict.

Table 16: Spatial evaluation of human-wildlife conflict and resource conflict

Typology of issues/ criteria for conflict areas	
Damage- production losses	**Alternative method of spatial assessment**
Intra-agriculture (crop damage by livestock)	Overlap between arable fields and livestock distribution density kernels (scored 1 out of 4 for relative overlap with cattle density and 0 if no arable production or no concentration of cattle) (If cattle separated from arable by drift fences then weighting is adjusted)
Livestock predation by wildlife (cattle encroachment into PA / movement of predators out of PAs)	Overlap of cattle distribution with protected areas (scored 1 out of 4 according to relative cattle density with 0 for no overlap or proximity of a PA)
Livestock predation by wildlife (distribution of predators outside of PAs)	Overlap of large predator ranges with all settlements (one score for each know large predator from wild dog, lions, leopard, cheetah, spotted hyaena, brown hyaena and jackal)
Livestock predation by wildlife (proximity of settlements to PA and vulnerability of all livestock to predation / movement of predators out of PAs)	Proximity of main settlements to PAs (5 within 1km / 4 within 3km / 3 within 5km / 2 within 7 km / 1 within 10km)
Livestock predation by wildlife (distribution of and proximity of cattleposts to PA and vulnerability of all livestock to predation / movement of predators out of PAs)	Concentration of associated small settlements around the main conflict site and relative proximity to PAs (scored as above)
Crop damage by wildlife	Overlap between arable fields and core wildlife distribution density kernels (scored 1 out of 3 according to relative overlap)
Crop damage by wildlife	Overlap between arable fields and elephant distribution density kernels (scored 1 out of 4 according to relative overlap)
Competition for resources	
Ground water resources	Density of boreholes per 25 sq/km around area
Water resource around Rivers	Density of boreholes close to rivers (number of boreholes within 100m buffer zone of river per 10km)
Grazing resources between wildlife and cattle	Defined carrying capacity across the majority of the surrounding land (1 for high CC through to 8 for low CC)
Grazing resources between wildlife and cattle	Overlap of low soil fertility / poor carrying capacity with high densities of wildlife (scored 1-6)
Grazing resources between wildlife and cattle	Overlap of low soil fertility / poor carrying capacity with high densities of cattle (scored 1-6)
Grazing resources between wildlife and cattle	**Total overlap between poor soil / wildlife and cattle**
Grazing resources between wildlife and cattle	Density of wild herbivore populations outside of PAs (scored 1-5, with 5 for high density)

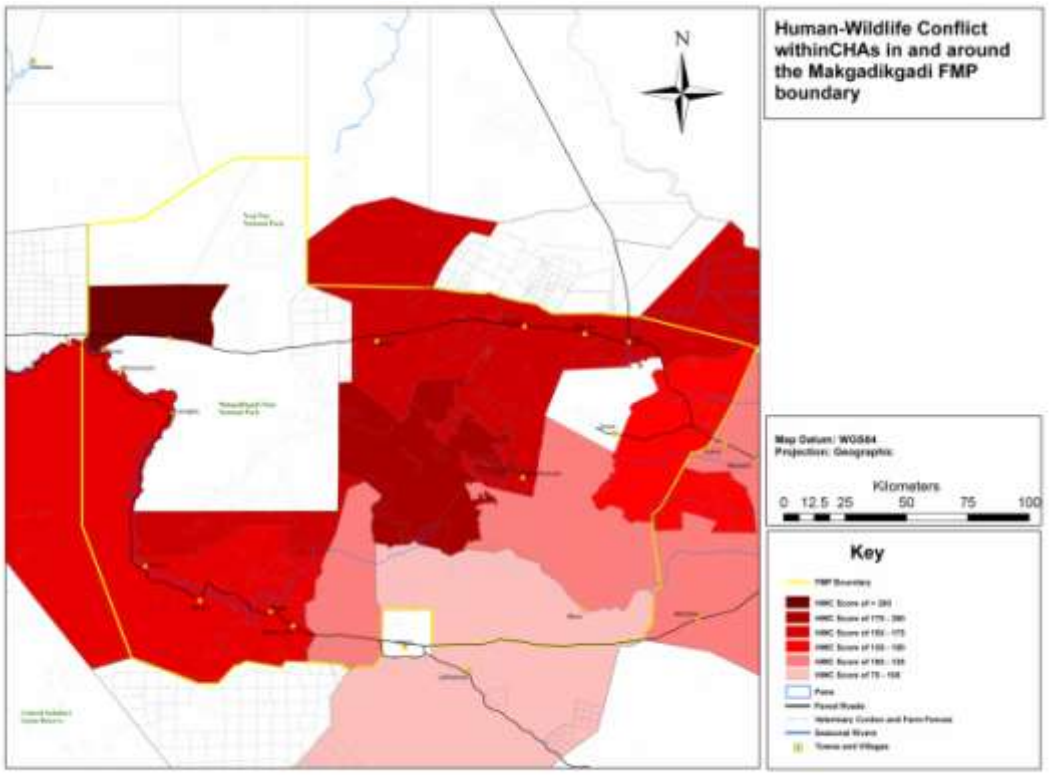
Grazing resources between wildlife and cattle	Evidence of rangeland degradation / relative deterioration in NDVI of area
Disease transmission & health risks	
Livestock wildlife disease	Proximity of FMD free zone with FMD vaccination zones (0 for no risk, 1 for close to boundary, 2 within old buffer zone and 3 within FMP vaccination zone, 4 close to FMP buffalo area, 5 inside buffalo area
Wildlife- human health risks	Areas with records of conflict (0 no history of disease / 1 close to area with history, 2 distant history, 3 recent history of disease)
Planning & management conflicts	
Changes in land use (past 20 years) - new infrastructural developments such as tar roads, fences & mines / cattle expansion / farming expansion (0 for no major changes / 1 for slight changes / 2 major changes / 3 very significant changes)	Records of development from old management plans and local knowledge
Mining	Overlap of mining prospect licences for various metals (0 for no overlap / 1 for close proximity to overlap / 2 for direct overlap)
Mining	Overlap of mining prospect licences for precious stones (0 for no overlap / 1 for close proximity to overlap / 2 for direct overlap)
Fences	Proximity of fences that cause detrimental impact to wildlife movement (0 for not close fences or fences have no detrimental impact / 1 for fences that have a slight negative impact / 2 for fence that has detrimental impact)
Illegal intrusions	Illegal settlement development into areas that conflicts with wildlife land use (0 for no issues / 1 for slight issues / 2 for large problems)
Detrimental impacts to Birdlife	
Human disturbance of birdlife	Proximity of all settlements to water spots / birdlife hotspots (5 within 1km / 4 within 3km / 3 within 5km / 2 within 7 km / 1 within 10km)
Effective Mitigation	
clustered field development	(3 for no effective clustering of fields / 1 for good effective clustering of fields and 0 for no fields in that area)
drift fences	(3 for no effective drift fences / 1 for good effective drift fences)
conflict fences	(3 for no effective fence / 1 for good effective fence and 0 for no fence required)
buffer zones	(3 for no effective buffer zone / 1 for good effective buffer zone)
Tourism	(3 for no benefits to community for tourism / 1 for high benefits from tourism)
Community assistance & Training	(3 for limited assistance & or training provided to community / 1 for high levels of assistance and training)

Figure 42: Results of the spatial evaluation of conflict in the Makgadikgadi region



Note: This compares very well with the distribution of conflict determined by the amount of compensation paid to farmers by DWNP

Figure 43: Total conflict scores within each CHA, providing an evaluation of conflict per CHA



From the spatial assessment it is clear that the majority of conflict within the region occurs around the periphery of the Makgadikgadi Pans National Park. Key conflict areas are;
A) The Boteti River
B) CT11
C) Phuduhudu

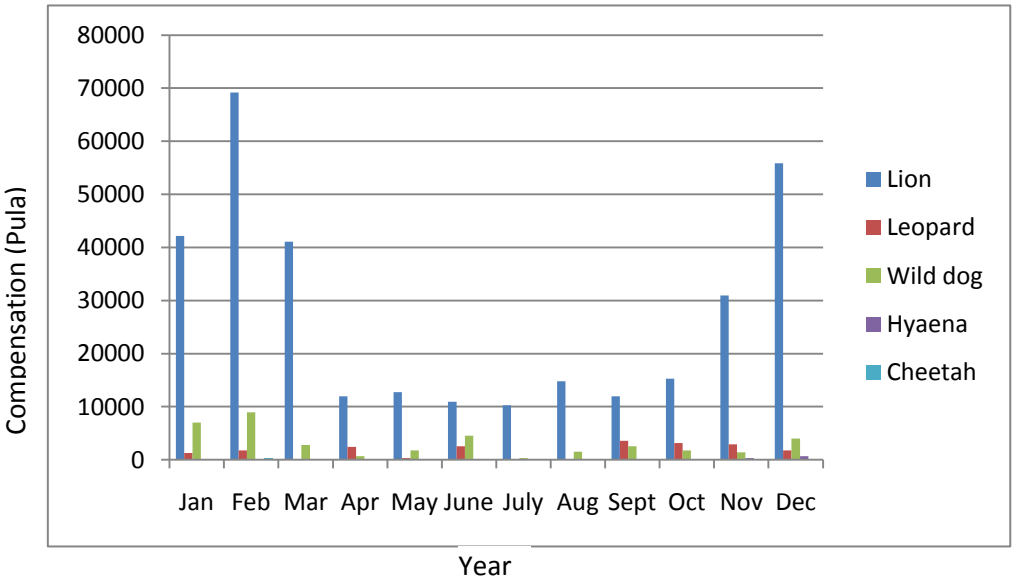
The Boteti region
This area follows the villages within vicinity of the Boteti River that includes Moreomaoto, Meno-a-Kwena, Xhumaga, Tsoi and Rakops. The close proximity of many cattleposts and the associated livestock to the boundary of the MPNP causes significant carnivore/farmer conflicts with predators leaving the park and killing livestock. Farmers in the region complain about lions in particular. Maude (2005) showed that cattleposts located more than 15 km from the MPNP boundary had considerably fewer problems with lions than those located within 15km. Actual average perceived numbers of animals killed by lions per year was found to be 1.8 animals per cattlepost, worth a total of approximately $221 within 15 km of the MPNP boundary. Greater than 15 km from the MNP boundary the average is 0.4 animals killed by lions per cattle post, worth a total of approximately $65. There is no such variability depending on the distance from the MPNP boundary for the other livestock predators.

It was hoped that the erection of a game proof fence in 2004 in the vicinity of the western and southern boundary of the MPNP, would alleviate the conflict between subsistence farmers and lions in the Boteti region. However lions continue to kill livestock in the region at high levels (PAC records and G. Maude personal observations). PAC data from the region does show a significant drop in compensations paid out for lion predations of livestock in 2005 and 2006, after the fence was erected. This may have partially been due to the

erection of the fence. However, from 2001 until the end of 2004 a government ban on the killing lions by farmers was in place. This is likely to have been a contributing factor as to the reason why from 2001 to 2004 livestock predation levels went up, as resident lion populations increased. When the ban was lifted in 2005, farmers reacted with high levels of persecution of lions in their areas (personal observations) thus causing a massive reduction in livestock predation by lions. This pattern is also illustrated in the Rakops region as most of the cattleposts there are not within vicinity of the Boteti fence and compensation levels dropped markedly in 2005 and 2006.

There are several factors that cause lions to predate livestock in the Boteti region. The most relevant is the movement of the lions' main food source, zebra (Hemson 2005), away from the Boteti area and eastwards towards the salt-pans during the wet season (Brooks 2005). This results in low resident game densities in the Boteti region, and the lions seeking livestock as a replacement food to the departed zebra. Arguably when the zebra are absent, the resident game in the Boteti is insufficient to fully sustain the resident lion prides. Lions are known to select the most numerous prey in any single area (Mills and Biggs, 1993), and with the movement of the migratory herds cattle become the most numerous herbivore in the Boteti region. This movement away from the Boteti is typically between December and April but this is variable depending on the patterns of rainfall. The effect of this movement on livestock depredation by lions is clearly shown as compensation levels are at their highest in the wet summer months when the migration is absent from the Xhumaga area (Figure. 44). No such pattern exists for the other livestock predators as zebra are probably not their primary food source.

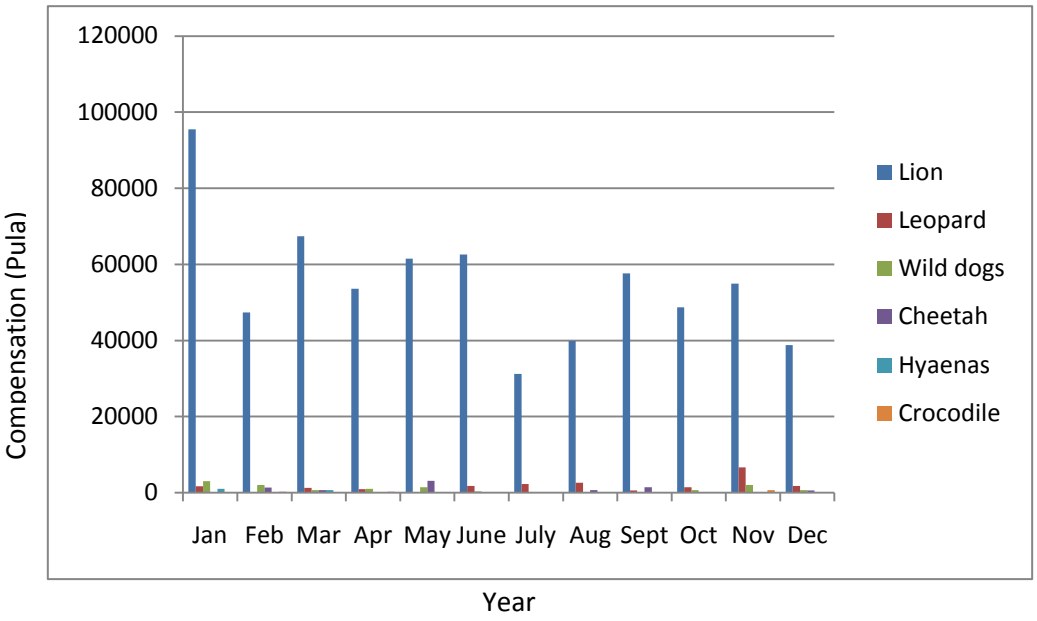
Figure 44: Compensation levels by month for the various predators in the Xhumaga region.



There are no clear monthly differences in predation levels by the lions or the other predators in the Rakops area. The zebra and wildebeest migration does not move far south of the MPNP and their movements are therefore not within close proximity of Rakops at any stage of the year. The lack of any seasonal trend in predation levels by lions in the Rakops region suggests that problem lions live in close proximity to Rakops year round and are not influenced by the movement of zebra and wildebeest within the MPNP (Figure 45). The erection of the Makgadikgadi fence along the southern boundary of the Park, may therefore have fenced this sub-population of lions out of the park. More recent data from PAC is

required to see if retaliation by farmers following the lifting of the ban on lion shooting post 2004 led to the decimation of this sub-population, or if there is still a small number of lions living within the community area.

Figure 45: ***Compensation levels by month for the various predators in the Rakops region.***



Due to structural and maintenance deficiencies of the Makgadikgadi conflict fence along the Boteti River (fence was not sunken into the ground and is therefore no predator proof, while lack of maintenance for the last year has resulted in significant elephant damage), lions have not been prevented from crossing out of the MPNP, since its erection in 2004, to predate livestock. At present and for the last few years, the fence has not been electrified due to constant breakage by elephants and the impact of the flowing Boteti River across the fence in some sections. All of the solar panels along the fence that power the electrification of the fence have also all been stolen. The absence of electricity makes it even easier for the lions to dig under the fence, especially as the fence is aligned across very sandy substrates. Since erection, maintenance efforts on the fence have also been limited (the maintenance was contracted to a private company, but the contract expired in March 2009 and not been renewed) and this in combination with a bad design, primarily not being dug in, has resulted in the fence failing to act as an effective barrier.

The fence has influenced the resident lion population and the farmers in the Boteti in several ways:

1) Although not stopping the lions crossing into livestock areas it is likely to have influenced the lion's spatial ecology.

2) Fences of this nature provide a line in the sand that demarks the area available for wildlife and for people. This typically results in farmers becoming less tolerant of predators that move outside of the area designate by the fence for wildlife, and into the areas designated for livestock, resulting in potentially increased effort by the farmers to eradicate wildlife, in particular predators, from their area.

3) Before the erection of the fence lions were continually wary of people even when inside the boundary of the park. This skittish behaviour made them more difficult to persecute. After the erection of the fence the lions, as well as many other wildlife species within the Park became less skittish and started to habituate to people and vehicles. This response may be related to less interaction with communities and more interaction with tourists who relate with wildlife species at a different level. However, when lions cross the fence now, they are less wary of the farmers and thus easier to persecute.

4) The fence has made it easier for farmers to persecute the lions as it is more difficult for the lions to move around "unnoticed". The farmers can monitor holes that the lions regularly use to cross and target them at these points by setting snares, gin traps, poison baits or even waiting in the vicinity of the hole to shoot them as they cross. The fence also makes it more difficult for the lions to return swiftly into the park towards sunrise and thus easier to persecute. Previously to the fence the lions were able to easily move outside of the park, predate livestock and then simply cross back over the dry riverbed at any point.

5) When the fence was initially erected it acted as a partial barrier, in particular when electrified, and very probably did reduce the number of livestock animals predated by lions. This conclusion is partially supported by the results of the PAC data that shows a decline in compensation paid after 2004 for lions. While problem lions are still moving into community areas, cattle are restricted from moving into the park. This undoubtedly makes them less vulnerable to lion predation.

In summary the erection of the fence appears not to have reduced the level of conflict in the area significantly, but has in fact actually made lions easier to persecute. The fence has had a different impact to other predators, with a significant impact on reducing the movement of hyaenas out of the park. The home ranges of brown hyenas living within the MPNP and within NG49 show a clear response to the alignment of the fence, not crossing the fence at any point. This response may be influenced by a differentiation in prey selection / foraging requirements of brown hyenas to lions, but may also be influenced by social boundaries to clan home ranges. Unfenced cutlines to the east of the MPNP create a similar response in brown hyenas' behaviour, which is a response to clans using the cutlines as clear visible boundaries to clan home ranges.

There is no data available on the response of the fence to other predator species movement and behaviour and we can only guess at the impact to species such as leopard and cheetah. Other conflict fences, such as the Phefodiafoka fence along the north eastern boundary of the CKGR have not stopped such predators, with both cheetah and leopard having been observed moving under the fence into communal areas (Brooks pers. obs.), and it may be that both leopard and cheetah also move under the Makgadikgadi fence in a similar manner to lions.

CT 11 region

The levels of lion/human conflict within the CT 11 region are arguably less than those found in the Boteti region, but are still significant, especially for the local farmers (Hemson 2005). In a similar, but reverse pattern to that of the Boteti, predation levels of livestock by lions in the CT 11 region are at their highest during the dry months of the year (Hemson 2005), when the zebra migration is resident along the Boteti. During these dry months the abundance of resident prey is low (Maude 2010), so that lions and other large predators have little choice but to kill livestock if they are to remain in the area. The lion population is therefore supported by livestock above what it might be in a natural system. Table 17 shows

that outside of the park in the wet and dry seasons, the community area of CT11 has up to 17 times more biomass of animals than within the national park. This is mainly due to livestock present within CT 11 but helps explain why carnivores move out of the park and come into conflict with farmers during the dry season. While these data were collected only within the CT11 region, they will more than likely reflect a similar pattern of differential animal biomass around the rest of the MPNP. The result helps to explain why predators from across the region are drawn to move out of the comparative safety of the Park and into the community areas in search of food

Table 17: Diurnal and nocturnal biomass estimates (BM) of wildlife and livestock for different zones around and within the MPNP for the wet and dry seasons

Transect Type	Location of transect (Biomass (kg/per km2))		
	MPNP	Community Areas	Boundary region
Wet night	55.6	59.3	80.0
Dry night	65.8	47.6	32.6
Wet day	1,378.6	9,407.5	12,177.3
Dry day	287.3	5,130.2	1,136.7

Source: Maude 2010

There are many cattle posts located in close proximity to the MPNP boundary and apart from the Makgadikgadi fence along the western and southern Park boundaries there no barriers to prevent movement of predators out of the park, or livestock inside. Livestock move freely and often remain in the bush overnight and will grazes deep into the national park. From a survey of pastoral farmers by Hemson (2005), only 3% of farmers said that they herded their cattle during the day, thereby having no influence on where they went and how far they traveled from their cattlepost, while only 13% said that they regularly kraaled their cattle at night, so that freely moving cattle could move many days travel from any cattlepost. Under these circumstances predation of livestock by predators is inevitable.

Phuduhudu

The proximity of a large village with a significant amount of free roaming livestock in close proximity to the MPNP will inevitably lead to human wildlife conflict. The exact levels of conflict have not been quantified within Phuduhudu by independent research and we are dependent upon gaining information from the PAC records to more accurately define the problems in this area. The extent of the problems will be linked to the amount of wild prey available to predators through the seasons and the ease of access to livestock as is the case to the east, west and south of the Park.

3.5.5 Mitigation strategies for Human Wildlife Conflict and application / problems in the Makgadikgadi Region

Community awareness in the Makgadikgadi

Community awareness has been at the forefront of the fight against human-wildlife conflict within Botswana, but its application has been uneven. Areas such as Chobe and the pan handle have received greater attention, with much of the Makgadikgadi ignored. A recent World Bank Funded initiative implemented by the Department of Wildlife and National Parks (DWNP) to improve awareness and training of mitigation skills has only selected two settlements within the Makgadikgadi: Xhumaga and Moreomaoto, with other areas of intense conflict such as Rakops, Phuduhudu, Gweta and Nata ignored. Many of the

communities within the area are unaware of new simple techniques such as the chilli pepper technique, having only heard about it from the radio and TV.

Way Forward – Need to improve the extent and duration of community awareness programs in the Makgadikgadi, especially in light of fluctuating environment and consequential changes in the areas affected by conflict and the relevant intensity and type of conflict. E.g. expanding elephant population and people's current lack of readiness to combat the conflict.

Direct Compensation in the Makgadikgadi

In Botswana compensation is paid to all those farmers whose livestock is killed or crops are damaged by wildlife outside of PAs and only to those who can prove they have adequately protected their property. In mixed land use MWAs compensation is also paid, but at the same level. The communities often bitterly complain that the scheme is not fair, paying a far lower value than the damage caused, while the system is also blamed for being slow and ineffective. These views were expressed at each of the four focal group discussions held at Gweta, Phuduhudu, Rakops and Mmatshumo, citing low relative compensation, delayed assessment and subsequent payment. As an appeasement method, direct compensation it is not working. Within the Makgadikgadi People are embittered about wildlife and place even more blame onto the government for not dealing with the issue properly.

During the FGDs nearly all of the farmers complained about the system, identifying the value of payment, assessment procedure, the efficiency of assessment and the removal of some species such as hyenas from the compensation list as issues of most concern. They said that the levels of payment must be increased to a properly compensate for their losses, while slow assessments meant compensation was always paid very late.

Way Forward– Need to change the direct compensation system paid by Government to farmers, as it is not working as an appeasement method and creates greater levels of antagonism towards Government and consequentially wildlife. Alternative forms of compensation should be investigated such as Insurance Schemes. These are operated at a community level with quick, well paid compensation that is policed by the communities themselves, i.e. if a farmer is not utilising practical forms of mitigation such as herding / kraaling / fencing etc then compensation is not paid. These factors are much better assessed at the community level.

Indirect Compensation in the Makgadikgadi

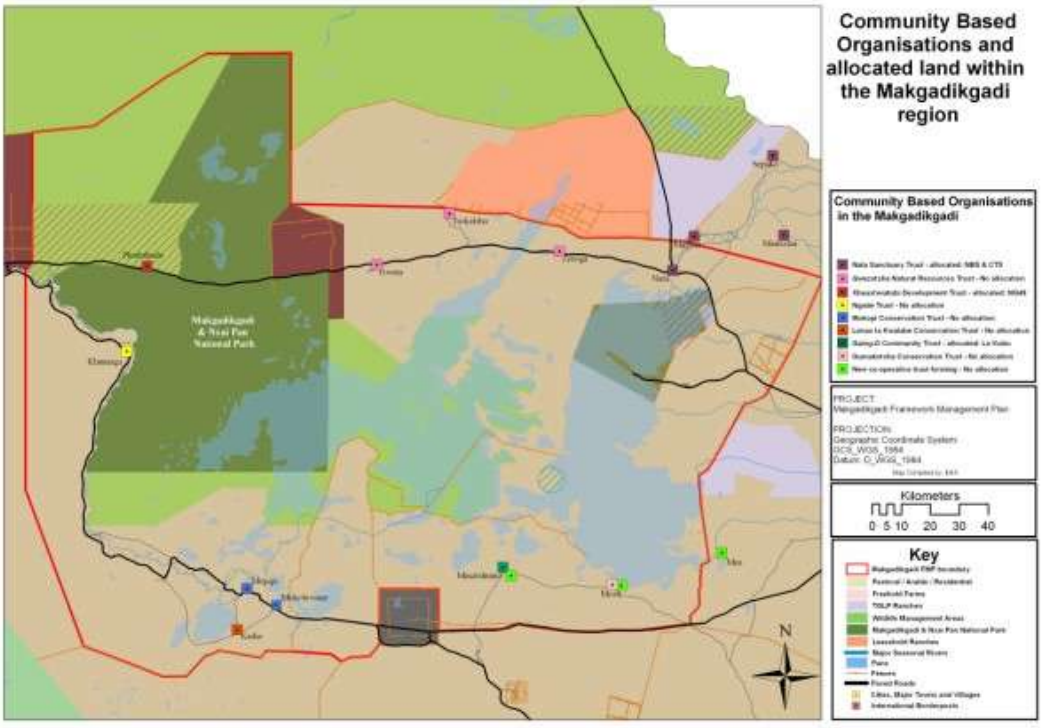
The CBNRM movement has been operational within Botswana since the 1990s, with differing levels of success. Many of the WMAs around PAs have been allocated to communities through a representative legal entity. Many of these 'Trusts' have gone into partnership with commercial tourism operators to manage and run tourist facilities within these areas, but little or no financial benefit has been seen to trickle down to the household level. Poor supervision at the start of the CBNRM movement in Botswana, along with corruption in the community trusts are some of the principal reasons for the failure of the system, so that the Botswana Government has recently reviewed how funds accrued through the CBNRM system will be used to benefit communities (CBNRM Policy, 2007).

In total only 1,895km^2 of land is allocated towards communities for community based management in the Makgadikgadi region (Nata Bird Sanctuary; 230km^2 / CT5; 536km^2 /

NG49; 1,128KM^2 / Le Kubu; 1km^2). More land needs to be allocated for the use of the communities. This land allocation could take the form of tribalisation of some state land such as CT10 and CT11, or the leased allocation of these areas to communities for subsequent tendering of these areas to the private sector. Tourism sites should be identified across the region, with some of these earmarked for allocation for community management. Management could take the form of total community management or joint management with a joint venture partner. To determine which sites could be allocated to which community, it will first be important to identify which communities have affiliations with different areas, and which communities may be able to work together. Those communities that suffer the most from human-wildlife conflict should be prioritised with regard to allocation.

Way Forward – Need more community allocated WMAs and/or tourism sites in the Makgadikgadi region or other areas that are allocated to community based organisations or Trusts in which to operate tourism initiatives. The Trusts must be carefully managed with improved monitoring to ensure fiscal responsibility and accountability. An assessment of current community affiliations with different areas of the Makgadikgadi and which communities are able to work together must first be undertaken before site allocation. Thos communities that suffer the most from human-wildlife conflict must be prioritised with regard to allocation

Figure 46: Current CBO active within the Makgadikgadi region and the allocated land under their management



Insurance Schemes in the Makgadikgadi

There has been limited use and implementation of insurance schemes in Botswana, but communities have been presented with the idea in recent consultations, although none are known to be operating within the MFMP area.

During the FGDs, none of the farmers said they had heard about Insurance schemes, while there was significant interest about the scheme in Gweta (90% of participants said they would like such a system), it was the least favoured option in Rakops and Mmatshumo from a list that also included; provision of practical mitigation training and development of in-direct benefit systems that included tourism and game farms.

Way Forward– Insurance schemes could provide an improved alternative to current direct compensation. The Botswana Government could divert funds from direct compensation into helping establish the Insurance Schemes, while the creation of improved opportunities for trusts and CBNRM activity in conflict areas will provide further support of the schemes. Increased community awareness about the schemes is vital.

Crop Protection Strategies

A) Fencing Fields in the Makgadikgadi

Most communities fence their fields within Botswana, but the implementation of fencing is variable. Some farmers have not refurbished their fences for many years, with signs of dilapidation, while others invest heavily in wire fencing combined with thorn bushes. The most common form of fencing is *Acacia* thorn bush, which while effective against larger problem animals does not stop species such as porcupines.

The percentage of people who fenced their fields according to feedback from the FGDs varied according to their location. Only 50% of arable farmers from Mmatshumo erect fences, as their fields are protected by drift fences, while in almost all farmers fence their fields elsewhere. The most popular form of fencing is using traditional thorn branches with almost 50% of those who do fence their fields using just branches, while a 30% use wire fences and branches.

B) Chilli Pepper Deterrents in the Makgadikgadi

There has been a significant push by the DWNP, NGOs and independent researchers within Botswana to improve community awareness and implementation of the chilli pepper mitigation strategy. Most of the focus has been along the Pan Handle of the Okavango and in the Chobe District, where elephant populations are higher. However, the increasing spread of the elephant population south into the Makgadikgadi requires this information and assistance to disseminated and spread across the northern Makgadikgadi region.

During the FGDs some of the farmers had heard about the strategy, with some preliminary training provided in Gweta, but nearly 100% of all farmers showed an interest in learning more about the strategy and its effective implementation.

C) Field clusters in the Makgadikgadi

There has been an increased appreciation of the vulnerability of isolated fields in Botswana. Research undertaken by DWNP in the early 2000s showed that there was also poor decision

making in the site selection, with fields located close to elephant foot paths and isolated from other fields (Mosojane, 2006). However, while this information has been acknowledged and incorporated into land use development plans there is still little evidence of coordinated implementation. Improved departmental coordination is required between the Department of Wildlife and National Parks / Department of Lands / Tribal Land Boards. The approach to field allocations must change in conflict areas.

Way Forward– From the review it is clear that the combined use of field clusters, with a strong protected fence around the periphery and protected with chilli-pepper impregnated rags forms the best field protection strategy. Communities must be encouraged to work together in protecting these clusters, while fields must be allocated or re-allocated within defined locations for clusters. Improved cross departmental coordination is vital to help implement this strategy, while all farmers must be encouraged to fence their fields to limit conflict. Compensation should only be paid for fields in clusters in conflict areas.

Potential field clusters that could be designed around villages and settlements such as Nata, Gweta and Phuduhudu in the northern part of the FMP area are illustrated in Figure 48. These could help reduce the impact of human-elephant conflict especially. The field clusters could be arranged around existing 'clusters' with additional space to allow for human population expansion and an increased demand for land. Clusters are prioritised closer to the main settlements, as those fields at the extreme periphery of any settlement ate more liable to conflict. People with peripheral fields outside of clusters would be compensated for moving their fields.

Figure 47: Arable field distribution within the Makgadikgadi region.

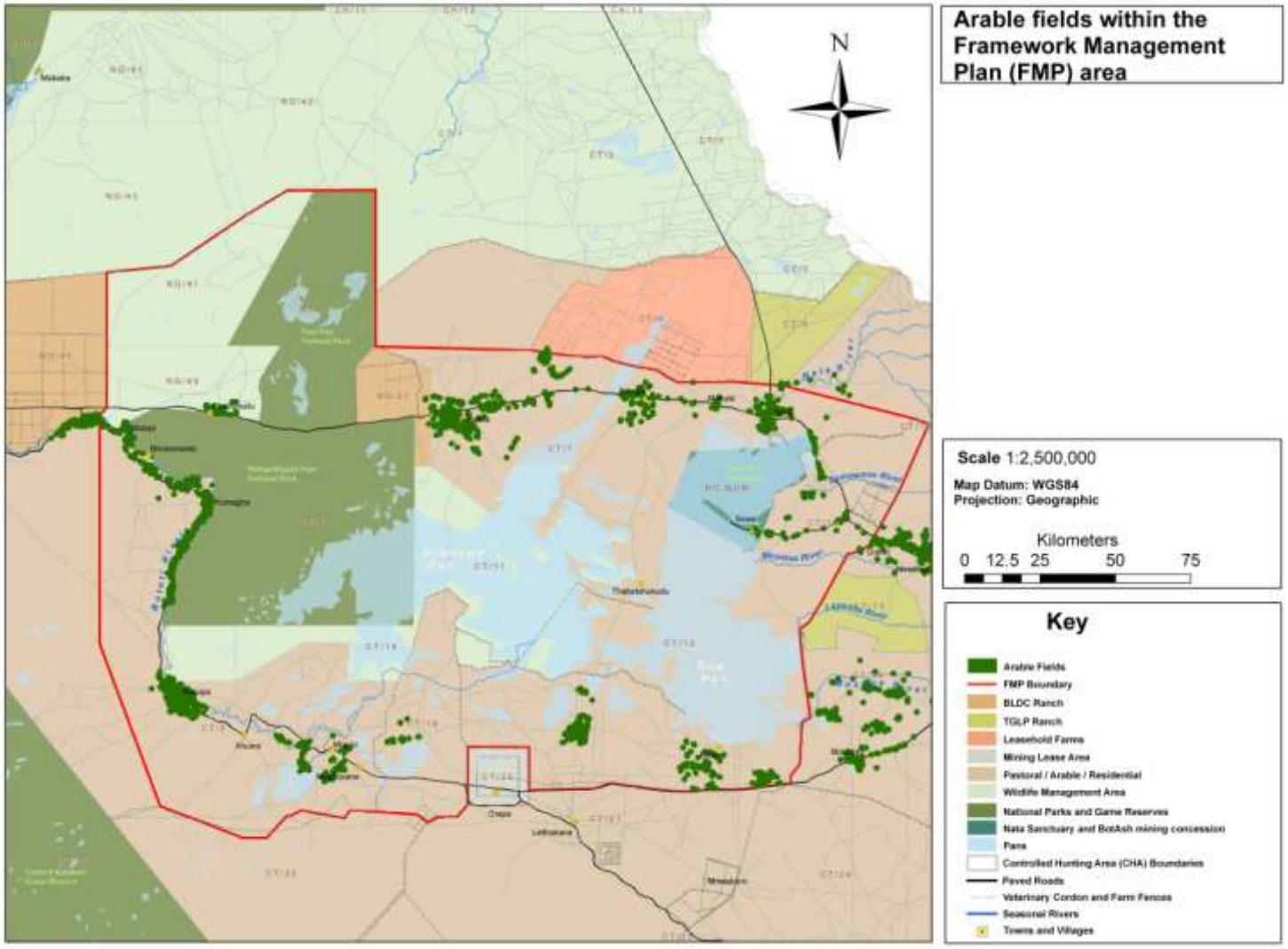
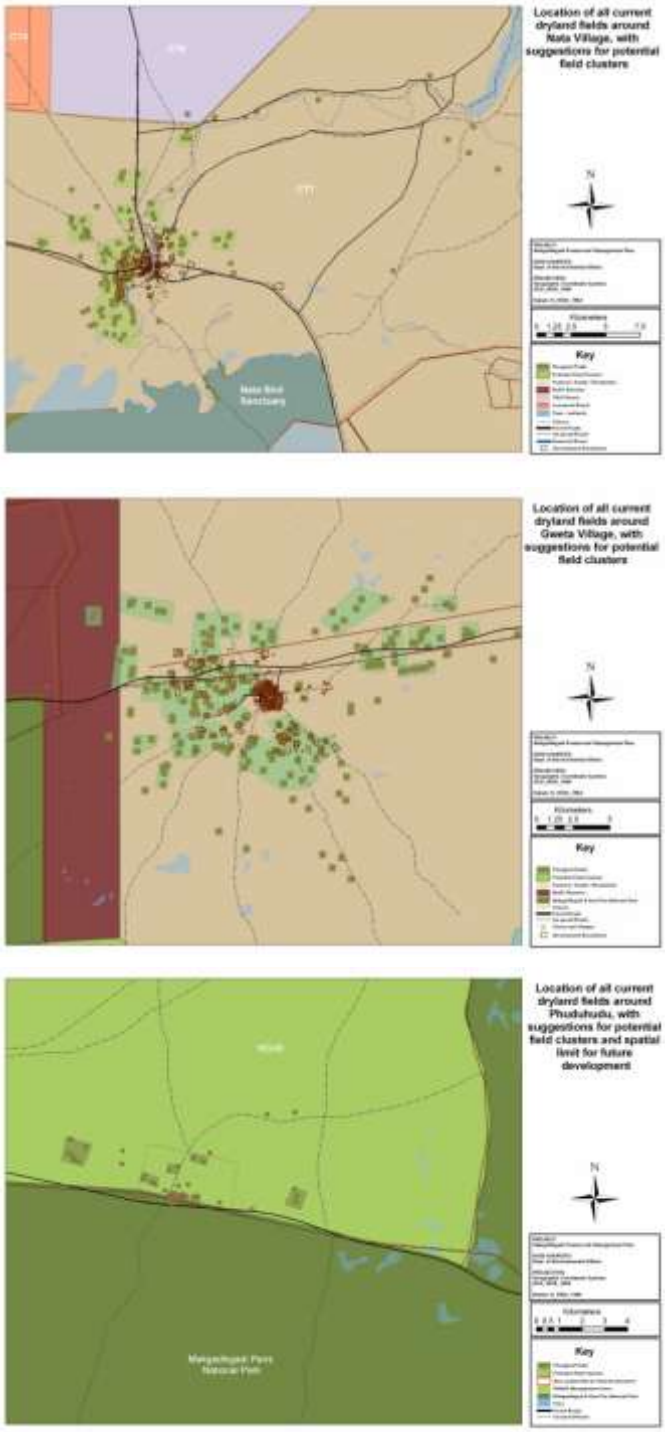


Figure 48: Potential field clusters for some villages in the MFMP



Animal Husbandry

A) Herding in the Makgadikgadi

In the Makgadikgadi, and across most of Botswana, the lack of available surface water ensures that cattle walk back to their kraals on most nights to drink. Cattle are then enclosed for the

night and released the next day to graze. This system does not require the attention of a herd boy. For families with small herds and limited resources it is hard to stimulate a change in behaviour, but for remote owners using the 'mafisa system' the employment of herd boys is more common practice, so that the relative impact of conflict is placed more heavily upon the poorer families.

B) Kraaling in the Makgadikgadi

There is a large variation in the use of cattle herding across the region. A mean of 77% of farmers at the FGDs across the region kraal their cattle at night, which leaves 23% of cattle herds across the region liable to depredation. While people know the potential dangers of leaving their cattle out at night the increased workload would seem to be an obstacle for some. An approach was undertaken by the Kalahari Conservation Society, in association with the Makgadikgadi Lion Research Project in the late 1990s, to help pastoral farmers along the Boteti River improve the use and design of their kraals. While it was clearly proven that an improved rate of kraaling had a significant impact on reducing the rates of depredation on cattle, people in the area were reluctant to undertake the additional demands of herding activities, while after the end of the project the upgrading of kraals by farmers in the region was stopped. Farmers found it easier to blame the government for the problem, expecting DWNP to solve the issues rather than taking a pro-active role in conflict mitigation themselves.

Way Forward – Community awareness programs once initiated must be continued for extended periods, otherwise the taught mitigation methods fall out of practice. A change in herding behaviour within communities cannot be readily expected, and improved incentives required to encourage farmers to kraal livestock, such as the use of community based insurance schemes, where compensation is paid locally – communities are better able to determine who is kraaling and who is not than DWNP. Payment of any form of compensation must be linked to good kraaling.

Problem Animal Control

A) Non-lethal methods in the Makgadikgadi

i) Translocation

In Botswana translocation of problem animals has been employed across the country, but specifically within the Central Kalahari Game Reserve (CKGR) and the Kgalagadi Transfrontier Park (KGP). From 1997 through to 2001, 38 male lions were translocated up to 50km into the park, of which 14 were translocated more than once within the 4 years, as they returned to their original territories following each translocation event (FAO,2008), while in Namibia a similar record of observations has been made (WWF SARPO, 2005). While levels of conflict are high in the Makgadikgadi problem lions have not been captured and translocated. The majority of problems lions are shot by local farmers before the DWNP can react to any specific problem.

ii) Change in spatial movement patterns and feeding behaviour of predators

Hemson (2005) showed that, before the erection of the fence the majority of lions were either resident on the east or western side of the park, with a small number of migratory individuals. Resident lions, which remain in either area after the zebra and wildebeest leave are therefore

responsible for the majority of conflict in the absence of the zebra. While it would appear that since the erection of the fence, and the newly developed water holes (10) in the Boteti region, the wild resident herbivore population (i.e.; impala, kudu, hartebeest etc and therefore exclusive of the temporary present zebra) numbers have increased in the region, their numbers are probably not as yet sufficient to fully support the resident lion prides. The fence may be responsible for helping the numbers of resident wild herbivores increase by restricting access to the park for poachers, but it is most likely that restricting access to cattle within the park and improved rainfall over the past 5 years has resulted in improved resource availability, facilitating the herbivores population increase. If this trend continues and the wild herbivore numbers increase the lions may adjust their foraging behaviour. However, such an increase in resident herbivore densities may still take many years and it may be possible to affect the lions foraging behaviour through other means. To get the lions to prefer selecting wild prey over livestock, a method called Controlled Taste Aversion could be used to condition the lions feeding behaviours (see below). Even at present, with relatively low resident wild herbivore populations, such a system could be successful. The zebra and wildebeest migration is often only no more than 1 days travel away for a lion from either the Boteti or CT11. Using a system such as Controlled Taste Aversion could compel lions to move towards the migration in search of wild prey over selecting livestock.

Therefore the two main approaches to attempting to adjust the spatial ecology of the predators are to increase the wild prey density or use Controlled Taste Aversion.

a) Increasing wild prey density within the Boteti Region

i) Translocate game- While the wild herbivore populations along the Boteti are potentially increasing, the rate of increase is still slow, as the remaining numbers of impala, kudu and hartebeest had been reduced to almost a point of no return by competition for resources with cattle and by poaching. The ecological factors are now more favourable to such resident species and the rate of increase of these species would be served well with the introduction of more numbers. The fence remains a significant barrier to herbivores (cutting off access to significant portions of the riparian woodland and access to the flowing river) and although the introduction of wild game into the Boteti area may have mixed results, the translocation of species such as kudu, impala that typically live in the woodland habitat associated with the Boteti area would help to increase the wild prey densities in the future. This would only serve to help reduce the selection of livestock by predators. Game could be translocated from destinations such as the Orapa Game Farm, where there are more than 700 impala, 200 eland, 120 kudu and 60 hartebeest. Just a fraction of these numbers translocated into the Boteti region could help propel the increase in the resident populations.

ii) Provide water holes to the east of the Boteti- The resident lions prides in the Boteti area spend a significant amount of their time within a few kilometers of the fence and thus the western boundary of the MPNP. When the zebra leave the Boteti region and move eastwards, the lions remain living close to the fence and are easily attracted by livestock on the other side of the fence. Developing extended pipelines pumping water into water points further from the fence would help to improve resident wild herbivore densities in these localities, which may serve to also attract lions away from the fence. The recent provision of artificial water holes by KCS and DWNP has been very close to the riverbed, and within the dense riparian thickets. The habitat has not proved conducive to attracting wild herbivores

which are afraid to spend long drinking at these water points. Moving the water points further from the riverbed would help serve two purposes; 1, attract wildlife densities away from the fence and 2, improve the relative use of the new water points. If one or two water holes where located approximately 5-10 km east of the riverbed, resident herbivore densities in the area will increase. Care would have to be taken before providing such water holes to be sure they did not influence the migratory patterns of the zebra detrimentally. Further thought and consultations would be advised before doing this.

b) Controlled Taste Aversion

Conditioned taste aversion (CTA) is a form of learning for animals that involves a natural defensive mechanism enabling predators to survive encounters with prey with toxic anti-predator defences (Milgram *et al*., 1977). When mammalian predators experience illness after consuming prey with toxic defences, they form an aversion to the taste and scent of these prey animals (Riley & Tuck 1985). Long after recovering from the effects of a sub-lethal dose of the toxin, predators will avoid offending prey wherever they are encountered. In a natural system, any predator fortunate enough to survive the first encounter with toxic prey (such as a bird eating a poisonous beetle) form a rapid and permanent learned aversion to the prey, which reduces the risk of future incapacitation or death.

The use of CTA in mitigating wildlife conflict has shown that predators develop an aversion to prey in a way that could for example, stop them from killing livestock. A single meal of food containing a hidden dose of an aversion agent can produce very long lasting aversion to the taste and scent of target prey among mammalian predators and to the visual characteristics of prey among avian predators. The procedure includes offering predators meat baits composed of ground meat of the target livestock species wrapped tightly with fresh hide of the same livestock animals. Hidden within the bait is a dose of an aversion agent sufficient to induce the physiological effects that produce the aversion, but otherwise undetectable by taste or scent. In this way upon encountering the bait the predator must chew through the hide to obtain the meat inside. In so doing, the predator is exposed to the exterior taste and scent of the target prey. Then the predator very quickly consumes the interior meat. Within about 30 minutes the aversion agent induces a short-term change in physiology that can be described subjectively as “nausea”. The predator shortly recovers and the only lasting effect is a dramatic change in the willingness to approach and attack target prey with the same taste and scent as that of the baits that induced the aversion effect. Even though the meat bait is inanimate, predators will still avoid targeting live prey because the scent and taste of these prey have become aversive and this “learned disgust” disrupts the normal predatory sequence of behaviour. Since most predators track their prey by following scent, then predators with an aversion to livestock tend to avoid, rather than follow the scent of livestock. This tends to maintain distance between the two. CTA is also estimated to be 86% cheaper than using poison control efforts (Gustavson et al. 1982).

There are some questions that still need to be answered as to if the method will work with lions as it has not been tested yet and also as to how this method can be implemented effectively in the field with free ranging lions. However, if proposed tests on captive lions prove successful it would be worth experimenting with the method on the lions in the Boteti region.

B) Lethal Control of Problem Animals in the Makgadikgadi

The DWNP through its problem animal control (PAC) division undertakes lethal mitigation across the country where persistent problems occur, with a limit of up to 2% of the local population

that can be lethally controlled. However, DWNP prioritises translocation of predators over lethal control. The Governments implementation of the lethal approach is mainly focused on elephants. The costs involved in translocating elephants and the large size of the elephant population have lead to an increased use in this practice. However, the increased use of this practice is a cause for concern, with high incidents of lethal control reported from across the northern part of the FMP. There are no minimum thresholds or quotas and the system is open to mis-use by communities as the meat from the killed animal is shared amongst the community. Communities can therefore over state the level of conflict to gain direct benefit. The potential detrimental impact of this strategy was highlighted in NDP10, with recommendations to reduce the killing of problem animals by 10% from current levels.

The impact on the mortality of lions on lion/human conflict in the Makgadikgadi region is clearly shown by figures that show reduced levels of conflict after the lifting of the ban on shooting lions, due to farmers responding to this by purposely killing lions. The lethal control of predators is much debated on many levels both moral and otherwise. However, what can't be disputed is that with the removal of predators livestock predation will decrease. The concern is as at what level does the viability of predator populations become compromised? There are three sources of human induced lion mortality; 1, by PAC removing problem lions, 2, through commercial hunting and from 3, the farmers killing problem lions. At present commercial hunting of lions is banned. Killing lions in defence of livestock by farmers is allowed if they kill lions only using a legal method. Shooting is allowed and the use of gin traps close to the farmer's home. The use of poisons to kill carnivores is banned. PAC units are not presently using lethal methods of control, but are translocating problem animals into protected areas.

Thus the level of lethal control of lions that predate livestock in the Makgadikgadi is entirely down to the number of lions killed by farmers. Allowing the farmers to kill lions is an effective and cheap way of reducing livestock predation as showed by the significant reduction in livestock killed in 2005 and 2006 when farmers were again allowed to kills lions in defence of their livestock. However as it can't easily be controlled, viable carnivore numbers in the region could be threatened through persecution by farmers. As such is it important to enforce present rules controlling the number of lethal controls of predator and the circumstances under which they are eliminated by farmers.

Way Forward – A review of the impacts associated with the translocation of problem animals must be undertaken. Is it cost effective or even beneficial? Minimum thresholds for conflict must be set before lethal control is used. Conflict reports must be assessed immediately through more localised structures, otherwise the system is open to abuse, while the wrong individuals are liable to be killed through delayed implementation.

Fencing in the Makgadikgadi

Within the Makgadikgadi there are a significant number of fences aligned across the region (Figure 49); farm fences, drift fences, veterinary control fences, conflict fences, with one fence having recently been decommissioned, while another has been proposed to the east of the

Makgadikgadi Pans National Park. This was to be developed within NDP10, but die to financial constraints has subsequently been delayed. Until when it is not presently clear.

The fences in the Makgadikgadi region were erected between the 1960s to the mid 2000s to help control the spread of disease and to try and improve cattle production through commercial ranches, while a series of drift fences were erected to the south of the salt pans to reduce conflict between pastoral and arable agricultural practices. In some cases historical records of wildlife numbers are not accurate enough to determine what impact these fences have had on local wildlife populations, but some of the fences have been associated with mass die-offs events and are known to restrict wildlife movement;

A) The Phefodiafoka fence has blocked the movement of wildebeest from the CKGR northwards towards the waters of the Boteti River and Lake Xau (Williamson & Williamson 1981, Williamson and Mbano, 1988; Parry, 1987). Wildebeest found west of Rakops between the Boteti and the CKGR are thought to be a remnant this CKGR population, while wildebeest translocated from CT8 into the Makgadikgadi Pans National Park in 2004 after the erection of the Makgadikgadi fence are also believed to have been a relic of this migratory population. Mortality of wildebeest along the Kuke fence and eastern CKGR boundary fence has been an area of concern and was recently assessed by DWNP (Makhabu, 1999).
B) The Nxai Pan buffalo fence was erected in 1968, to the north-west of the Nxai Pan National Park. Measuring 100 km in length, it cut off an important migration route between the Okavango Delta and the Makgadikgadi system. It is not known what impact this had on wildlife population levels as little to no research was undertaken in this remote area. However, in the late 1990s the fence was recognized as no longer serving any veterinary purpose, and was officially declared a 'decommissioned' fence (Albertson, 1998). The fence was finally decommissioned in 2000, with a subsequent positive impact on wildlife. Bartlam-Brooks (2009) found that zebra had re-established the migratory movement between the Delta and the Makgadikgadi, with further evidence of the importance of this route confirmed by Chase (pers comms), recording elephant movement along the same path as the zebra.
C) The veterinary cordon fences aligned within and across the salt pans of the Makgadikgadi have detrimentally affected bird populations. Flamingos fly low over the salt pans between breeding and feeding areas and have been significantly affected by these poorly aligned fences.
D) The Makgadikgadi wildlife conflict fence is the most recent fence to be erected. The fence was developed in response to the dramatic increase in levels of human-wildlife conflict along the Boteti River, following the drying-up of the River in 1991. While associated with small isolated die-offs within poorly aligned sections of the fence it is believed that the fence has had a positive impact to the wildlife populations of the region by mitigating the conflict for grazing resources between livestock and wildlife. The fence has not however successfully reduced the levels of human-predator conflict with depredation of cattle and the lethal control of lions by community members still common place. The most important step that would result in the biggest gain in reducing predation of livestock by lions in particular, but also other carnivores, would be to reduce the permeability of the fence. This could be done in steps depending on the available budget and logistics involved as outlined below:

1) The fence could be electrified again as was initially done after the fence was erected. The presence of electricity along the fence made it less permeable. The sections of the fence that cross the river can be by-passed.

2) The fence could be "dug in" section by section starting in the areas with the highest densities of lion and those areas that account for most of the lion associated conflict or the so called "hot spots". Although it would not be as effective, this could be done relatively cheaply by instructing the grading team (clearing the line of the fence free from vegetation) to push soil towards the fence and pile the soil up against the fence.

The hot spot sections include:

i) The section of fence running opposite Xhumaga village northwest from the DWNP entry gate up to approximately 5 km past Leroo- la- Tau lodge.

ii) The section of fence running opposite Meno-a-kwena safari camp south for 3 km and north for 4 km.

iii) Eventually aim to achieve having dug in the fence running from the main Maun-Gweta tar road all the way down to the DWNP entry gate and Xhumaga.

iv) To finally have the whole fence dug in but with maintenance emphasis on the "hot" spots.

3) To ensure that maintenance schedules on the fence are regular in particular in the defined "hot spots" and harness tourism operators in the area to help maintain sections near their lodges. As holes appear they need to be closed up swiftly. Tourism operators have shown a willingness to help participate in fence maintenance.

The implementation of the fencing component in the National Agricultural Development Policy initiated the erection of drift fences across select areas of Botswana, including within the FMP study area; such as around Mmatshumo. These single 1.2m high fences were erected with the sole purpose of limiting conflict between livestock and wildlife. When this aspect of conflict is assessed it is clear that the implications of the livestock – arable conflict can be as severe as that wildlife-arable conflict. It is therefore important to view livestock conflict at a wider scale, associating the conflict more with land use issues that purely wildlife issues. While fences are effective at limiting all forms of conflict, it is clear there have severe limitations at the ecological scale, but the application of this strategy also has social implications. By erecting fences around wildlife areas communities become cut-off from wildlife and in many cases the benefits that wildlife may provide; i.e. the indirect benefits of wildlife. It is essential to ensure that "separation" of wildlife and people does not hinder "integration" of culture and nature in the landscape, so that people can benefit from tourism, and still practise other land uses such as pastoralism and agriculture (Lamarque *et al*., 2008).

Way Forward – The rationale behind the development of each conflict and disease control fence should be reviewed and compared with current levels of effectiveness. Are fences within the Makgadikgadi region fulfilling the jobs they are meant to? If not how can they be improved or should they, or sections of them be decommissioned.

Further assistance must be provided to communities to improve the current levels of crop and livestock protection through fencing. The provision of assistance should only be provided for clustered fields, where possible and collective kraals where possible.

Figure 49: Fence alignments within the Makgadikgadi FMP area

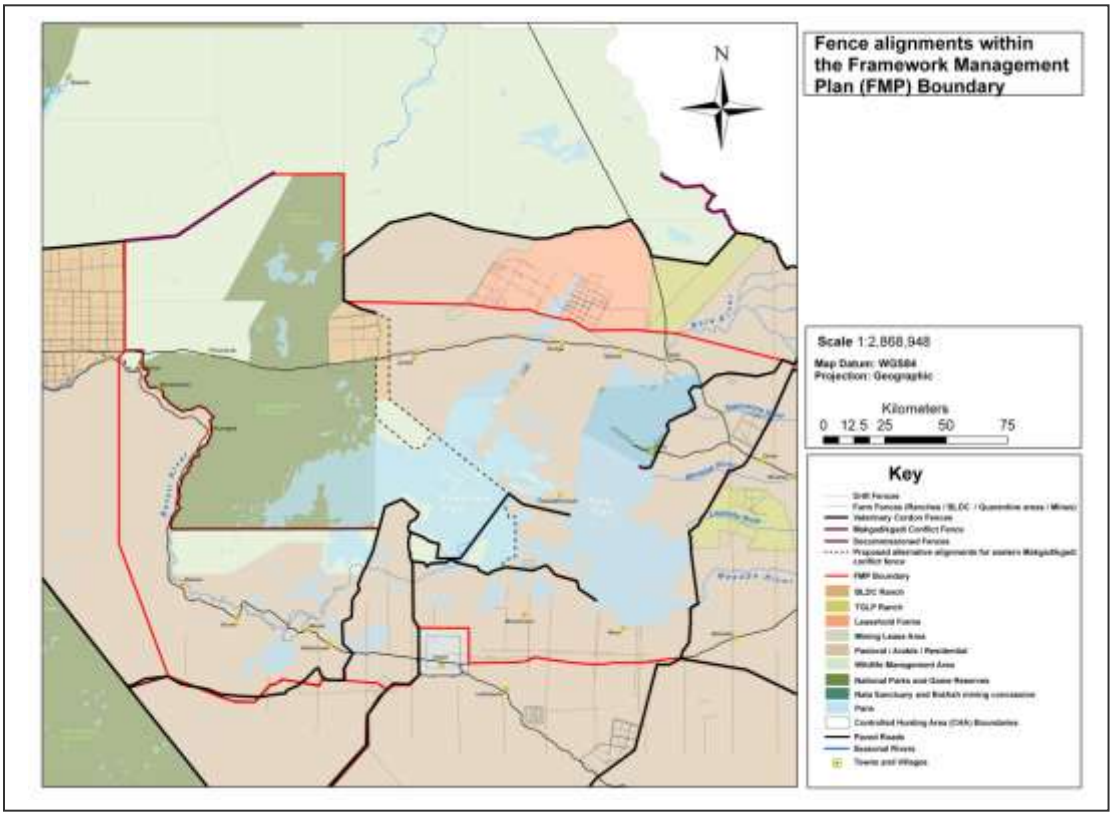


Figure 50: Department of Veterinary Disease control zones

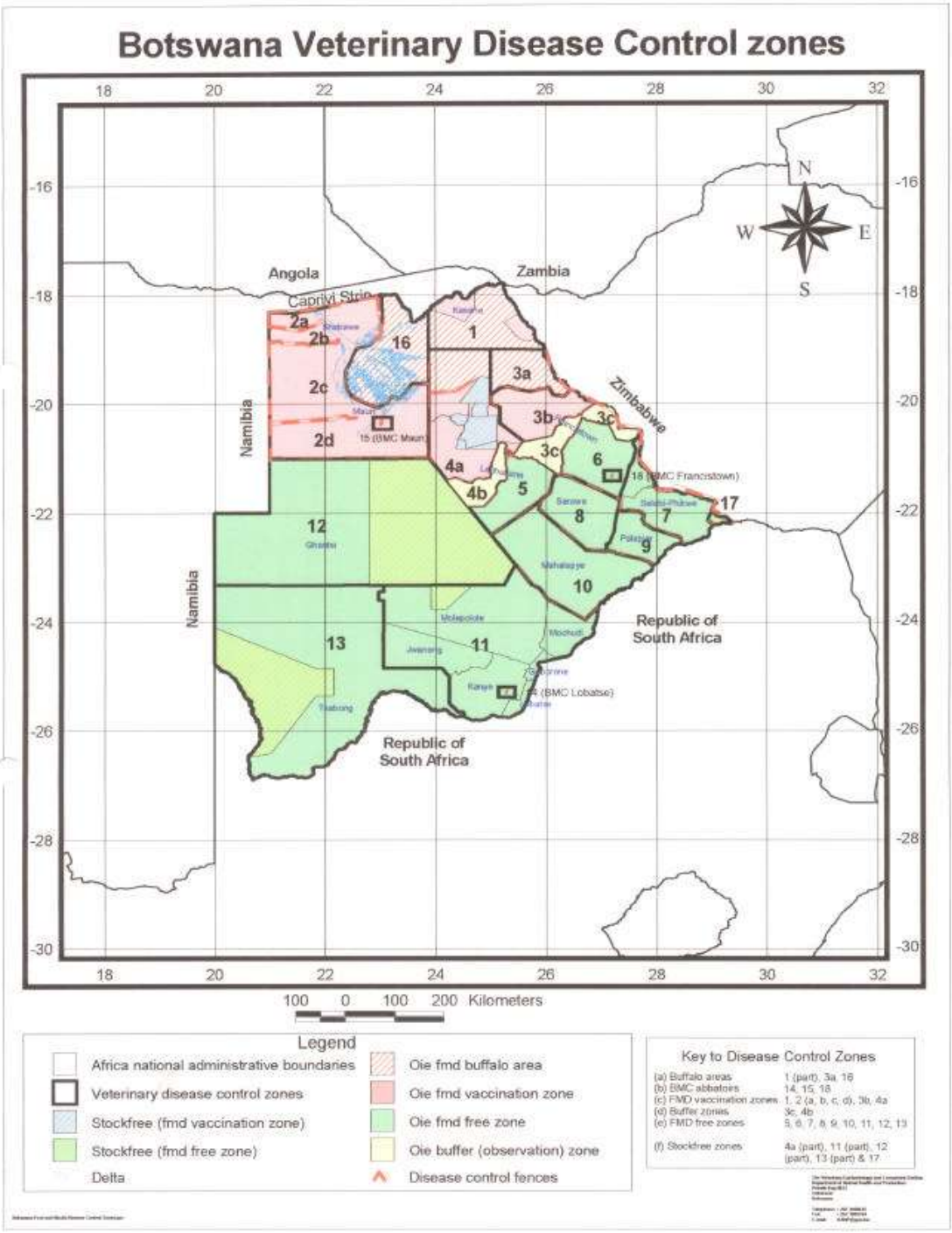


Table 18: Makgadikgadi Fences Review

Fences	Location	Date Erected	Purpose & Type	Effectiveness	Benefits	Negatives	Recommendations
Phefodiafoka fence	Along the north-eastern border of the CKGR	1996	Conflict Mitigation / Single fence; 1) Requested by communities to stop cattle intrusion into the CKGR and reduce depredation of cattle by predators 2) Separates CT8 to the east of the fence, which is an FMD vaccination zone , from the CKGR, an FMD and stock free zone	Stops movement of most large mammalian wildlife out from park and cattle into the park. However is transgressed by lions / cheetah / leopards limiting effectiveness at mitigating conflict	Controls potential spread of FMD from the Boteti and Makgadikgadi region into the CKGR, from where it could spread to the important cattle regions of Ghanzi. However, CT8 (Vet. Zone 4a) is soon to be declared an FMD Free zone, nullifying the disease control requirements of the fence.	1) Has blocked the movement of wildebeest from the CKGR northwards towards the waters of the Boteti River and Lake Xau 2) Restricts the connectivity of the northern conservation area from the southern conservation area and all the benefits this would bring the ecological system of Botswana 3) Mortality of wildebeest along the Kuke fence and eastern CKGR boundary fence has been an area of concern and was recently assessed by DWNP (Makhabu, 1999).	Review the potential for a fenced corridor link between the CKGR and the MPNP, with an extension of the Phefodiafoka fence
Western Orapa fence	Along the western boundary of Orapa and continuing up	1979	Disease Control / Single fence; 1) Separation of wildlife areas to	Initially effective. Later followed with the development of the Kedia fence to create a buffer	Controls potential spread of FMD from the Boteti and Makgadikgadi region into the main cattle	There are no known significant detrimental impacts to wildlife caused by the fence, as the fence is aligned	Assess the current role the fence plays in disease control now that the FMD buffer

Fences	Location	Date Erected	Purpose & Type	Effectiveness	Benefits	Negatives	Recommendations
	along the eastern border of CT19 and to the south along the eastern border of CT20		the west and north from the veterinary FMD free zone 5	zone between the FMD Free Zone and the FMD Vaccination Zone along the Boteti River	areas of Central District	away from existing concentrations of wildlife.	zone 4b has been declared a green zone.
Kedia fence	Along the northern boundary of CT20 and then surrounding the western, northern sections of CT19 and then along the south-western part of Sua Pan towards Mosu	1988	Disease Control / Double fence; 1) Creation of the Vet. buffer zone 4b, an FMD observation area in association with the western Orapa fence, which includes CT20, a fencing component ranch 2) Restricts movement of cattle and wildlife from the FMD vaccination zone 4a	The fence is effective in restricting the movement of cattle in this region. There is limited wildlife movement in the area (other than that within CT8). The upgrading of zone 4a, however, to an FMD free zone brings into question the need for the fence.	1) Provides an effective buffer zone from the current FMD vaccination zone 4a to the FMD free zone 5. 2) Acts as an effective drift fence, restricting movement of cattle out of CT19 and into the pastoral areas of CT8	There are no known significant detrimental impacts to wildlife caused by the fence, as the fence is aligned away from existing concentrations of wildlife.	Assess the current role the fence plays in disease control now that the FMD buffer zone 4b has been declared a green zone.

Fences	Location	Date Erected	Purpose & Type	Effectiveness	Benefits	Negatives	Recommendations
Makgadikgadi Conflict Fence	Along the Boteti River and southern boundary of the MPNP	2004	Conflict Mitigation / Double electrified fence; 1) Requested by communities to stop wildlife movement outside of MPNP into community areas to reduce depredation of cattle by predators and reduce conflict for grazing resources	The fence has improved rangeland condition for wildlife in the MPNP by stopping cattle intrusion into the park, but has not stopped human-predator conflict as the fence is poorly maintained and predators still move into community areas	1) Reduced environmental constraints for zebra and wildebeest and may enable wildlife population to stabilise and improve 2) Separates wildlife from people and enables communities to align the fence to create potential tourism facilities close to the riverbed	1) Has not stopped human-predator conflict 2) Has made it easier for community members to track predator movement through holes in the fence and undertake lethal control 3) Restricted access for wildlife to important riparian woodland habitat 4) Restricted access for wildlife to Boteti River along 90% of its length 5) Has not been properly maintained and its poor management threatens the upgrade of vet. zone 4a into an FMD Free zone	Improved maintenance of the fence is of absolute importance, while realignment of some sections of the fence would improve access for wildlife to the Boteti River and enable the development of CBNRM initiatives
Nxai Pan Buffalo fence	Along the northern boundary of NG47	1968	Disease Control / Single fence; 1) Restricted movement of buffalo from the Delta region towards the Makgadikgadi and cattle populations	Not effective. Recognised as serving no veterinary purpose in 1998 and decommissioned which was implemented in 2000	None	1) Restricted movement of migratory wildlife such as zebra between the Delta region and the Makgadikgadi and could have had a significant detrimental impact on wildlife numbers in the Makgadikgadi 2) Wildlife mortality was	

Fences	Location	Date Erected	Purpose & Type	Effectiveness	Benefits	Negatives	Recommendations
			in Boteti region			recorded along the fence (Albertson, 1998). 3) Restricted tourism potential in NG47 / NG49 and MPNP	
North of Gweta Fence	From the eastern boundary of Nxai Pan NP, along the northern boundary of CT7 and then around the southern boundary of CT5 to the Zimbabwe border		Disease Control / Single fence; 1) Restricts movement of wildlife south from Chobe WMAs into communal grazing areas 2) Separates veterinary zone 3a, an FMD buffalo area from zone 3b, an FMD vaccination area3) Forms the south-eastern boundary of the northern conservation zone	The fence has been effective limiting movement of wildlife from zone 3a into zone 3b, while channelling seasonal movement of wildlife from the WMAs into the Nxai Pan area	1) Restricts movement of wildlife from the WMAs in to the communal arable / pastoral area of CT7 and the Gweta region 2) Forms an effective barrier to prevent movement of wildlife into the TGLP ranches of CT4 and CT6		

Fences	Location	Date Erected	Purpose & Type	Effectiveness	Benefits	Negatives	Recommendations
Nata fence	Around the northern and western boundary of CT14		Disease Control / Double fence; 1) Restricts movement of cattle and wildlife from the FMD vaccination zone 3b into the observation buffer zone 3c2) Helps create the veterinary departments observation buffer zone 3c	The fence is effective along most of its length at restricting cattle movement, but poor maintenance and recent hostility to changes in the alignment and subsequent holes being cut in response to these changes have allowed cattle to move into the FMD vaccination zone, especially around the Nata Bird Sanctuary	Creates the eastern boundary fence of the Nata Bird Sanctuary and realignment of the fence enables connectivity between the wildlife reserve around the Soda Ash plant and the Nata Bird Sanctuary	1) Realignment of the fence in the Semowane area has been badly received by local communities, with the fence being cut in places	
Eastern Sua fence	Along the eastern boundary of CT14, as far as the Zimbabwe border to the northeast and to the TGLP ranch (CT23) to the southwest of Sua	1955	Disease Control / Double fence; 1) Restricts movement of cattle from the observation buffer zone 3c to the FMD free zone 6 to the east	The fence is effective along most of its length at restricting cattle movement	1) Forms an effective barrier to prevent spread of disease into the FMD free zone 2) Forms the western boundary of the CT15 TLGP ranch		

Fences	Location	Date Erected	Purpose & Type	Effectiveness	Benefits	Negatives	Recommendations
Thabatsakudu fence and Mmatshumo fence	Along the north western boundary of CT21 and slicing into the south-western part of CT11		Disease Control / Single fence; 1) Restricts movement of cattle from the observation buffer zone 3c to the FMD free zone 5 to the south	1) Large sections of the fence are aligned across open salt pan and ineffective at controlling movement of any animal2) The section of fence closer to Mmatshumo restricts movement of cattle into the area around Kubu, in which there are little to no wildlife and it would seem limited threat from disease transmission, the effectiveness of the fence could be questioned	1) There are little to no benefits provided by the section of fence aligned through the salt pan 2) There is limited cattle to the north of the Mmatshumo area and little to no wildlife and the fence serve limited benefits apart from maintaining the boundaries of the buffer zone that might be better developed by other means	1) The fence across the open pan is a hazard to low flying wetland birds, especially flamingos	

Fences	Location	Date Erected	Purpose & Type	Effectiveness	Benefits	Negatives	Recommendations
BLDC ranch (NG45)	Adjoining the Makalamabedi Veterinary control fence		Cattle Production through fenced ranching / Single fences	The fences have since fallen into disrepair and wildlife (predators and herbivores) move across the area	1) The BLDC commercial operation is no longer functional and the ranches are not fully effective 2) Some of the ranches within the BLDC ranch have been leased out to private individuals for game ranching 3) the Phuduhudu community's cattle may be translocated into the BLDC ranch to mitigate conflict	1) The fences extend the wildlife migration from the Makgadikgadi to the Okavango by a considerably distance	
BLDC ranch (NG51)	To the east of the Nxai Pan NP extension		Cattle Production through fenced ranching / Single fences	The fences have since fallen into disrepair and wildlife (predators and herbivores) move across the area	1) The BLDC commercial operation is no longer functional and the ranches are not fully effective		
Nata State Ranches	To the south of CT2 and to the west of CT5		Cattle Production through fenced ranching / Single fences	The fences provide an enclosed for effective private cattle ranching	1) the benefits from the ranching are only derived by the private owners		

Fences	Location	Date Erected	Purpose & Type	Effectiveness	Benefits	Negatives	Recommendations
Mmatshumo drift fences	aligned north south throughout the northern part of CT21	1992	To mitigate the conflict between cattle and arable farming / Single fences	The drift fences have proved very effective at stopping the conflict, by restricting cattle movement into arable areas during the growing season	1) The arable farmers benefit from the fences 2) the cattle farmers do not suffer from the system, as cattle are allowed into the arable areas after the growing season, so that the fences enable a reserve of forage for the dry season		
Proposed eastern Makgadikgadi fence	Along the south-eastern and north-eastern boundary of CT11	N/A	TO mitigate the conflict between people and wildlife south of Gweta	The fence may prove to be effective at mitigating conflict if it is a predator proof fence, otherwise predators will move under the fence during the dry season when the zebra and wildebeest migration is resident on the Boteti	1) The Gweta community should benefit from reduced conflict with wildlife 2) fencing the area will enable improved protection and policing of the CT11 area - possible through as a concession with a tourism operator	1) the fence will restrict access by wildlife into the woodlands to the northern of CT11 which is used by the zebra and wildebeest during the wet season 2) the alignment of the proposed fence excludes an area called KauKae from access by wildlife, at which there is a permanent seep of water - however changing the alignment would exclude cattle from the area	

Land Use Planning

"*Land use planning is a fundamental human-wildlife conflict management strategy which offers possibly the best chance of overall long term success*" (Lamarque et al., 2008). The benefit of applying a land use approach to human-wildlife mitigation is that it tackles the root cause of the problem and if undertaken successfully can create a landscape where people and wildlife can co-exist with limited conflict (Muruthi, 2005). Rather than many of the other mitigation strategies it is a long-term approach and can be used to enhance current land use practices.

To implement effective land use mitigation it is imperative to have government support with a coordinated approach from different government departments, backed up by a strong policy framework. Before commencing with a land use approach, it is first vital to gather in-depth, baseline information to inform decision makers and to make the right land use decisions, if applied rashly, a change in land use strategy can lead to an increase in conflict, rather than reducing it.

To reduce conflict through a land use approach there are four things that can be done; A) alter people's land use activities in their current location, B) move people and/or livestock from the current location, C) move wildlife from the current location and D) create a buffer zone between people and wildlife.

Manipulating human activities in the Makgadikgadi

In the Okavango Panhandle region it has been shown that isolated fields are more vulnerable to elephant raids than clustered fields (Songhurst, pers. comms.). Clustered fields can be defended jointly and more cheaply through deterrents such as the chilli method, while clustered fields can be located away from historical animal paths that lead wildlife towards conflict and away from the boundaries of PAs. By developing a community based approach to implementing mitigation strategies each person becomes jointly responsible for the protection of each other crops and failure to undertake mitigation therefore has extended social repercussions. However, the financial and temporal costs of establishing such a system are high. Most poor rural people cannot afford to undertake this costly exercise and remain vulnerable to conflict.

In the Makgadikgadi there has been no or limited attempt to regulate the development fields at a landscape scale, so that fields are developed where people have applied for them. These are generally within those locations with the best soil, but can be dispersed across wide areas.

Way Forward – The Botswana Government should help to subsidise the abandonment of old fields in conflict areas and encourage communities to develop new fields within clusters. The system could be assisted through funds generated by CBNRM activity. Suitable areas for field clusters must be defined around each village and settlement before they are established.

Relocation in the Makgadikgadi

The approach has been used with success within the Makgadikgadi area. Land was made available for people to the north and east of Gweta to relocate to away from the conflict hotspot on the eastern border of the Makgadikgadi Pans National Park. The offer was taken up by some farmers, but not all who did not always want to leave because of social issues.

Due to the abundant undeveloped land available within Botswana, it is a strategy that could be successfully applied, but would require extensive government backing.

The relocation of the cattle from Phuduhudu has been suggested as the best strategy to reduce conflict levels in this area of the FMP study area. Cattle would be relocated from the settlement which is located within a WMA on the border of the MPNP to the Makalamabedi Botswana Livestock Development Commission's (BLDC's) ranch to the west of Phuduhudu. The ranch has available space, has good grazing resources and is easily accessible from the main tarmac road. There are problems with water access which is delaying the translocation. The translocation is under the jurisdiction of the DWNP who do not have the funds to pump water from Phuduhudu. It could be suggested that water is pumped from the Boteti or a shorter distance boreholes are drilled within the ranches.

Way Forward – Solutions to the problem that is restricting the relocation of cattle from Phuduhudu to the Makalamabedi BLDC ranch must be resolved, thereby reducing the conflict. Other areas within the Makgadikgadi where this strategy could be utilised should be identified, such as moving cattle from CT11 to the Odiakwe BLDC ranch.

Zoning in the Makgadikgadi

There is a well defined and integrated land use planning approach within Botswana that has, in many areas, already encompassed many of the above mentioned recommendations. Most of the PAs in Botswana are surrounded by WMAs that serve as buffer zones and form large inter-connected conservation areas of compatible land use, i.e. the northern conservation area.

Within WMAs of the northern conservation area, or any of the other WMAs there is no distinction in the compensation paid for loss of property, regulation on the ground is poor, enabling more people to move into the WMAs and develop farms and cattle posts illegally, even through the risks of conflict are greater. While the development of LACs within this context would be of great benefit, they can only work if the recommendations are enforced. One of the biggest problems of enforcing recommendations and policing the WMAs within the Makgadikgadi region is the remote management. The main WMAs: CT10 and CT11 are stateland, under the jurisdiction of the Department of Lands. This department does not have a large presence within the area and the available man power is too low to monitor activity and enforce recommendations. The other WMAs: NG47 and NG49 are better managed, as they have either local communities (Phuduhudu), or private concessionaires undertaking management.

Way Forward - Land use practices in the Makgadikgadi must be assessed with conflict hotspots identified using government information on the incidences of disease transmission, PAC reports, feedback from local communities and wildlife researchers. The land use implications of the conflict must be analysed using a multi-criteria approach, incorporating land use practices and development, ecological factors and also social dimensions to help define the best, or most optimal changes in land use to mitigate the conflict.

Any recommendations for changes in Land Use or zoning must be first approved and then implemented by all appropriate government departments.

Improving the use of communal land

The use of communal land has been a subject of debate within Botswana for several decades. The question is; how to optimise the use of this land to ensure that all of the people can benefit from its use without over exploiting its resources. At present there is limited direct, on-the-ground management and severe rangeland degradation has been reported in many areas of Botswana and the Makgadikgadi, such as around Rakops and Mopipi.

As it is such an historical problem many of the past management plans for the region and have proposed mitigation strategies to try and improve the use of the communal lands. The Ngamiland Integrated Land Use Plan (2009) advises the implementation of the Agricultural White Paper no 1 (1991) that recommends the concept of communal land management under the following guidelines:

- Preparation of detailed land use and management plans for the areas;
- Permanent agricultural extension teams will be attached to each group of communities;
- The community will be assisted where necessary with water development;
- The community will be assisted in fence development;
- Mobile artificial insemination teams will be dispatched to community fenced areas;
- Services and technical assistance in range management and rehabilitation through provision of seed and trees essential for prevention of soil erosion will be provided; and
- Farming cooperatives will be encouraged to provide necessary inputs and marketing services.

The review of the National Land Use Map (2009) highlights the relevance of the Revised National Policy for Rural Development (2002), where proposed Community Land Management Associations (CLMAs) will try to uphold the objectives of the Policy, i.e.;

- Promotion of communal livestock production
- Maintain the subsistence role of livestock in clearly designated communal areas
- Fencing of community managed zones around settlements
- Protect village (20km radius) exclusion zones from further commercial fencing
- Introduce improved management systems for communal land grazing and ranching
- Preserve livestock grazing by controlling overgrazing and degradation

The National Land Use Map (2009) advises that such attempts at improving the use of the communal lands should be initiated from within the community, with the continued use of decision-making through the kgotla, with involvement of chief and land overseer was seen as important for incorporation of local knowledge. This would gain community acceptance in a way difficult for a district land board to achieve through spaced and relatively short visits.

Way Forward – The degradation of the communal lands through mismanagement is causing an increase in human-wildlife conflict. A detailed review of all the existing recommendations from previous reports and an assessment of the current problems should be undertaken, which is aimed to improve the use of the communal areas.

3.2.6 Summary of the Principal reasons for the current failure of identified conflict mitigation strategies

1. Community awareness

a. **Limited implementation in the Makgadikgadi** – There have been few or no sustained programs of community awareness with regard to developing viable household and community based conflict mitigation strategies. There is little to no awareness about the potential use of strategies such as, chilli peppers, field clusters and insurance schemes

Way Forward – Need to improve the extent and duration of community awareness programs in the Makgadikgadi, especially in light of fluctuating environment and consequential changes in the areas affected by conflict and the relevant intensity and type of conflict., e.g. expanding elephant population and peoples current lack of readiness to combat the conflict.

2. Direct compensation

a. **System not working as an appeasement method** – there is no indication within the region that the system is working to help appease community's attitudes towards wildlife. The communities still blame government for the problems, while there is still an obvious negative attitude towards wildlife. Until the communities take a more central role in tackling conflict on their own through mitigation such as insurance schemes or developing in-direct benefits from wildlife through tourism, then there will continue to be a negative attitude towards wildlife
b. **Compensation paid is too low** - The payments are too low and until payment is closer to the market value of the lost property people will continue to blame government and dislike wildlife. Government cannot afford to pay full market value and therefore a different system should be introduced.
c. **Application process is inefficient and payment too slow** – As the assessment of damage must be made by a DWNP officer, the response time is slow, while payment from the central government is also slow. A more localised system such as a community operated insurance scheme could be more efficient. This would help offset the negative attitude towards wildlife if applications were dealt with rapidly.
d. **Not all forms of conflict are compensated, i.e. livestock lost to hyaenas / black-backed jackals** – Over one third of the perceived value of livestock lost to predators in the Makgadikgadi is caused by jackals and hyaenas. Damage caused by either of these species is not compensated for by DWNP. If the government if going to successfully appease communities with direct compensation these species must be included within the system.

Way Forward– Need to change the direct compensation system paid by Government to farmers, as it is not working as an appeasement method and creates greater levels of antagonism towards Government and consequentially wildlife. Alternative forms of compensation should be investigated such as Insurance Schemes. These are operated at a community level with quick, well paid compensation that is policed by the communities themselves, i.e. if a farmer is not utilising practical forms of mitigation such as herding / kraaling / fencing etc then compensation is not paid. These factors are much better assessed at the community level.

3. In-direct compensation

a. **Problems in the CBNRM system** - There are some problems with the operation of some CBOs in the country, which in places need external support to maximise efficient operations.
b. **Current distribution system of funds generated by CBNRM not reaching household level** – One of the principal objectives of CBNRM in conflict areas to generate money through developments such as wildlife-based tourism. These funds form a crucial part of the in-direct compensation system, but to be effective must reach the household level.
c. **Limited land made available for community use in the Makgadikgadi region** – There are only 9 Community Based Trusts in the FMP area, with only 4 areas of land allocated to some of these four trusts. If community based tourism is going to be successful at providing compensation to those communities who suffer from conflict then more opportunities must be made available for the communities to develop viable tourism operations. To do so, more land must be allocated, prioritising those communities that are under the most sever conflict.

Way Forward – Need more community allocated WMAs and/or tourism sites in the Makgadikgadi region or other areas that are allocated to community based organisations or Trusts in which to operate tourism initiatives. The Trusts must be carefully managed with improved monitoring to ensure fiscal responsibility and accountability.

An assessment of current community affiliations with different areas of the Makgadikgadi and which communities are able to work together must first be undertaken before site allocation. Thos communities that suffer the most from human-wildlife conflict must be prioritised with regard to allocation

4. Insurance schemes

a. **Limited use of the system at present** – The system has not been used much within Botswana, but has been successfully used in Namibia and India. The Botswana Predator Group is launching a trial project in Shorobe and it could also be trialled at one village within the Makgadikgadi
b. **Lack of awareness in communities about the schemes** – Communities when asked about the system were positive about its potential, but had not been made aware of it in the past. This is similar to most other forms of conflict mitigation.

Way Forward– Insurance schemes could provide an improved alternative to current direct compensation. The Botswana Government could divert funds from direct compensation into helping establish the Insurance Schemes, while the creation of improved opportunities for trusts and CBNRM activity in conflict areas will provide further support of the schemes. Increased community awareness about the schemes is vital.

5. Fencing fields

a. **100% of fields are not fenced** – While the majority of fields in the region are fenced, not all households do fence their fields. This may be related to financial position of the household, or lack of conflict in some areas. All households must be encouraged to fence their fields, while those in high conflict areas should be encouraged to use additional mitigation strategies, i.e. chilli pepper / field clusters. Government could direct funds to those poor families that cannot afford to fence their own fields. This would prove cheaper than paying compensation in the long-term.
b. **Majority of fields fenced using basic thorn bush approach** – Most fields are fenced using simple thorn bushes. The cost of more advanced methods is prohibitive. In high conflict areas, the government could provide financial assistance to help develop appropriate fences.
c. **Fenced fields cannot stop smaller mammals from causing conflict** – It is almost impossible to stop all forms of conflict and small mammals such as porcupines cause extensive problems. Methods to mitigate this could be investigated.

6. Olfactory deterrents: chilli pepper

a. **Limited community awareness about use of chilli pepper as a deterrent in the region** – Limited community awareness campaigns form a central problem throughout this report. There was little to no knowledge about the use of chilli peppers as an effective form of mitigation. Much greater awareness must be made, especially to the north of the region in villages such as Nata / Zoroga / Gweta / Phuduhudu. The elephant population will continue to grow as will the problems unless a more concerted effort is made to help communities help themselves to reduce the conflict.
b. **No training has been made available in the region** – The communities need more than just awareness campaigns, they must be provided with practical help in the use of effective mitigation strategies such as using chilli peppers. Again, funds spent by government on these training programs will be cheaper than paying compensation in the long-term.

7. Field clusters

a. **The benefits of this strategy are long known, but there is no implementation** – The use of field clusters is very successful at mitigating conflict, while reducing household costs of conflict mitigation. Potential ideas for field clusters have been provided in this report, but each village must be integrally involved in the development of such clusters. The most optimal location for soil type, distance to people homes etc needs to be made. While many current fields could be included within proposed clusters some will have to be moved and those people compensated for the additional work involved.
b. **There is no cross departmental coordination to help implement this strategy** - A change of attitude is required at the community level, as well as a concerted

integrated government approach. All land boards, land over seers, local district planners etc must be made aware of conflict problems in key areas. A land use approach to allocating fields must be made that helps to mitigate future conflict.

Way Forward– From the review it is clear that the combined use of field clusters, with a strong protected fence around the periphery and protected with chilli-pepper impregnated rags forms the best field protection strategy. Communities must be encouraged to work together in protecting these clusters, while fields must be allocated or re-allocated within defined locations for clusters. Improved cross departmental coordination is vital to help implement this strategy, while all farmers must be encouraged to fence their fields to limit conflict. Compensation should only be paid for fields in clusters in conflict areas.

The Botswana Government should help to subsidise the abandonment of old fields in conflict areas and encourage communities to develop new fields within clusters. The system could be assisted through funds generated by CBNRM activity. Suitable areas for field clusters must be defined around each village and settlement before they are established.

8. Livestock herding

a. **Not 100% of cattle are herded due to lack or resources and man power / money** – Only 3% of farmers herd their livestock. This may be due to urban shift of the youth and lack of man power or the extensive use of the mafisa system within the Makgadikgadi

9. Livestock kraaling

a. **Not 100% of cattle are kraaled at night** - Only 3% of farmers herd their livestock, while only 13% kraaled at night according to Hemson in 2005. The number of farmers kraaling their livestock at night has increased dramatically now that evidence of kraaling is required for compensation to be paid.
b. **Strategies to help implement improved kraaling / herding fail after the end of project specific activities** – farmers need more incentive to undertake kraaling and herding. 100% of cattle should be kraaled every night . To ensure this cattle must be herded as well. Current levels of kraaling are almost 90% thanks to linking it with the payment of compensation. The same emphasis must now be placed on herding and the use of guarding dogs to further ensure cattle return to the kraal every day and help reduce conflict.

Way Forward – Community awareness programs once initiated must be continued for extended periods, otherwise the taught mitigation methods fall out of practice. A change in herding behaviour within communities cannot be readily expected, and improved incentives required to encourage farmers to kraal livestock, such as the use of community based insurance schemes, where compensation is paid locally – communities are better able to determine who is kraaling and who is not than DWNP. Payment of any form of compensation must be linked to good kraaling.

10. Translocation of problem animals

a. **Delayed assessment means the wrong animals can be translocated, while there is no research about the impact translocation has on the ecology of the predator populations** – More research must be done on the effectiveness of problem animal translocation – both for the good of the animals in question and for the effectiveness of the system as a whole. The best way to ensure the right animals are identified is if a more localised system of community compensation is used, such as the insurance schemes.
b. **Translocated animals return to their native home range** – The return of translocated animals to the point of conflict is well documented, questioning the use of the strategy at all. More emphasis should be placed on more effective long-term mitigation strategies.

11. Lethal control of problem animals

a. **Delayed assessment means the wrong animal can be killed, while there are no current thresholds on the number of elephants than can be shot using this approach by government, or limited control over the number of predators being shot by farmers** – The number of elephants being shot each year by DWNP is rising, due in part to increased human-elephant conflict and also a possible use of the mitigation strategy to appease communities who are suffering from conflict. The use of lethal control should be restricted to use only by DWNP staff to control the extensive shooting of predators by farmers, while a cap must be placed on the number of elephants shot to ensure the situation is more carefully evaluated first before an animal is shot.

Way Forward – A review of the impacts associated with the translocation of problem animals must be undertaken. Is it cost effective or even beneficial? Minimum thresholds for conflict must be set before lethal control is used. Conflict reports must be assessed immediately through more localised structures, otherwise the system is open to abuse, while the wrong individuals are liable to be killed through delayed implementation.

12. Veterinary cordon fencing

a. **Potential changes in the FMD zoning of the region means some fences may no longer be serving their intended purpose** –Many of the fences were erected in the 1950s and 1970s and may now, with changes in wildlife movement and land use patterns, be no longer serving an active purpose.

Way Forward – The rationale behind the development of each conflict and disease control fence should be reviewed and compared with current levels of effectiveness. Are fences within the Makgadikgadi region fulfilling the jobs they are meant to? If not how can they be improved or should they, or sections of them be decommissioned.

13. Relocation of people / livestock

a. **DWNP does not have the funds to pump water to the BLDC ranches, where it is proposed to translocate the Phuduhudu cattle** – The cattle within Phuduhudu graze within the WMA and within the MPNP. They are exceptionally vulnerable to lion predation. The movement of cattle from the settlement of Phuduhudu to the BLDC ranches in NG45 has been agreed upon by the communities, but lack of funds is limiting the implementation of this strategy.

Way Forward – Solutions to the problem that is restricting the relocation of cattle from Phuduhudu to the Makalamabedi BLDC ranch must be resolved, thereby reducing the conflict. Other areas within the Makgadikgadi where this strategy could be utilised should be identified, such as moving cattle from CT11 to the Odiakwe BLDC ranch.

14. Land use zoning

a. **There is no distinction in compensation paid depending upon which zone people live** – Compensation and forms of assistance are not appropriately targeted towards those who need them. Identifying zones of conflict and hotspot areas would ensure that a) poor households can be financially assisted to help protect themselves against conflict, i.e. assistance with the fencing of fields, training in effective conflict mitigation such as chilli peppers and b) people living within high conflict areas receive less government direct compensation, but are encouraged to develop community based insurance schemes to ensure more effective implementation of compensation assessment and payments
b. **There is no on-the-ground management of the buffer areas zoned to mitigate conflict, i.e. the WMAs CT10 & CT11** – The statelands of CT10 and CT11 are being encroached by disputed settlements. If permitted to continue the areas will no longer be able to effectively serve as buffer zones between people and wildlife. These areas should be leased to local communities or the private sector to help with localised management.

Way Forward - The land use implications of the conflict must be analysed using a multi-criteria approach, incorporating land use practices and development, ecological factors and also social dimensions to help define the best, or most optimal changes in land use to mitigate the conflict.

Any recommendations for changes in Land Use or zoning must be first approved and then implemented by all appropriate government departments.

15. Improved management of communal lands

a. There have been many reports and recommendations about how to improve the use of the communal lands but little implementation – the problems associated with the over utilisation of communal lands versus the problems of exclusive use of ranches is well known, but the problems within communal areas of the Makgadikgadi are acute. Rangeland degradation is severe as is conflict between pastoral and arable farming.

Way Forward – The degradation of the communal lands through mismanagement is causing an increase in human-wildlife conflict. A detailed review of all the existing recommendations from previous reports and an assessment of the current problems should be undertaken, which is aimed to improve the use of the communal areas.

4 Linkages with other components within the MFMP

4.1 Ecology & Hydrology

To help understand how and why the populations of different species have been fluctuating or declining within the region it is important to place those trends within the context of the Makgadikgadi wetland system. As a semi-arid, saline environment, with stochastic rainfall patterns and limited external hydrological input, the region is highly susceptible to environmental perturbations that can have dramatic impacts on wildlife populations and the movements of those species across the region. Wildlife population declines should not be attributed to human related causes alone and a contextual understanding of the Makgadikgadi region's ecology and hydrology is therefore vital.

The cause of human-wildlife conflict is often driven by the availability of resources or the lack of them. Competition for diminishing resources such as surface water and good grazing can lead to increased levels of conflict. The assessment of ideal mitigation strategies must take the ecological dynamics of an area into consideration, assessing seasonal variation in resource availability.

4.2 Tourism Component

The long-term conservation of the wildlife resources of the region is crucial if diversification in the rural economy through eco-tourism development is to become a more widespread reality that affords direct benefits to local communities. One of the objectives of the report is to provide information that can lead to the identification of key wildlife areas that, along with a series of other ecological, social and development factors, may support viable tourism enterprises. Data generated through this report will be used in the tourism component to help identify potential tourism sites.

The use of tourism and CBNRM initiatives to provide indirect compensation to rural communities who bear the brunt of the conflict problems. By enabling rural communities to generate financial benefits from wildlife it is hoped that they will take a more active role in the management and conservation of wildlife, thereby bringing a change in attitude towards wildlife from a purely negative perspective.

4.3 Economic Valuation Component

The wildlife resources within the Makgadikgadi region provide an important economic resource that can be used for sustainable consumptive and non-consumptive tourism. Understanding the population size and current trends is vital in assessing the indirect use value of the region as a wildlife refuge and of course as a direct use value for consumptive off-take. The data generated from the report will thus be used in the economic valuation component of the MFMP.

The loss of property (livestock and arable produce) through human-wildlife conflict is of significant importance to poor rural communities. When viewed at the national scale the relative loss of livestock and produce may be small, but at the household level such loss can be catastrophic.

4.4 Land Use Component

Information on the distribution and density patterns of wildlife species generated from the report will be utilised to help assess the current trends in human-wildlife conflict within the

region. The Makgadikgadi area experiences some of the most intensive human-wildlife conflict in Botswana. The cause of this conflict has been attributed to the proximity of human and livestock populations around the protected areas of the "Pans Parks" and stochastic environmental fluctuations that affect resource availability and increase competition for resources between wildlife and livestock. Understanding the cause and effect relationships that regulate these wildlife movements is vital if we are to predict and mitigate for on-going conflict. It is believed that wildlife populations have been detrimentally affected by these conflicts with flagship predator species and key migratory species showing attributable declines in numbers over the past few decades. To ensure that wildlife resources are effectively conserved within the region, improved conflict mitigation strategies are required.

Human wildlife conflict can, in many places, only be controlled through effective land use planning. Separating people and livestock from wildlife through land use buffer zones, fences and migration corridors can serve to reduce the prevalence of conflict and thereby help to alter local community's perceptions of wildlife. Data generated through this report will be utilised by the land use component to help identify areas of human-wildlife conflict that can be mitigated for through effective land use change recommendations.

Where it was possible to identify the core areas used by different species within the region through kernel home range analysis, we have taken these areas to use in the MCA of the spatial implications of land use development. Using peer assessed spatial impacts of different current and possible future developments to define impact buffers the core home ranges of wildlife can be overlaid onto proposed developments and current land use zonations to help define the potential of development on the viability of wildlife populations in the Makgadikgadi.

Land use planning and the development of buffer zones around PAs, the relocation of people and livestock and the change in human activities within different land use zones, with the creation of LACs to help monitor impacts in the region.

4.5 Socio-economic Component

One of the principal objectives for the MFMP is to improve people's livelihoods through the wise use of the wetland's natural resources. Wildlife are one of the most important ecological resources in the system, but are not one of the most important economic resources, with few direct benefits accruing to local communities through the consumptive and non-consumptive use of these wildlife resources. The region is characterised by one of the highest rates of human-wildlife conflict in the country and many people have a negative attitude towards wildlife. Almost half (41%) of the MFMP study area (14,730km^2 out of a total of 36,622km^2) is protected as WMAs (6,952km^2), National Parks (7,549km^2) and wildlife sanctuaries (230km^2). Any calls to conserve more land in favour of wildlife must take these issues into consideration, with proposals for improved community involvement and generation of benefits through tourism, while comparing these potential benefits with current livelihood strategies and the potential impact upon these through any land use changes.

4.6 Policy Component

Wildlife is currently protected and conserved through the Wildlife Conservation Policy (1986), the National Policy on Natural Resources Conservation and Development (1990), the

Wildlife Conservation and National Parks Act (1992), the Elephant Management Plan (2007), the Predator Management Strategy (2006), the crocodile management plan, rhino management plan and ostrich management plan and the SADC protocol on wildlife conservation and law enforcement. While these Acts and Policies are broad ranging there is still limited legislation to help the conservation and protection of endangered species within Botswana, while several other policies come into direct conflict with the conservation of endangered species such as: the Tribal Land Act (1968), National Policy on Agricultural Development (1991), Agricultural Resources Conservation Act (1974) and the Diseases of Animals Act. This report provides information on the current status and threats towards certain species within the Makgadikgadi region and therefore helps to highlight the rational for adjustments and improvements within these Acts and Policies.

The effective implementation of human-wildlife mitigation strategies is dependent upon a strong policy framework.

5 Planned Activities and Recommendations for MFMP

5.1 High priority recommendations for MFMP

5.1.1 Wildlife Resources

1. The Makgadikgadi conflict fence aligned along the Boteti River must be maintained. Current lack of maintenance is leading the fence to fall into a state of disrepair through elephant activity. The fence is no longer an effective barrier and its current state will affect the re-zoning of the CT8 area as an FMD Free Zone, while enabling human-wildlife conflict to prevail.
2. Improved monitoring of the Buffalo herds in the Makgadikgadi is required. There is concern about the proximity of buffalo along the Boteti River with cattle on the other side of the fence.
3. Improved anti-poaching patrols and DWNP APU presence within the region is required to ensure that animals in the region are not vulnerable to poaching in the future. Poaching may have been responsible for the decline of many of the herbivore species within the system and its current level of occurrence must be defined.
4. The newly established water points developed by KCS and DWNP along the Boteti River must be structurally improved. The bush surrounding the water points must be cleared for a distance of up to 50m to encourage wildlife to use them.
5. The alignment of the Makgadikgadi conflict fence along the Boteti River should be adjusted, to improve the number of access points to the riverbed for wildlife. This would do several things;
    a. Improve access to drinking points along the length of the riverbed and therefore improve access to grazing resources along the length of the Boteti River;
    b. Reduce the high impact of elephants to the riparian woodland around Xhumaga and Meno-a-kwena;
    c. Improve the amount of riparian woodland accessible to wildlife;
    d. Improve the potential for communities to benefit from wildlife by developing CBNRM tourism operations on the western bank of the Boteti River.
6. The alignment of the Makgadikgadi conflict fence should be adjusted away from those areas where it is placed close to water points such as at Meno-a-Kwena and in the Xhumaga area, as predators are using the fence as part of their predation strategy.
7. The proposed fence to be erected to the east of the Makgadikgadi Pans National Park must include the CT11 area. This is a vital part of the wet season migratory range of zebra and wildebeest and its exclusion would be of significant detrimental impact to the population.
8. Developing water points in NG49 and in the north western areas of the park would help facilitate wildlife's improved access to grazing resources and break their restrictive central place foraging strategy. Greater water distribution would also reduce the vulnerability of wildlife to fires, which could denude all of the grazing in close proximity to the Xhumaga region if a fire were to occur in this area.
9. Firebreaks should be placed within the National Park, running North-to-South 20km to the east of Xhumaga. These will help to protect the forage along the Boteti River. Protection of these dry season forage reserves is vital now that the zebra and

wildebeest are unable to move over to the west of the Boteti River to graze as they used to during periods of fire.

10. Remove cattle from the Phuduhudu area and place them into NG45, this would reduce the problems of human-wildlife conflict in this region.
11. There must be no fence developed along the southern boundary of NG49. This fence was proposed as a conflict mitigation strategy for this region, but its development would cut of the important migratory corridor between the Okavango and the Makgadikgadi. This corridor is not only used by zebra, but also by species such as, elephant, rhino, buffalo and giraffe.
12. The Dept. of Roads should not be permitted to develop fencing along the Gweta-Makalamabedi main tar road which bisects the park. This fence would have the same impact as the proposed conflict mitigation fence.
13. Compensation for the loss of livestock from hyaena kills should be paid. The lack of compensation compels farmers to shoot hyaenas to solve the problem.
14. If the river stops flowing again an additional deep pool must be dug to enable the pod of hippos to split under social stress conditions. In ability to split will result in further calf mortalities.

5.1.2 Human Wildlife Conflict

1. **Improved In-direct compensation** – More effort must be made to develop more wildlife-based tourism ventures, or other forms of tourism development in the region to help provide funds to those communities that are under the greatest pressure from human-wildlife conflict in the region
2. **Insurance schemes** – Community based compensation would ensure that damages are quickly assessed and payments made in a short time frame, while policing of all farmers to ensure they undertake effective mitigation would be the most effective form of encouragement.
3. **Chilli Pepper deterrents**- the use of this effective strategy must be utilised to greater effect in the northern Makgadikgadi settlements, with greater emphasis on community awareness and training made available by Government.
4. **Field clusters** – Integrated land use planning with district land use planners and land boards to ensure fields are only allocated within proposed clusters and away from conflict zones. Communities to be integrally involved in field cluster development
5. **Land use zoning** – A comprehensive holistic assessment of human-wildlife conflict to develop more buffer zones and to identify conflict hotspots to help government target those in most need of assistance.
6. **Improved management of communal areas** – use of land use zoning to help maximise use of communal grazing and arable areas that ensures conflict for limited resources is reduced and land is not degraded any further.

5.1.3 Birdlife Resources

1. Immediate implementation of the flamingo sanctuary regulations, with further consultations and local stakeholder involvement.
2. A management plan for the flamingo sanctuary should be conducted in conjunction with that for the surrounding community tourism area initiative lead by Birdlife Botswana, to outline the appropriate and effective management of the sanctuary and that of a surrounding ‘buffer’ area that can be utilized in a sustainable way to benefit the local communities through the CBNRM initiative. These management plans can be combined.

3. Provision in all EIAs reviews of physical obstacles to bird migration on and nearby the wetland system, e.g. fences and power lines to include the need to ensure effective collision mitigation using appropriate devices, particularly, within 10km of the major wetspots.
4. Fences crossing open pan should be avoided.
5. Raptor friendly power lines should be mandatory in the MFMP area.
6. Effective protection and IWRM should protect all major 'wetspots' that comprise the main wetland bird habitat in the system.
7. A revision of the bird hunting quotas for certain species, for which the MWS provides an important habitat, e.g. Yellow-throated sandgrouse, should account for new population estimates and trends of these species in the area.
8. Development of country species-specific action plans for those globally threatened birds, for which the MWS comprises a major habitat, e.g. Lesser Flamingo and Chestnut-banded Plover.

Table 19: Summary of Human-Wildlife (and livestock-arable conflict) mitigation strategies

Mitigation strategy	Methods	Aims	Benefits	Level of Effectiveness	Problems
Community awareness	Kgotla meetings / practical training	To inform and advise community members about mitigation strategies	Can provide long-lasting benefits by teaching core mitigation principles	Can be effective if communities are encouraged and provided logistical support at the start of the process	a) Same message not always delivered to all communities b) Communities need support to help implement the strategies
Direct compensation	Payment of compensation money to help cover costs of lost property through human-wildlife conflict	Increase community tolerance to wildlife through payment for loss of property; i.e. it aims to appease communities	If it works properly it can help to appease communities and enable them to continue living with wildlife and associated problems	Not very effective.	a) Process is detrimentally affected by bureaucratic delays, long time-lags for payment and low payment. b) Communities not encouraged to improve mitigation or to co-exist with wildlife c) Creates dependence and associates blame with government and disassociates blame from the communities d) Is a short-term strategy and does not deal with the root cause of the problem e) A well run compensation scheme can attract more people into an area to benefit from the scheme
Indirect compensation	Engage communities in wildlife based tourism through CBNRM	To increase tolerance of communities towards wildlife through greater sense of ownership and to improve community based conservation	a) Can generate substantial, long-term economic benefits for communities that can be used to improve rural livelihoods b) help to change community attitudes to wildlife	Can be effective if benefits are shared equitably and reaches those who suffer from conflict	a) Many communities are not experienced in operating tourism ventures and need support. b) Corruption can divert funds away from those community members that the strategy is meant to help

Mitigation strategy	Methods	Aims	Benefits	Level of Effectiveness	Problems
Insurance schemes	Farmers pay annual premium against risk of conflict and are compensated through the scheme	Increase community tolerance to wildlife through payment for loss of property; i.e. it aims to appease communities	Operates at a local level, so that conflict can be assessed quickly with rapid payment	Can be very effective if farmers are properly informed about the benefit of the scheme	Requires financial investment by the farmer, which can be difficult if they are accustomed to be simply supported by government
Fencing fields	Create a physical barrier to protect property	To separate wildlife and livestock from crops or livestock from wildlife	A variety of methods available and can be done with cheap readily available materials	Can be very effective if fences are well erected and maintained	a) Traditional fences do not stop elephants and additional support is requiredb) Most fences do not stop small species such as porcupines which can cause substantial damagec) Does not deal with the root cause of the problem
Chilli Pepper deterrents	Create an olfactory and taste barrier to stop elephants	Deter wildlife, especially elephants from entering the field	a) Is a relatively cheap mitigation strategy b) Is simple to replicate across many different environments c) Can be used to generate income of chillies are also sold to market	Can be very effective if communities are properly taught how to implement	a) It is a labour intensive strategy b) Due to time costs of the strategy it is best used with field clusters c) Can lead to invasive species problems
Improved crop varieties	Use of improved crop varieties that have a different harvest time	To enable communities to harvest crops before peak periods of conflict	Is not a time consuming strategy	Can be effective if conflict has distinctive seasonal peaks	a) Can be very costly b) Requires government support
Acoustic deterrent	Produce load noise to ward off problem animals	To create a short-term disturbance to ward of wildlife	Is a simple form of mitigation and one of the oldest used by all communities	Not effective for the long-term	a) Is a short-term mitigation strategy, while animals can quickly become accustomed to the noise b) Can expose people to danger

Mitigation strategy	Methods	Aims	Benefits	Level of Effectiveness	Problems
Field clusters	Develop fields in adjoining plots forming concentrated development	a) To enable communities to defend fields as a unit and reduce time and costs of other forms of mitigation b) to prevent isolated fields from being exposed to conflict	a) Reduces exposure of isolated fields to conflict b) Reduces costs of defending fields through collective approach c) Improves community spirit	Can be very effective at reducing conflict	a) communities sometimes require subsidies to help support moving fields, which is costly and time consuming b) It may not be possible to find large enough areas of suitable habitat for large field clusters
Herding Livestock	Proactively herding livestock with herd boys and dogs	To reduce the exposure of livestock to depredation through vigilance	Is a cheap and easily applied mitigation strategy	Can be effective if vigilance levels are high and dogs are well trained	a) Does require readily available manpower to herd livestock
Kraaling Livestock	Proactively herding livestock into a protective kraal every night	To reduce the exposure of livestock to depredation through protective fence	Can be a cheap and easily applied mitigation strategy	Can be very effective if livestock are kraaled on a regular nightly basis and kraaled within well designed and strong kraals	a) Requires readily available manpower to herd livestockb) Can be costly to build effective kraals
Non-lethal Wildlife Mitigation	Translocation of problem animals away from conflict zone	To reduce the exposure of livestock to depredation through removal of problem animals	Provides a short-term relief from specific problem animals	Can be effective if individual animals have learnt how to tackle other forms of mitigation	a) Is only a short-term strategy, as most evidence suggests problem animals return to the same location b) It is often very hard to identify the correct problem animal c) There are unknown consequences on the ecology of the translocated species
Lethal Wildlife Mitigation	Shooting of specific problem animals	To reduce the exposure of livestock to depredation or crops to problem animals through their removal	Provides a short-term relief from specific problem animals	Can be effective if individual animals have learnt how to tackle other forms of mitigation	a) Is only a short-term strategy, as the problem animal is often replaced by another problem animal b) It is often very hard to identify the correct problem animal

Mitigation strategy	Methods	Aims	Benefits	Level of Effectiveness	Problems
Fencing	Separation of wildlife from livestock and crops, and also livestock from crops	To separate wildlife and livestock from crops or livestock from wildlife and to reduce the expose of livestock to disease transmission	Can be used as part of a larger land use planning process and can help to deal with the root cause of the problem, i.e. spatial overlap between conflicting entities	Can be very effective if the alignment of fences is properly assessed to minimise negative environmental impacts	a) Costly b) Can cause extensive negative environmental damage if inappropriately aligned
Land Use Planning	Define optimal, compatible land uses through effective zoning of areas and movement of people & livestock to appropriate zones	To achieve long-term resolution to conflict by tackling the root causes of the conflict, i.e. spatial overlap and competition for resources by people and wildlife	Can achieve long-term resolution and mitigation of conflict and can enable communities to maximise benefits from wildlife and to continue traditional livelihoods through optimal land allocation and zoning	Can be the most effective strategy if supported by well defined policy framework and government support	a) Requires well coordinated government support from various government departments and agencies b) Requires well defined policy framework and legislation

5.2 Recommendations for IMP

5.2.1 Detailed Predator Survey

It is essential that a detailed predator survey is undertaken within the Makgadikgadi region. There are no viable baseline data for the population of cheetah within the system and it is therefore impossible to define appropriate management strategies, or to assess how development scenarios impact the predator guild.

5.2.2 Improved herbivore population monitoring

Improved monitoring of the buffalo, eland, red hartebeest, impala, kudu, roan, sable, and springbok populations is required to help assess their conservation status and would aid the viable conservation of the species within the system. Aerial surveys of the region are desperately required to determine if the Makgadikgadi conflict fence has had a beneficial effect on the zebra and wildebeest numbers in the region.

5.2.3 Allocation of potential tourism land to CBOs

A community appraisal exercise must be undertaken across the whole Makgadikgadi region, with an aim of assessing which communities have an affiliation with any distinct part of the region, or any aspirations to work in a certain region. The appraisal should take into consideration historical community links with areas, such as natural resource use etc. The appraisal should identify which of these areas overlap with recommended tourism sites developed from the tourism component of the MFMP. Depending upon the tourism potential of these sites it could be recommended that communities are allocated the sites on a leased basis, on which they may, if desired, enter into joint venture agreements with the private sector to assist them with the tourism development. To ensure that the funds generated through such tourism operations reach those communities and households that are currently suffering from human-wildlife conflict prioritisation of site allocation should be given to those communities with the greatest relative conflict. The distribution of funds to households and the working arrangement of the joint venture partnership must be closely monitored to ensure benefits reach the communities, especially at the household level.

5.2.4 Improved community awareness and implementation of insurance schemes

A pilot system to test the benefits and pitfalls of the insurance compensation system should trialled in one of the Makgadikgadi settlements. The current direct compensation system used by DWNP is not working. It is not a successful appeasement mechanism, with significant administrative problems. Many of the problems faced by the current system could be removed by switching to a community based insurance system, where evaluation of conflict is undertaken locally, while payment for the loss is made through the insurance scheme which would be able to pay a higher level of compensation. Improved administration such as the rapid evaluation of conflict, assessment of value lost, identification of problems animals etc and importantly the relative application of mitigation strategies would enable compensation funds to be more efficiently used.

5.2.5 Improved community awareness and training in the use of chilli pepper

Improved training and community awareness programs similar to those undertaken within the pan handle and Chobe regions must be provided to the northern part of the Makgadikgadi

5.2.6 Assessment of potential development of field clusters in high conflict areas

A pilot scheme of the field cluster approach should be trailed in one of the northern Makgadikgadi settlements. The costs of development could be linked with the testing of an

insurance scheme. Community appraisal is essential to determine the most optimal areas for field clusters, there are several ecological and social based factors that will determine the success of the project, i.e. soil quality and distance to farmers. Community agreement is essential if the project is to be successful.

5.2.7 Implementation of land use zoning recommendations from the MFMP

A land use approach to human wildlife conflict will be the best long-term solution and mitigation strategy, but forms part of a holistic approach to land use. The results from this human wildlife assessment will be used in combination with those from other components to generate optimal land use recommendations. The land use zoning issues of conflict in the region can only be assessed in relation to other land use requirements. The holistic multi-criteria spatial assessment developed during the MFMP will provide a series of recommendations for the IMP. These should be implemented to help reduce levels of human wildlife conflict in the region.

5.2.8 Investigation of methods to improve the use of communal areas

There have been many reports prepared over the past 20 years about the implications of poor management of the communal lands in Botswana. Most of these reports generated recommendations for improving the situation, with many recommendations failing to be implemented. A review of these reports must be undertaken, with an assessment of why various recommendations were not implanted. Those that still warrant attention in light of the current situation should be highlighted with a view to implementation.

5.2.9 Developing a Wildlife Migratory Corridor between the Makgadikgadi and the CGKR

There is a strong likelihood that the development of a much mooted corridor between the CKGR and the Makgadikgadi would lead to a migratory movement of wildebeest and other species becoming re-established. The re-established zebra migration between the Okavango Delta and the Makgadikgadi is testament to the adaptability of species within the system. Migratory movements are known to be a significant factor in the development of larger, more resilient populations (Fryxell & Sinclair, 1988).

5.2.10 Wildlife management and research

To effectively conserve wildlife populations within Botswana a science based approach is required. Long-term research on the population dynamics of wildlife populations has shown how the age and sex structure of populations is affected by different environmental impacts, so that management must be tailored to the specific structure of the population, rather than just the population's size (Gordon, Hester & Festa-Bianchet, 2004). Long-term planning is therefore essential when making large-scale land use changes that affect wildlife populations. An in-depth understanding of the dynamics of wildlife populations, such as birth rates, death rates and age structure and assessing how these are affected by land use change, environmental fluctuations and development impacts is the best approach for ensuring effective long-term management (Gordon, Hester & Festa-Bianchet, 2004). Research on herbivore ecology has shown that landscape scale distribution patterns are driven by herbivore/vegetation interactions at extremely small scales, of down to several meters, as herbivores select grazing patches based on the quality of grass within small patches. Localised impacts to vegetation can therefore have cascading effects on biodiversity at the landscape scale. For management to be effective spatial scale must be taken into consideration (Gordon, Hester & Festa-Bianchet, 2004).

5.2.11 Biodiversity monitoring and management

To effectively conserve wildlife populations within the MFMP, there is need for:

1. Comprehensive inventory studies of biodiversity in the MWS should be carried out in order to gain a better understanding of the full complement of the systems' fauna, which will also form a basis, on which effective monitoring of the systems biodiversity can be conducted.
2. In depth ecological studies on the fauna of the systems main 'wetspots' will identify the biological characteristics of each, their importance to biodiversity and the variation among them that sustains habitat and fauna diversity.
3. In depth studies on key Odonata and aquatic crustacean species, for example, will help identify important bio-indicator thresholds and facilitate their use in an effective ecosystem health monitoring programme.
4. Research into the role of the different faunal groups in the ecosystem functioning and integrity should be promoted and implemented.

6 References

Alberson, A. 1998. Northern Botswana Veterinary Fences: Critical Ecological Impacts.

Anderson, M.D. 2000a. Greater Flamingo. In The Eskom Red Data Book of Birds of South Africa, Lesotho and Swaziland (ed. K.N. Barnes), p 138. BirdLife South Africa, Johannesburg.

Anderson, M.D. 2000b. Lesser Flamingo. In The Eskom Red Data Book of Birds of South Africa, Lesotho and Swaziland (ed. K.N. Barnes), p 138. BirdLife South Africa, Johannesburg.

Anderson M.D. 2000c. The status of flamingos in the Northern Cape Province, South Africa. Ostrich 71 425-437.

Baldus, R.D. 2005. Community in Tanzania to Harvest Problem Crocodiles African Indaba e-Newsletter, 3(3): 20.

Bartlam-Brooks, H., Bonyongo, C. And Harris, S. Will reconnected ecosystems allow long distance mammal migrations to resume?: A case study of a zebra migration in Botswana. In-Press. Oryx

Bengis, R.G., Kock, R.A. and Fischer, J. 2002. Infectious animal diseases: the wildlife/livestock interface. Rev. Sci. Tech. Off. Int. Epiz., 21(1): 53-65

Berry, H.H. 1972. Flamingo breeding on the Etosha pan, South West Africa, during 1971. Madoqua, 5, 5-31.

Brooks, C. 2005. Foraging Behaviour of Burchell's Zebra. Ph.D Thesis. University of Bristol, UK.

Carruthers, V. 2001. Frogs and Frogging in Southern Africa. Struik, Cape Town.

Channing, A. 2001. Amphibians of Central and Southern Africa. Protea Bookhouse, Pretoria. 470 pp.

Clauss, B. And Clauss, R. 2002. Common Amphibians and Reptiles of Botswana. Gamsberg Macmillan Publishers. Namibia.

Cumming, D.H.M. and Cumming, G.S. 2003. Ungulate community structure and ecological processes: body size, hoof area and trampling in Africa savannas. Oecologia, 134, 560-568.

Defries, R., Hansen, A., Turner, B.L., Reid, R. And Liu, J. 2007. Land use change around protected areas: management to balance human needs and ecological function. Ecological Applications. 17. 1031-1038.

Distefano, E. 2005.Human-Wildlife Conflict Worldwide: collection of case studies, analysis of management strategies and best practices

Eco-Logic Support Services, 2003. Site Inventory of the Makgadikgadi Palustrine Wetlands. Department of Environmental Affairs, Botswana.

Ecosurv, 2001. Consultancy Risk Analysis Associated with the Introduction and Rearing of Disease Free Game into the Foot and Mouth Disease, Vaccinated, Surveillance and Non-Vaccinated Zones of Botswana and the Development of Guidelines to Control and Monitor the Processes Involved. Dept. Animal Health and Production. Gaborone.

FAO, 2005. Strategies to mitigate Human-Wildlife Conflict in Mozambique. Anderson, J. & Pariela, F. Report for the National Directorate of Forests & Wildlife. 68 p.

Hancock, P. 2008 The Status of Globally and Nationally Threatened Birds in Botswana – 2008. Birdlife Botswana Publication, Gaborone.

Hemson, G. 2004. The ecology and conservation of lions. D.Phil. University of Oxford.

Hemson, G. 2001 Report for Botswana DWNP, Office of President and Kalahari Conservation Society. Makgadikgadi Lion Research Project, Maun.

IRIN, 2004. Botswana beef industry woes expected to continue. Humanitarian News; UN Office for the coordination of humanitarian news. Gaborone

Kahl, M.P, 1975. Distribution and numbers - a summary. In: J. Kear K Duplaix-Hall (eds.). Flamingos. T & AD Poyser. Berkhamsted, UK.

Lamarque, F., Anderson, J., Chardonnet, P., Fergusson, R., Lagrange, M., Osei-Owusu, Y., Bakker, L., Belemsobgo, U., Beytell, B., Boulet, H., Soto, B. and Tabi Tako-Eta, P. 2008. Human-Wildlife Conflict in Africa; An overview of causes, consequences and management strategies. International Foundation for the Conservation of Wildlife & FAO. Rome.

Madhusudan M.D. 2003. Living Amidst Large Wildlife: Livestock and Crop Depredation by Large Mammals in the Interior Villages of Bhadra Tiger Reserve, South India. Environmental Management, 31(4): 466-475

McCulloch, G.P. 2003. The Ecology of Sua Pan and its flamingo populations. PhD thesis, University of Dublin Trinity College Dublin and Ministry of Environment, Wildlife and Tourism.

McCulloch, G.P., Hancock, P. and Soopu, J. In Press. A Report on Monitoring of the Makgadikgadi Pans IBA, 2009. Birdlife Botswana and UNDP.

McCulloch GP and Irvine K. 2004. Breeding of Greater and Lesser Flamingos at Sua Pan, Botswana, 1998-2001. Ostrich 75(4).

Meynell, P.J. and Parry, D. 2002. Environmental appraisal for the construction of a game proof fence around Makgadikgadi pans national park. Scott Wilson Kirkpatrick & partners, Gaborone.

Muruthi, P. 2005. Human Wildlife conflicts: Lessons learned from AWD's African heartlands. AWF Working Papers, July 2005, 12 p.

Ogada, M., Woodroffe, R., Oguge, N. and Frank, G. 2003. Limiting Depredation by African Carnivores: the Role of Livestock Husbandry. Conservation Biology, 17(6): 1521-1530

Parker, G.E., Osborn, F.V., Hoare R.E. and Niskanen, L.S. (eds.) 2007. Human-Elephant Conflict Mitigation: A Training Course for Community-Based Approaches in Africa. Participant's Manual. Elephant Pepper Development Trust, Livingstone, Zambia and IUCN/SSC AFESG, Nairobi, Kenya.

Penry, H. 1994. Bird Atlas of Botswana. Pietermaritzburg: University of Natal Press.

Prins, H.H.T. 2000. Competition between wildlife and livestock in Africa. In Wildlife conservation by sustainable use (eds H.H.T. Prins, J.G. Grootenhuis & T.T. Dolan), pp. 51-80. Kluwer Academic Publishers, Boston / Dordrecht / London.

Rutina, L. 1995. Habitat Utilization and Breeding Success of Terrestrial Game Birds in the Makgadikgadi Ecosystem, Botswana. Msc Thesis, Durrell Institute of Conservation and Ecology, University Of Kent.

Sekhar, N.U. 1998. Crop and livestock depredation caused by wild animals in protected areas: the case of Sariska Tiger Reserve, Rajasthan, India. Environmental Conservation, 25(2): 160-171.

Skelton, P.H., Bruno, M.N., Merron, G.S., van der Waal, B.C.W. 1985. The fishes of the Okavango drainage system in Angola, South West Africa and Botswana: Taxonomy and distribution. Ichthyological Bulletin. No. 50.

Simmons, R. E. 1996. Population declines, viable breeding areas, and management options for flamingos in southern Africa. Conservation Biology, 10, 504-514.

Simmons, R. E. 1997. Southern Africa's Lesser flamingos - a summary. In Conservation of the Lesser flamingo in East Africa and Beyond. (ed. G. Howard), pp 50-61. IUCN Lake Bogoria Conference, Nairobi, Kenya.

Simmons, R. E. 2000. Declines and movements of Lesser flamingos in Africa. In Conservation Biology of Flamingos (eds. G. A. Baldassarre, F. Arengo & K. L. Bildstein), pp 83-84. Waterbirds 23, Special publication.

Simmons, R.E Anderson MD McCulloch G. 2001. Flamingo survey in Namibia, Botswana and South Africa. In: Johnson AR Arengo F (eds) 2001 Flamingo Specialist Group Newsletter No. 10: 37-42. Tour du Valat, Camargue, France.

Sitati, N.W., Walpole, M.J., Smith, R.J. and Leader-Williams, N. 2003. Predicting spatial aspects of human-elephant conflict. Journal of Applied Ecology, 40. 667-677.

Treves A. and Karanth K.U. 2003. Human carnivore conflict and perspectives on carnivore management worldwide. Conservation Biology 17(6): 1491-1499Williamson, D., Williamson, J., and Ngwamotsoko, K.T. (1988) Wildebeest migration in the Kalahari. African Journal of Ecology, 26, 269-280.

Tyler, S. J. and Bishop, D. 1998. Important Bird Areas in Botswana. In: Barnes, K. J. (ed.) Important Bird Areas of Southern Africa. Johannesburg: BirdLife South Africa.

Tyler, S.J. 2001. A Review of Waterbird Counts in Botswana, 1991-2000. Babbler, Special Supplement No. 1, Stephanie Tyler. Wetlands International, Birdlife Botswana P. Bag 00300, Gaborone.

Woodroffe R. and Ginsberg J.R. 1998. Edge effects and the extinction of populations inside protected areas. Science, 280(5372):2126-2128.

Wordon, J., Reid, R., and Gichohi, H. (2003). Land-use impacts on large wildlife and livestock in the swamps of the greater Amboseli ecosystem, Kajiado District, Kenya. In LUCID Project Working Paper, Vol. 27. International Livestock Research Institute, Nairobi, Kenya.

WWF, 2007. Human-wildlife conflict, http://www.panda.org/about_wwf/what_we_do/ species/problems/human_animal_conflict/index.cfm

WWF SARPO. 2005. Human Wildlife Conflict Manual. Southern African Regional Programme Office (SARPO).Action Set Printers, Harare Zimbabwe, 30 p.