North West Parks Board
North West Province
Republic of South Africa

Madikwe Game Reserve

Management Plan series

MANAGEMENT PLAN FOR

ELEPHANTS

AUTHORIZATION

This Elephant Management (EMP) for Madikwe Nature Reserve was drafted and recommended by a multi-disciplinary team consisting of:

NAME	POSITION AND ORGANISATION
Pieter Nel, *Pri Sci Nat*	Acting Chief Conservation Officer North West Parks Board
Daniel Buljs, *Pri Sci Nat*	Scientist Production Grade B: Ecologist NW Department of Economic Development, Environment, Conservation and Tourism

This EMP is recommended for approval by:

NAME & TITLE	SIGNATURE & DATE
CEO: North West Parks Board DEDECT: Ms TMM Matshego	26/07/2022
NAME & TITLE	**SIGNATURE & DATE**
Chairman: North West Parks Board Dr Magome Masike	26/07/2022
NAME & TITLE	**SIGNATURE & DATE**
Head of Department: Economic Development, Environment, Conservation and Tourism Mr. Lufuno Tshikovhi	
NAME & TITLE	**SIGNATURE & DATE**
Member of the Executive Council Ms. Kenetswe Mosenogi	09/09/2022

This EMP is approved by:

NAME & TITLE	SIGNATURE & DATE
Minister of Forestry, Fisheries and the Environment Ms. BD Creecy, MP	31/3/2023

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Introduction

High levels of elephant (*Loxodonta africana)* impact result from the concentration of animals in specific habitats or areas at specific periods of time (Western 1989; Dublin *et al.* 1990; Cumming *et al.* 1997; Whyte *et al.* 2003; Owen-Smith *et al.* 2006; Van Aarde *et al.* 2006), which is often the case on confined fenced reserves. Therefore, given the developed nature of South Africa, this dictates that elephants in South Africa need to be fenced-in to protect them as well as to protect the human inhabitants from the surrounding areas (Owen-Smith *et al.* 2006; Du Toit 2010), and Madikwe Game reserve is one such area.

Section 2(2) of the National Norms and Standards for the Management of Elephants in South Africa, developed under the National Environmental Management: Biodiversity Act No. 10 of 2004 (NEMBA) calls for the need for an elephant management plan for all areas that have elephants. The aim of this Elephant Management Plan for Madikwe Nature Reserve is to outline the objectives, options, and procedures for the management of the elephant populations within this protected area. The plan must be viewed in the context of providing guidelines for the management of elephants within the limitations and confines of the protected area. It should form the basis upon which elephant management decisions are to be taken within the context of the current understanding of elephants.

Should any actions be taken upon the elephant population of Madikwe Game Reserve, they must be compliant with the elephant management plan as stipulated by the Norms and Standards for the Management of Elephants in South Africa (2008). Additionally, the plan does not authorize the carrying out of any restricted activities involving the elephant. Prior to carrying any restricted activities involving elephant the Madikwe Game Reserve will still be required to apply for a permit in terms of section 57(1) of NEMBA

As with all species management plans, an element of adaptive management must be applied when one considers the elephant management plan. There are still gaps in the knowledge base of elephants, and as these gaps are filled, so will the thinking in terms of elephant populations change. These gaps should not preclude management interventions where necessary. All options should be considered carefully and with caution before implementation.

Principles

- Elephant management plans are integrative to the Reserve Management Plan.
- The management plans will conform to the philosophy of adaptive management. This require the setting of unambiguous goals, designing strategies to achieve the goals and monitoring the effect of any interventions
- Providing a transparent, accountable process for planning, within a structured, consistent framework for implementation, and adherence to, by managers.
- The process has to include all stakeholders at the appropriate development stage of the process.
- The elephant management plan is a living document that may be amended when necessary within a broader policy framework. All amendments are subject to the approval by the issuing authority.

Strategic thrust of the North West Parks Board

The North West Parks Board was established

- to ensure the establishment, development and efficient management of a network of formally protected areas in order to conserve indigenous bio-diversity, representative samples of natural ecosystems and habitats of critically important or threatened species,
- to facilitate the development, co-ordination and promotion of tourism in the Province, and
- to encourage visits to the Province from elsewhere and to travel about within the Province.

Vision
Sustainable and transformed wildlife conservation and eco-tourism for the benefit of all
Mission
Excellence in partnering with stakeholders to provide a world-class wildlife experience

The North West Parks Board, nested in the Department of Economic Development, Environment, Conservation and Tourism (DEDECT), North West Provincial Administration, needs to stimulate economic development, and this is primarily achieved through using protected areas to facilitate economic opportunities. This requires the creation of competitive tourism products in our reserves, some that may require the presence of the so-called "Big Five". Elephant will play an important role in reinforcing this type of tourist product and in certain reserves, it may be the primary reason for their reintroduction.

It is recognized that elephants are sentient beings and are complex animals with complicated family structures and herd dynamics (Scholes & Mennell 2008). This will be considered when management strategies and actions for elephant are formulated. It will need to involve an element of adaptive management to be implemented to guide management. Adaptive management requires the setting of unambiguous objectives, developing management

interventions, implementing monitoring programs and amending management depending on the outcome of the monitoring. However, because elephants are such complex animals and the opportunities for relocation are extremely limited, the precautionary principle will need to be applied in certain situations.

Section A. General information and inventory

1. General

1.1. Names of owner and manager

North West Parks Board:	Madikwe Game Reserve
CEO North West Park Board:	Ms TTM Matshego
Reserve Manager:	Moremi Keabetswe
Operations Manager:	Vacant

1.2. Postal address

Madikwe Game Reserve
P.O. Box 10
Nietverdiend
2874

1.3. Telephone and fax numbers.

Tel: (018) 350-9931
(018) 350-9932
Fax: (088) 350-9930
Email: madikweadmin@telkomsa.net

1.4. Farm name (including all registered farm names, numbers and portion numbers as per Land Survey Act (9 of 1927) in the fenced area)

The following farms in the North West Province comprise Madikwe Game Reserve (Fig 1):

Turfsloot 79 KP	Abjaterskop 107 KP
Naauwpoort 80 KP	Boschrand 109 KP
Turfsloot 81 KP	Kalkfontein 111 KP
Brakspruit 82 KP	Leeuwen 112 KP
Mooigenoeg 83 KP	Tweedepoort 113 KP
Derdepoort 84 KP	Genadendal 116 KP
Krokodildrift (Limpopo)	Rooderand 117 KP
Onverwacht 89 KP	Brandwacht 118 KP
Mooiplaats 94 KP	Doornhoek 134 KP
Weltevreden 95 KP	Wolwehoek 135 KP
Zuni Zuni 96 KP	Wonderboom 98 KP
Mooifontein 97 KP	Uitval 106 KP

Farms of the Madikwe East Land Owners Association, Limpopo:

Middelpoort

Sentellies

Kromdraai

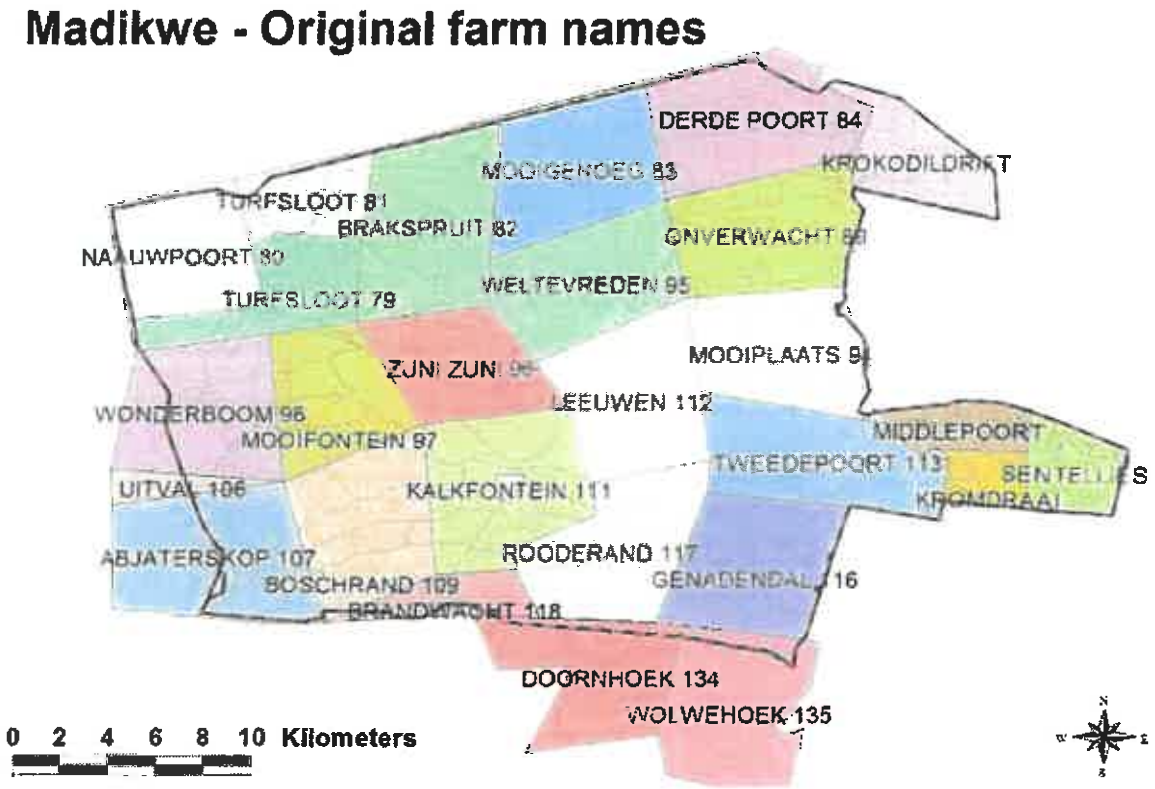

Figure 1: The farms making up Madikwe Game Reserve

1.5. Precise extent of the property and elephant enclosure

The area in which the elephants have free, uninterrupted range within the Madikwe Game Reserve fence is 60 549ha, while the total area is 61 075ha. The remaining excluded area can serve as an elephant-free refuge.

1.6. Description of the land uses and activities on neighbouring properties

The land adjacent to Madikwe Game Reserve predominately belongs to the state. Most of the state-land is under tribal administration, whilst a number of farms are leased to private farmers (along the southern slope of the Dwarsberg). Of the state land under tribal

administration, this is predominantly used for pastoral cattle farming. There are some private game farms on the west and south sides.

To the east of the reserve in Limpopo is private land that is already an established conservation area, the Madikwe East Land Owners Association (MELOA). They are receptive to the idea of incorporation into the greater Madikwe Game Reserve once the elephant population has been controlled.

1.7. Contact details and qualifications of Madikwe NR EMP authors

Name	Contact details	Qualifications
Pieter Nel	🖱 - hpnel@mweb.co.za	MSc. Wildlife Management (UP)
Pri Sci Nat	☎ - 0836548415	MBL. UNISA
	✉ - PO Box 21272, Protea Park, 0305	
Daniel Buijs	🖱 - buijsdaan@gmail.com	MSc. Zoology (UP)
Pri Sci Nat	☎ - 0833202727	MBA (UP)
	✉ - PO Box 510, Zeerust, 2865	

Contributors:	John Power	NW DEDECT, Directorate Biodiversity Management
	Prof Rob Slotow	University of KwaZulu-Natal
	Peter Leitner	Former Reserve Manager: Madikwe GR
	Declan Hofmeyr	Former Operations Manager: Madikwe GR
	Dr Audrey Delsink	Humane Society International (HSI), former Ecologist of Makalali Game Reserve
	Dr Jeanetta Selier	South African National Biodiversity Institute (SANBI)
	Dr Yolanda Pretorius	South African Wildlife College

Dr Hector Magome	Chairman: Conservation Sub-committee, North West Parks Board
Moremi Keabetswe	Reserve manager: Madikwe Game Reserve
Koos Potgieter	Chairman: Madikwe Concessionaire Forum
Craig Catton	Chairman: Madikwe Field Guides Association
Amos Setau	GM: Barokologadi Community Property Association
Dereck Milburn	Elephants, Rhino and People

1.8. Proximity to settlements, rural communities, and tribal land

The closest rural settlement to Madikwe Game Reserves is Molatedi village, which lies on the Eastern fence line. The Northern fence line is the border between South Africa and Botswana. The Southern fence line is comprised of private cattle farms and communal land.

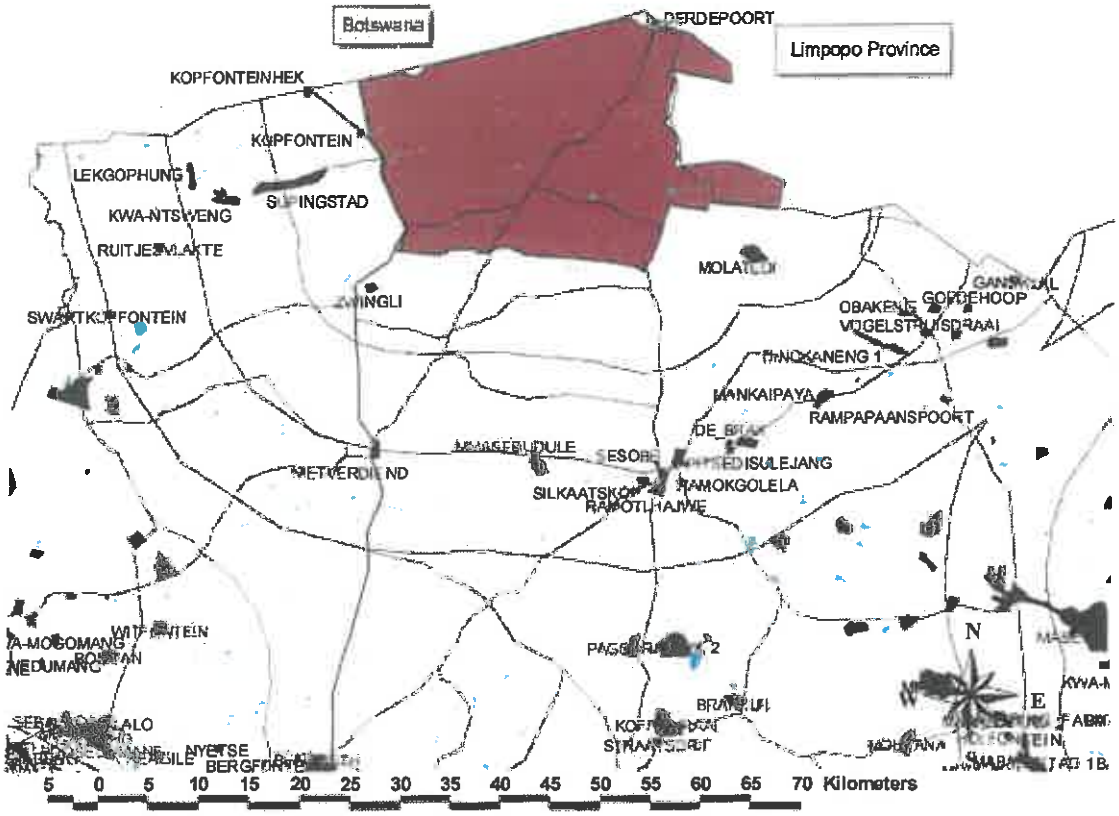

Figure 2: Location of rural villages in a 30km radius around Madikwe Game Reserve

There are a few villages scattered throughout the area (Fig 2), and the town of Zeerust is the nearest official town in South Africa (Fig 9), while the nearest city is that of Gaborone in Botswana.

1.9. Information as to whether there is potential for enlarging the property

The North West Parks Board (NWPB) embarked on a project to create a conservation corridor, proposed Heritage Park, the between Madikwe Game Reserve and the Pilanesberg Nature Reserve in the past. The corridor was estimated to take about 20 years before completion. The total area, once/if completed, should equate to about 275 000 ha (including Madikwe and Pilanesberg Reserves). The corridor alone will contribute 167 000 ha (see Appendix III for a map

of the proposed expansion). This proposed Heritage reserve area has been beset by challenges, so has been delayed in its development.

There here are, however, more achievable prospects of opportunities eastwards into Limpopo, i.e. MELOA, and some of which nearer Derdepoort, that have already come to fruition with a bridgehead across the Marico River. The inclusion of Molatedi Dam and surrounding land under control of the Department of Water and Sanitation (DWS) at the south-eastern side of Madikwe Game Reserve, via the farm Wolwehoek 932 KP, is being explored, while opportunities also exist on the south-western side.

1.10. Specifications of the perimeter fence.

Madikwe Game Reserve is surrounded by a 2.4 m Kombi Bonnox fence, with a 1 meter rock-packed apron (Figure 3).

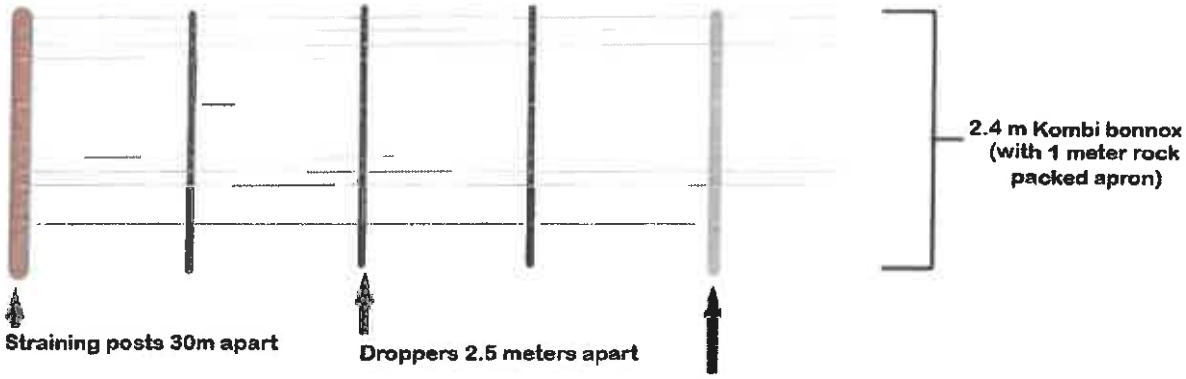

Figure 3: The configuration of the Madikwe game Reserve Perimeter Fence (electrification has not been included in this schematic) (D. Hofmeyr, 2011).

The fence is electrified with a single-off set electrified strand near the base. Above this is a double off-set strand (a live wire and an earthed wire), and another single off-set strand above this. At approximately 1.8m is another double off-set electrified strand (Figure 4).

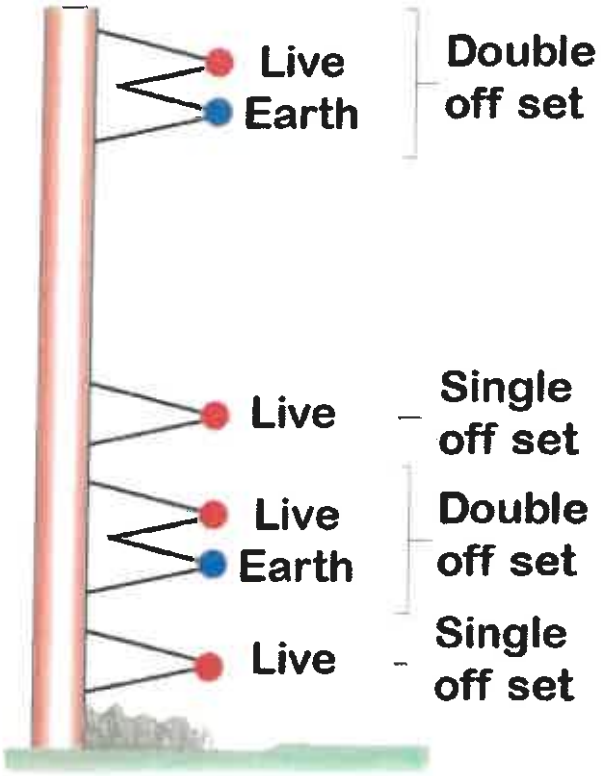

Figure 4: The Electric fence configuration of the Madikwe Game Reserve Perimeter fence (D. Hofmeyr, 2011).

Please refer to Appendix I for the schematic of the sectors of the Madikwe Game Reserve perimeter fence, as well as Appendix II for the inspection report of North West DEDECT for the keeping of species regulated in terms of the Threatened or Protected Species Regulations (TOPS), *inter alia*. The fence is thus of an approved standard for keeping elephants.

Trained Madikwe Game Reserve staff check for any damage to the fence and repair any damages immediately. They check the electric current on the fence at predetermined checking points and repair any deviations below the minimum voltage of approximately 5000V's, as required by the policy document entitled: "Operational Procedures and Guidelines for Wildlife Fencing Specifications in the North West Province", which is produced by DEDECT.

To date no elephant have escaped from Madikwe Game Reserve.

2. Ecological

2.1. General climatic data (e.g. rainfall, temperatures)

Madikwe Game Reserve is located in the summer rainfall areas. Mean annual precipitation varies around 500mm per year (Fig 5). The average annual rainfall for the six rainfall stations in the reserve is 518.8mm/year. Summers are very hot with average daily maximum temperatures exceeding 30°C. The mean average temperature is 19.4°C (Mucina & Rutherford 2006), and the area can be described to have a semi-arid to subtropical climate.

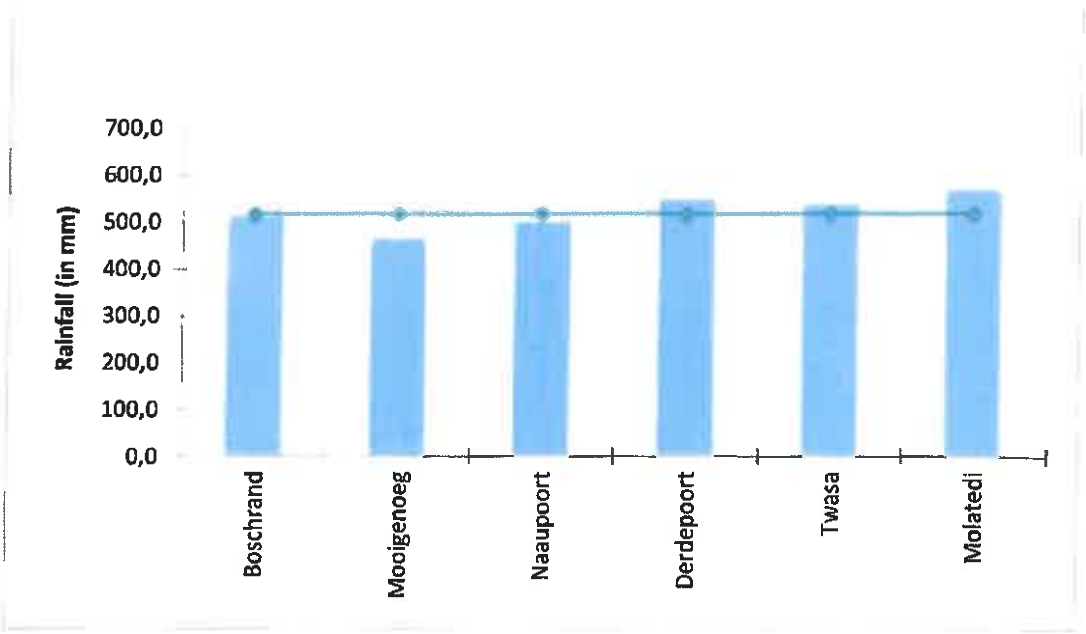

Figure 5: Average rainfall for the six rainfall stations in Madikwe Game Reserve

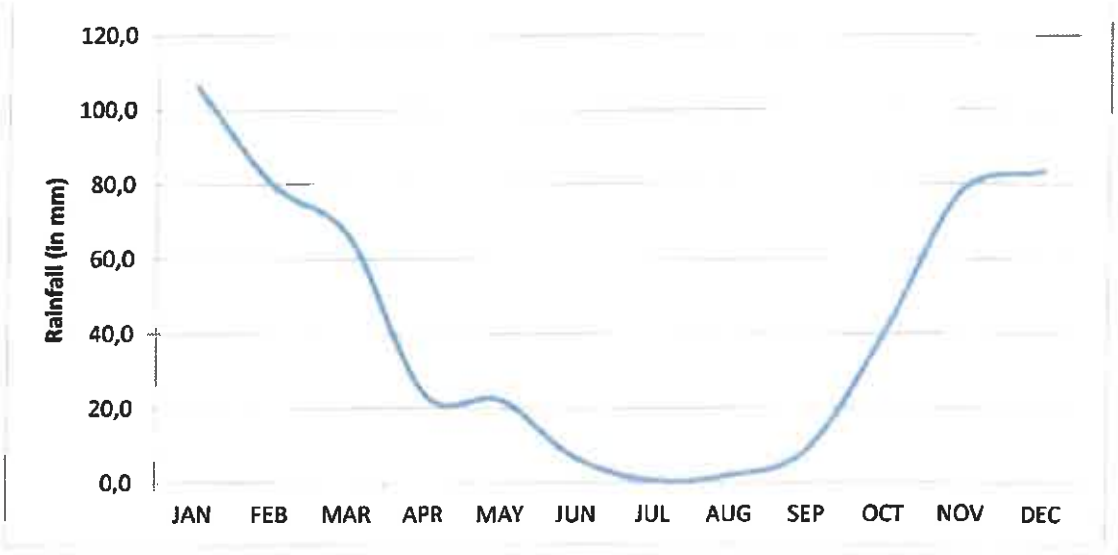

Figure 6: Seasonal distribution of rainfall in Madikwe Game Reserve

Like most savannas, there is a pronounced wet and dry season within Madikwe Game Reserve, with the rainy season generally starting in October, and ending around March (Fig 6). The area is a summer rainfall area, which experiences dry winters for the most part.

2.2. General description of the geology

Madikwe Game Reserve has a complex geological configuration (Viljoen & Moore 2007). In the north of the reserve, older igneous rocks underlay most of the landscape, whilst the southern half has younger rocks that are sedimentary in nature.

The important igneous rocks in the reserve are the granites that extend right across the northern half of the reserve. The granites are poorly exposed, but they are represented by the red sandy soils found on the surface, some of which is also wind-blown Kalahari sands (Viljoen & Moore 2007).

The central southern half is underlain by a prominent belt of dolomites. South of this band of dolomites is another band of shale with interbedded conglomerates. Some areas in this shale are

overlain by more recent deposits of black turf soils and calcrete. At the foot of the Dwarsberg on the southern boundary of the reserve, mafic lava protrudes from beneath the hills. The Dwarsberg is mainly comprised of quartzite. The Rant van Tweedepoort in the centre of the reserve that consists mainly of conglomerates, shale and quartzite. North of this range are the extensive diabase intrusions (see Viljoen & Moore 2007).

Granite is a coarse-grained felsic igneous rock with high silica content. Soils derived from granite generally have low clay content and are well leached. In contrast, diabase is a mafic dark coloured rock with an abundance of dark minerals, including feldspar. Quartzite is a metamorphic rock high in quartz and low in clay content. This creates soils with contrasting properties, which would affect the vegetation growing on it. The vegetation associated with the shallow quartzite soils on the hills has a sourish (viz dystrophic) character as oppose to those on the clay soils.

2.3. General description of the soils

Soils are a major consideration in any protected area as soil texture and depth have the most marked effect on plant growth. Soil texture and clay mineralogy affect the water holding capacity as well as the infiltration rate of the soil, which in turn, will help to dictate the vegetation profile of an area. Although elephants are successful generalist browsers and grazers, the success of the elephant population is ultimately dependent on the plant communities in an area, which are related to the soils.

In September 1983, a detailed soil survey was carried out by Loxton, Venn and associates, according to the South African National Soil Classification System. They found the basic geological parent material of Madikwe Game Reserve consisted of dolomite, shale, conglomerate and quartzite intruded by diabase south of the Rant van Tweedepoort. North of this, Ventersdorp system lava, conglomerate, breccias, Archaean norite and the Tertiary to Quaternary soils are dominant (see also Viljoen & Moore 2007).

Madikwe Game Reserve has large areas covered by black soil, black turf, brown sandy soils or reddish sandy soils classified as superficial drift. South of Derdepoort is a region rich in Kalahari

sands. The dark brown to reddish brown coarse sandy clay loam is a well-drained non-sticky soil. It compacts easily but has a tendency to erode when devoid of vegetation. Various species occur on these soils (i.e. *Dichrostachys* spp, *Vachellia* spp and *Combretum* spp) all of which attract elephant browsing.

A complex association of dark coloured sandy clay loams occur in depressions and drainage lines within the black clay area. They remain wet for longer periods than other soils and become wet very quickly, with occurrences of various plant genera (i.e. *Combretum* spp, *Ziziphus* sp., *Vachellia* sp., *Searsia* spp.). These areas may encourage concentrations of elephants during periods of moisture stress. These soils dominate the north-western parts of the reserve, although there are intrusions throughout the reserve of these black turf soils with high clay contents.

The central and southern areas are characterized by shallow soils on dolomites, while the areas in the north-east are mainly underlain by red loam soils (Fig 11), while there are deeper alluvial soils along the Marico River in the east.

2.4. Detailed description of the vegetation

The Madikwe Game Reserve was earlier described to have four major vegetation types (sensu Veld Types) as described by Acocks (1988), and these were: Mixed Bushveld, Kalahari Thornveld, Arid Sweet Bushveld and other Turf Thornveld types.

Given the archaic nature of this vegetation type classification, the newer classifications describe three different types arranged from north to south in horizontal bands (Mucina & Rutherford 2006), which seem to correlate with the geology. These are starting from the north, the Dwaalboom Thornveld, the Madikwe Dolomite Bushveld across the middle, with the Dwarsberg-Swartruggens Mountain Bushveld on the mountainous southern border (Mucina & Rutherford 2006). Being so broad, these are only useful at the landscape/regional scale, while more defined plant communities may be more useful at the reserve-level scale (see Fig 13).

In 1994, Dr Pete Zacharias[1] was commissioned to provide a vegetation description that would aid in the management of the reserve. Therefore, emphasis was placed on the general form (structure) of the vegetation and the major species that describe the vegetation or communities (habitat).

Broadly, there were two major vegetation units in the reserve (upscaled to above the vegetation types here), namely broad-leafed (dominated by *Combretum* spp) and microphyllous (dominated by *Vachellia, Senegalia* spp). The broad-leafed types are mostly located in wide bands that run from East to West in the central section of the park and bounded by elevated land units associated with the Rand van Tweedepoort as well as the Dwarsberg and various inselbergs scattered though the north of the park (*viz* Madikwe Dolomite Bushveld).

The microphyllous vegetation is associated with low-lying land units of red and yellow sands, or black and grey cracking soils in the north (i.e. Dwaalboom Thornveld), and along the northern foot slopes of the Dwarsberg. It has been found that the Madikwe elephants utilise the fine-leaved microphylous plant communities more so than the broad-leaved woodlands (Govender 2005).

Old lands are also common and scattered throughout the reserve, with one extensive area in the northern section in excess of 900 ha. These old lands are infested by *Vachellia tortilis* and *Dichrostachys cinerea,* in the process of secondary succession.

There is riverine woodland in the east along the Marico and are dominated by various tree species, of which *Ziziphus mucronata*, *Combretum erythrophylum* and *Searsia (Rhus) lancea* are predominant.

2.5. Preferred management density of elephants

Two hundred and nineteen (219) were elephants introduced into Madikwe Game Reserve in 1992 and 1993. In 1998, eight elephant bulls were introduced. The introduced elephants were skewed towards a dominating female sex ratio (Fig 7), resulting in an annual population growth rate of 8.4 %. Initially, the elephant density within the reserve was 0.3 elephants per km^2.

[1] Pete JK Zacharias. Grassland Science, University of KwaZulu-Natal.

The elephant population has grown to ±1455 in 2021 with a population growth rate of approximately 6-7% per annum in 2018[2].

Currently, the population is at about 2.4 elephants per km^2. There is no evidence of natural mortality yet, as the animals introduced were all young, so there is no expectation that the population growth rate will abate in the near future (Fig 8).

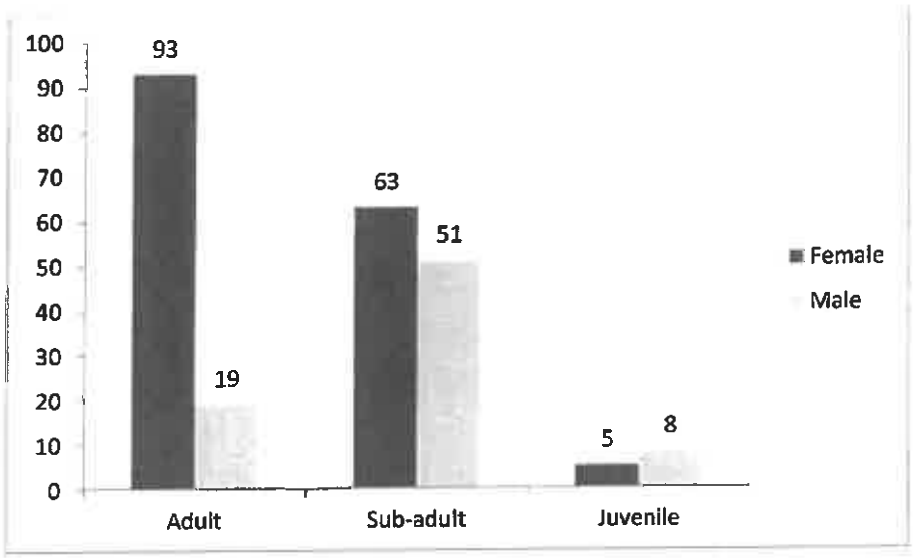

Figure 7: The demographic breakdown of the Madikwe Elephant founder population

Elephant populations are believed to have only one main limiting factor, which is water (Gaylard *et al.* 2003). However, for a semi-arid region, Madikwe Game Reserve is not water limited as there is an abundance of artificial water within the reserve (Fig 12). The assumption is that the high population growth rate will continue (Fig 8). The only possible factor that may temporarily dampen the high growth rate would be nutritional stress caused by a prolonged drought period, which will lead to nutritional stress, and possibly starvation. However, this extreme result is unlikely to happen in the near future. There is the limited probability that

[2] Delsink, A and Slotow, R. 2018. Madikwe Elephant Management Assessment Workshop. Summary of 1st Panel Workshop & On-Line Surveys. Internal report

intraspecific competition may lead to some type of density-dependent regulation because of an increase in elephant densities in the future.

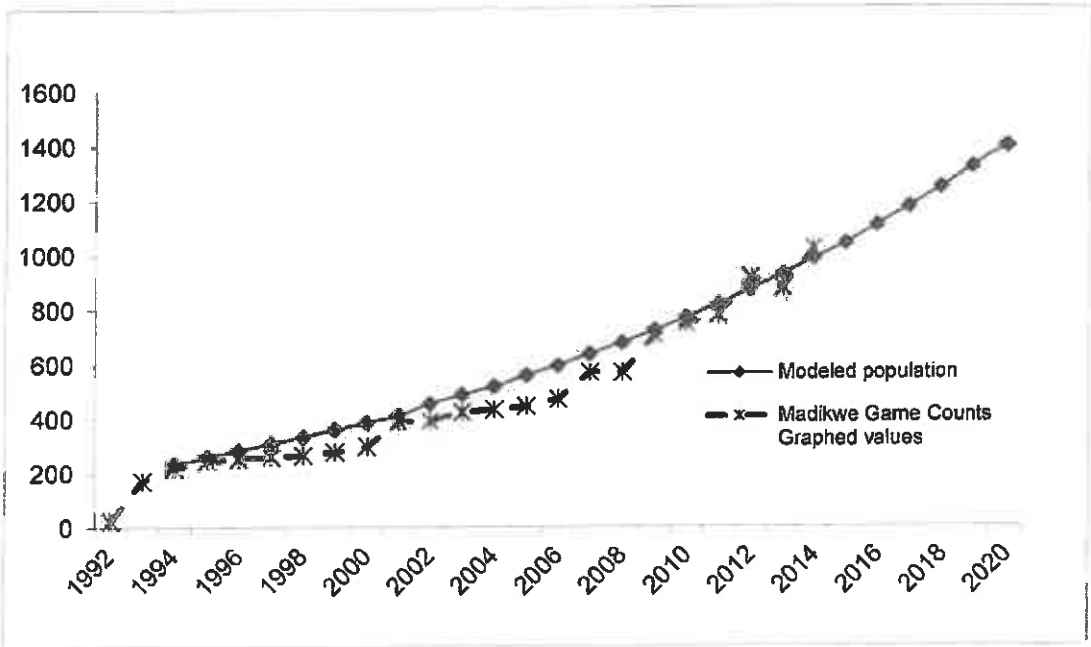

Figure 8: Elephant population growth in Madikwe Game Reserve since introduction

All actions will be according to the approved elephant management plan and standing permit and any additional permits that may be required according to the nature of the restricted activities may be applied for on *an ad* hoc basis. Where research is undertaken, the research will be done firstly according to reserve objectives, then secondly, according to the alignment with the National Elephant Research Strategy, and independent researchers will be asked to assign their research to the relevant programmes and themes according to this strategy.

Increasing elephant densities have significant impacts on biodiversity, though research conducted in similar sized reserves has not revealed substantial consequences for either animal or plant diversity, despite elephant population densities of 1–2 animals per km² regionally, and local concentrations of 4 – 8 elephants per km² (Owen-Smith *et al.* 2006). It should be noted that population density in Madikwe is lower than these purported thresholds.

An optimal population size of 500 elephants would be preferred, given accommodation of other biodiversity, while 1000 may be seen as an upper, economically determined capacity, provided that these numbers are merely approximated guidelines.

Agriculturally based, fixed stocking rates are a mere guideline and an integrative approach must be considered, looking to reconcile the social needs of elephants with that of biodiversity related objectives, while also including economic objectives, i.e. tourism.

2.6. Game species and numbers present on property

Madikwe Game Reserve boasts a variety of game species, managed specifically to enhance the wildlife experience in the reserve. Predation has a significant impact on ungulate species, and as is evident from Table 1, predation has a compounding effect on the decline of ungulate species not entirely suited to the area.

Table 1: Population estimates for animals in Madikwe Game Reserve over the past 10 years

Species	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Buffalo	832	844	1007	1033	1186	806	677	690	738	813	725
Elephant	777	912	875	1046	1015	1080	1172	1226	1318	1498	1455
Hippo	3	5	3	2	6	2	2	4	4	7	5
Eland	9	4	9	6	5	5	5	7	7	12	3
Gemsbok	45	44	36	40	31	32	33	29	30	30	32
Red Hartebeest	72	167	123	63	38	37	36	46	49	45	57
Impala	2879	3013	2664	3298	3199	3097	2985	4565	4722	4498	6110
Kudu	713	609	578	622	501	516	532	420	431	518	505
Waterbuck	72	190	159	164	109	108	107	110	116	108	125
Wildebeest	529	1350	1718	1568	1356	997	782	1227	1272	1453	1467
Zebra	1184	1203	1518	1705	1707	1740	1735	1715	1771	2240	1903
Warthog	104	114	125	167				250	247	387	478
Giraffe	145	136	138	172	182	186	195	213	224	204	197
Ostrich	5	25	7	6	4	4	4	14	14	8	15
Springbuck	43	15	24	23	23	23	33	32	33	15	19

Madikwe Game Reserve has a flourishing predator population and any downward trend in population numbers can be attributed to the impact of predation

There has been no notable impact of elephant on any of the herbivorous animals yet. There have though been a few incidents of aggression between elephants and rhinoceros, but these incidents are rare in occurrence (Slotow & Van Dyk 2001).

2.7 Sensitive habitats and species

There are small sections of Riparian vegetation on the eastern boundary of the reserve (along the Marico River), which is favoured by elephant, particularly during periods of moisture stress, like the late dry season (Govender 2005). The damage done by the elephants is notable, but most of the river is outside of the fenced in area (i.e. Tswasa, serves as a *de facto* exclosure where this vegetation can be protected). Madikwe Game Reserve was established as an economic development initiative in the area, and not as a biodiversity reserve, hence less important to focus on this than it is for Pilanesberg Nature Reserve. There are no specific habitat types that need conservation, as the reserve protects large tracts of representative vegetation types that may be partially threatened outside the reserve (see Mucina & Rutherford 2006), although there are isolated pockets of *Erythrophysa transvaalensis* (Transvaal Red-Balloon), which is a protected tree species (National Forest Act, 1998 (Act No. 84 of 1998)). These pockets of balloon trees occur in outcrops that are heavily pockmarked by erosion, and they are mostly inaccessible to elephants, so they cannot be construed as a sensitive species in this regard.

There has been research conducted on the impact of elephant on ground-dwelling invertebrates and it was found on the reserve that there was not necessarily any negative effect, but more a facilitation effect, where elephants provide refugia-like habitat for invertebrates i.e. felled logs, or dung, and thus heterogeneity is generated by elephant presence on the reserve (Govender 2005).

Three faunal species that are listed under the National Environmental Management: Biodiversity Act, 2004 (Act 10 of 2004): Threatened or Protected Species Regulations Threatened or Protected Species (ToPS) occur on the reserve (Wild dog *Lycaon pictus*, Black Rhinoceros

Diceros bicornis minor and Tsessebe *Damaliscus lunatus*). The effect of burgeoning elephant populations may only impact the black rhino. Black rhinos are very specific about their habitat, so there may be some level of resource competition between the rhino and elephant (Landman et al. 2013). However, the black rhino population has a very good growth rate at present (Table 1), and no incidents between elephant and black rhino have been reported. There is currently very little evidence that elephant impact on black rhino at all.

In terms of the wild dog, both the wild dog and elephants have their own ecological niche which does not overlap to the possible detriment to either species. The same would apply to tsessebe, although they are also part of the herbivore guild. The tsessebe population in Madikwe Game Reserve is very small, and they are under more pressure from interspecific competition and unsuitable habitat (in terms of severe bush encroachment), but this is beyond the ambit of this management plan.

The marula tree, *Sclerocarya birrea*, is also a nationally protected species (National Forestry Act, Act 84 of 1998), and it is well known that marula trees are heavily utilized and impacted by elephant (see Coetzee *et al.* 1979; Gadd 2002; Jacobs & Biggs 2002; Shannon *et al.* 2008), where most damage is done near the roads (Coetzee *et al.* 1979), and half the marula trees may be typically damaged by elephants to some extent (Jacobs & Biggs 2002). The species shows slow regeneration and recruitment from damage (Jacobs & Biggs 2002), and thus this species may be worth considering for monitoring – albeit visually from known specimens.

At this advanced stage, protection of marula trees, i.e. rock packing, placement of sharp rocks (see Du Toit 2010), and fenced-off trunks should be considered, though it may be too late already for regeneration as they have been impacted already.

In terms of tree damage, elephants impact upon nesting vultures (Whyte *et al.* 2003), and this would be something to be considered as part of monitoring on an *ad hoc* basis.

Rhinoceroses will be protected because there are enough older male elephants to control younger bulls (Slotow *et al.* 2000) to minimize attacks directed at either rhinoceros species by younger male elephants (see Slotow & Van Dyk 2001).

2.8. Disturbed or degraded areas such as bush encroachment and soil erosion

Prior to the establishment of Madikwe Game Reserve, the land was subjected to agricultural land-use, particularly cattle grazing. Between 1955 and 1996, there has been a 30% increase in the percentage of woody plant cover (Hudak & Wessman 2001) because of past intensive grazing. As a consequence, the reserve is heavily bush encroached with stands of sicklebush *D. cinerea, Senegalia erubescens* and *Senegalia mellifera.*

2.9. Description of all available water bodies and distribution thereof described

Madikwe Game Reserve is classified as falling within the semi-arid zone, with Kalahari affinities. However, the water supply within the reserve is ample. Each lodge has a watering point in the front of the lodge, and some have a grey water supply that is accessible to the game on the reserve. In addition, there are numerous dams that are maintained with a relatively constant water supply (Fig 10). The perennial Marico River passes through the eastern part of the reserve.

2.10. Maps

a) Location map

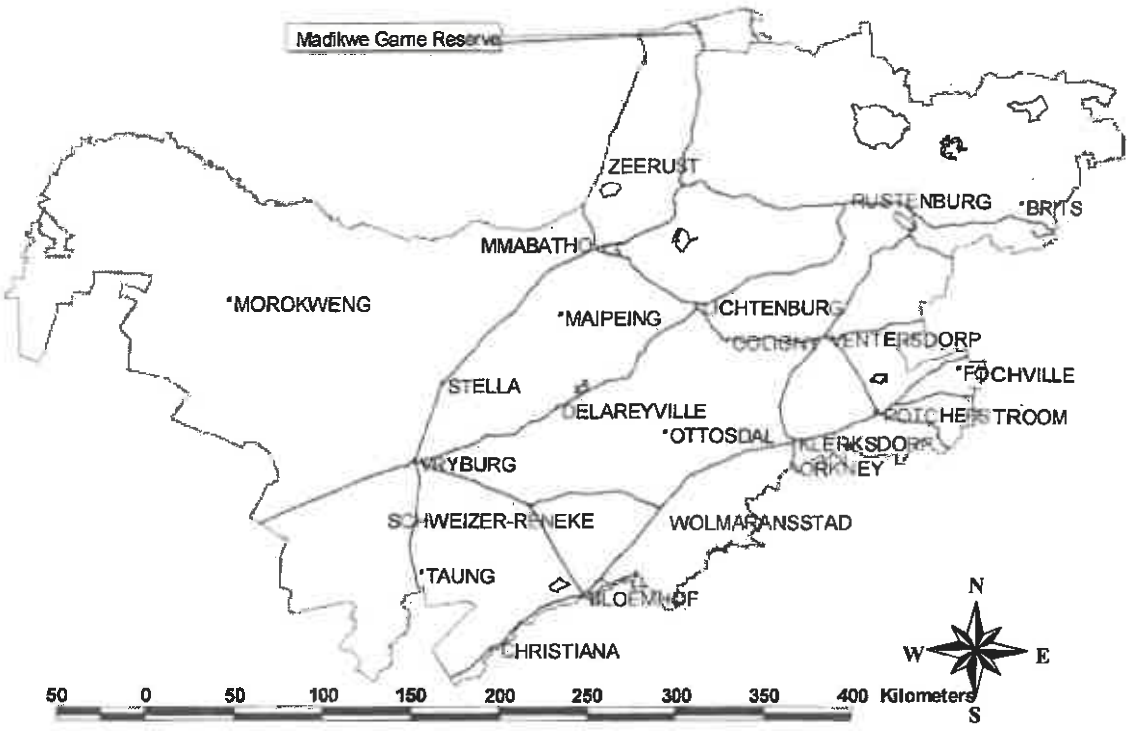

Figure 9: Location of Madikwe Game Reserve within North West Province

a) Topographic map of property (boundary of farm(s) and camp(s), roads, water points, infrastructure etc.)

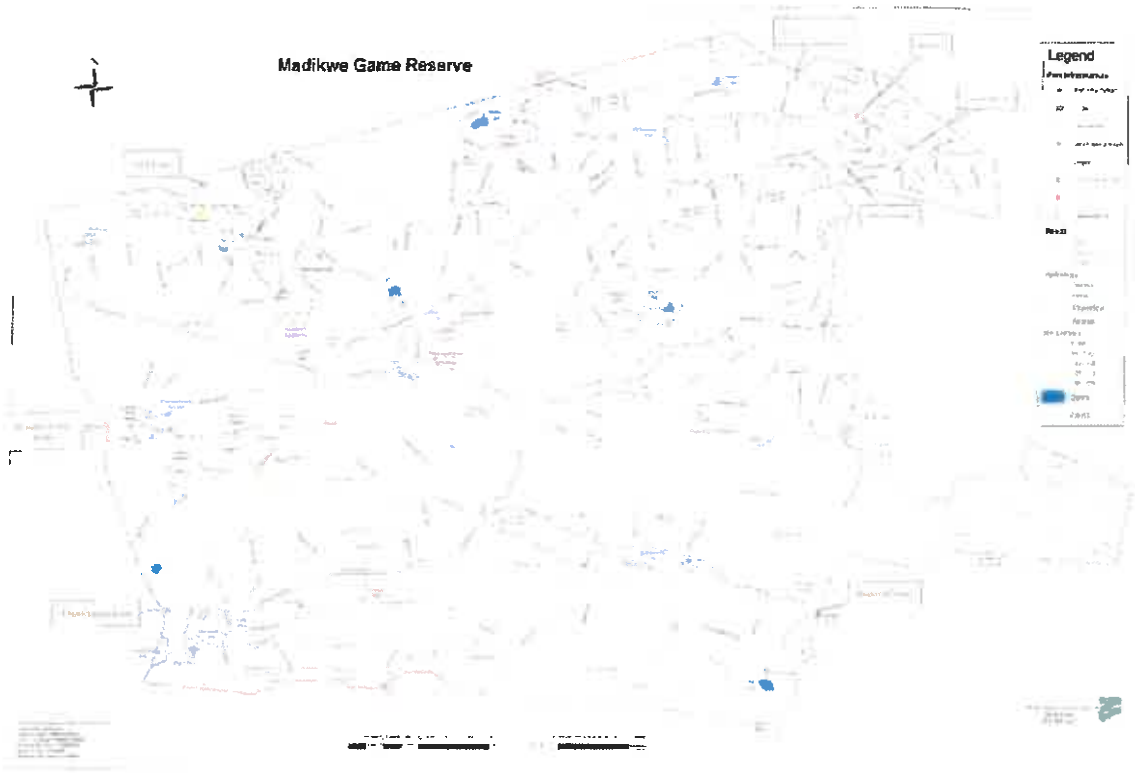

Figure 10: A general map of Madikwe Game Reserve, showing topography, roads, water points and all existing infrastructure

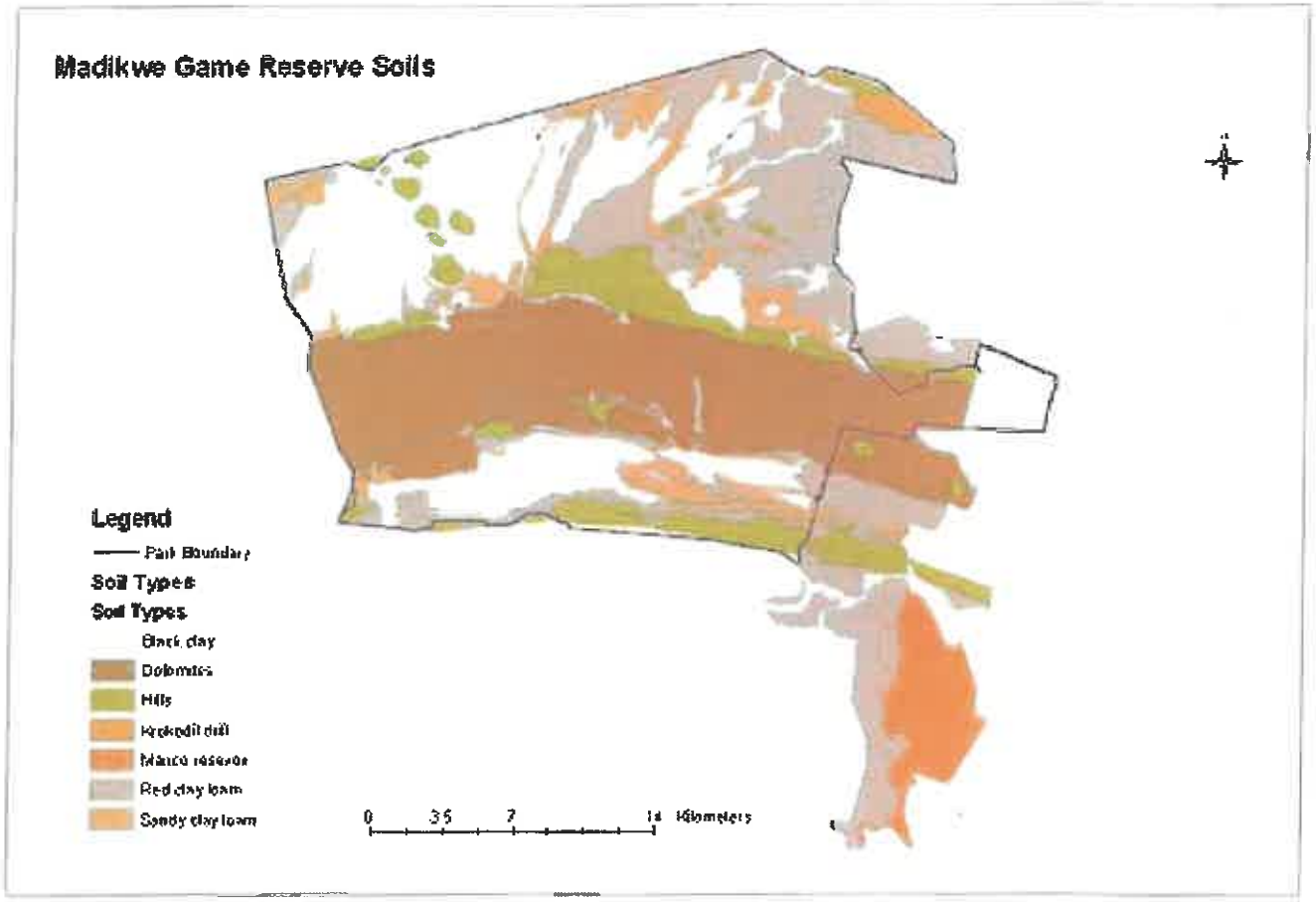

Figure 11: Soil map for Madikwe Game Reserve

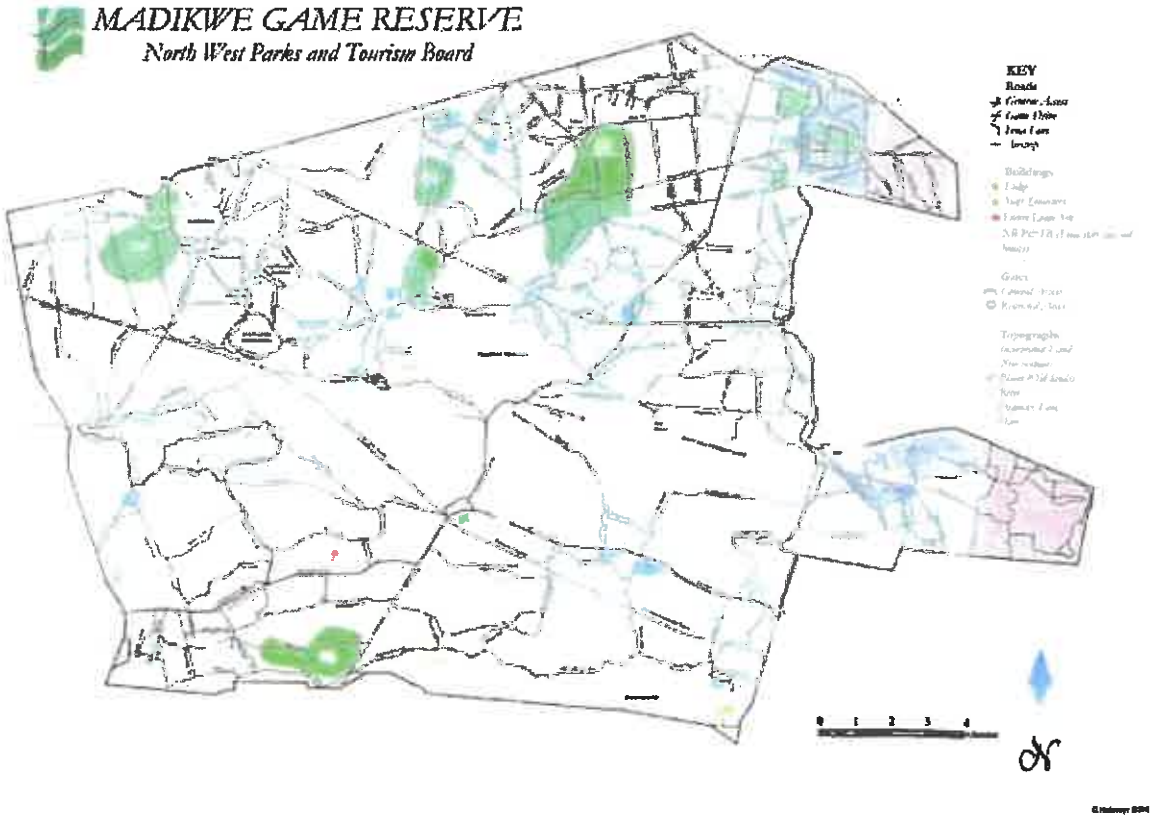

Figure 12: Map of Madikwe Game Reserve showing all the available water on the reserve, along with a 2km buffer zone surrounding each water point

b) Vegetation communities

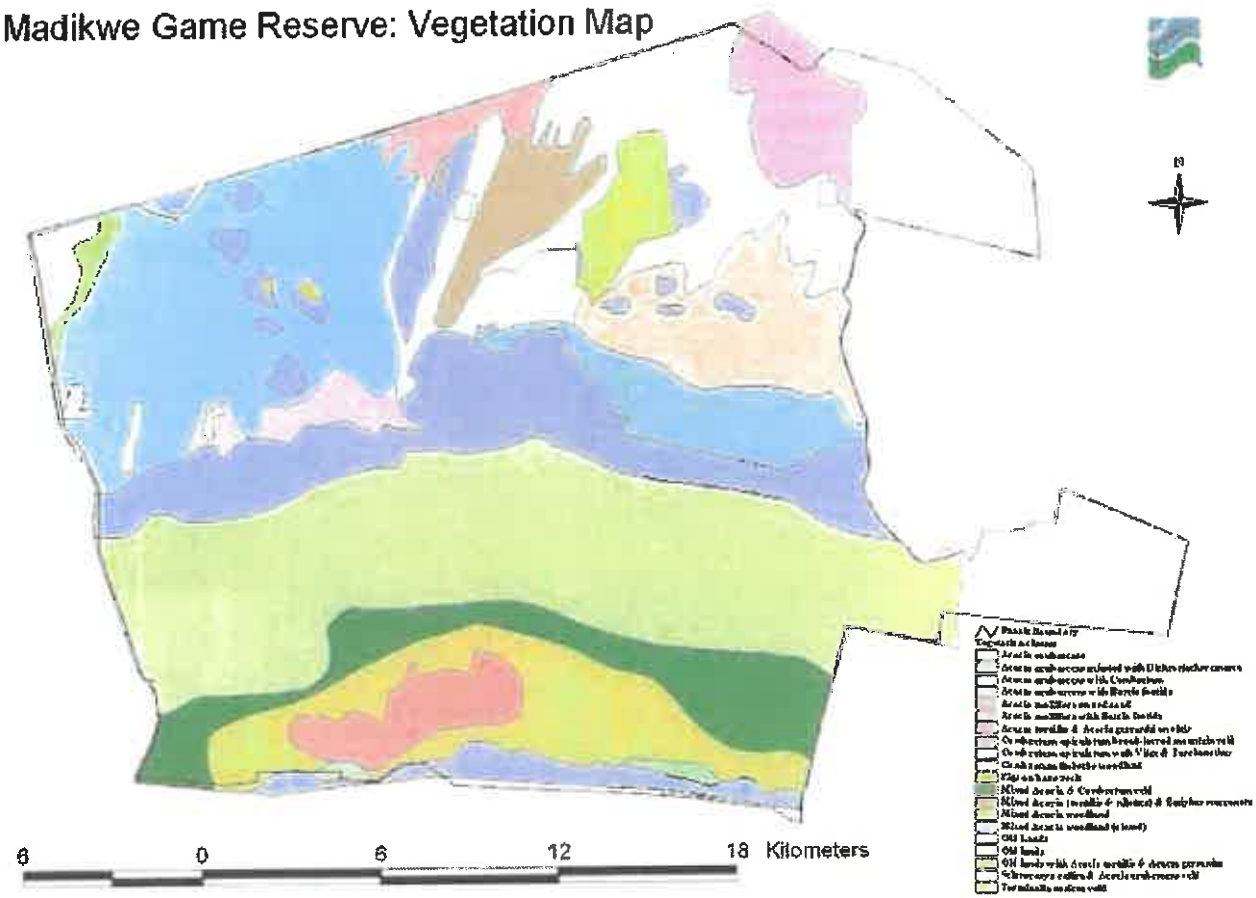

Figure 13: Vegetation map for Madikwe Game Reserve

Section B. Management goals and objectives

3. Habitat

3.1. Veld condition monitoring methods and time schedules

The last veld condition assessment was undertaken in 2001 following the methodology devised by Dr Pete Zacharias and Dr M. Peel (see Appendix III). The methodology has recently been reviewed to incorporate elephant impact analysis and implemented in June/July 2013. The same method will be considered for implementation every two years, given logistics that may affect the conducting of such (i.e. anti-poaching work etc.), or mere budgetary constraints.

The elephant impact assessment will include a visual survey of large trees within each site of the vegetation condition assessment, and the recording (photographic as well as data collection) of the impact will be noted. In addition, aerial photographs as well as satellite imagery will be assessed every ten years to examine the changes in the woody component. On an *ad hoc* basis, there will be visual assessments of individual trees and hotspots of use to assess impacts. Going forward there will be more reliance on interpretation of satellite imagery where aspects such as heterogeneity will be examined, and this may be in conjunction with sanctioned studies.

3.2. Rehabilitation programme for degraded areas

There are no seriously degraded areas within Madikwe Game Reserve, but there are some areas in need of remediation. The largest impact, which is currently being addressed, would be the bush encroachment because of the previous cattle grazing regime. Bush control programs subsidized by the Expanded Public Works Programme are in place to remove Sicklebush in selected areas.

Pilot research on the reserve has found that molasses application on sicklebush can increase utilization pressure by browsers, particularly elephants (Esterhuizen & Myburgh 2016), where this approach can be considered in this plan, but mindful that this was a pilot study and may not be very efficient in its outcome.

Unfortunately, some areas are so dense, that mechanical control are required.

3.3. Fire management plan

The objectives for burning in Madikwe Game Reserve are:

- Reducing and breaking up fuel loads to prevent intense late season wild fires
- To improve forage quality
- To promote game viewing in the reserve,
- To protect infrastructure

In achieving these objectives, the proposed approach is to burn a certain percentage of the reserve, taking note of areas that were previously burned the year before. The "fire season" will run from the middle of the dry season until the end of the dry season. Fire will also be used to break up high fuel loads that occur due to grass senescence and the occurrence of moribund stands. Control of these fuel loads will minimize the risk of high intensity wild fires that may be problematic to elephants. Annual fuel load assessments are carried out to determine high-risk areas in terms of wild fires. Generally, these areas are targeted for ignition during the early fire season. The detail on burning is availed in the reserve's ecological management plan.

3.4. Water provision

Artificial water provision is extensive within Madikwe Game Reserve, ensuring that water is not a limiting factor for elephant in Madikwe Game Reserve. Every lodge has a small water point for game viewing purposes in front of the lodge. In addition, there are small sections of the Marico River available to the game Reserve. There are also dams that are pumped with clean borehole water during the dry season.

An area of potential concern is the possibility of denuded vegetation around the water points. Should a prolonged drought period occur, the vegetation around the water points might become too denuded and unable to support the faunal component of the reserve. Elephants are strong competitors in such a case, and may react to the possible water stress long after other species become impacted. Indeed, elephants could initially supply previously unavailable browse for

other browsing species by knocking over trees. However, they may affect the grazing species by out-competing them in terms of graze availability and the overall impact of trampling.

3.5. Population management of other wildlife species

Both black *Diceros bicornis minor* and white rhino *Ceratotherium simum* are intensively managed, owing to poaching threats, with particular emphasis on maintaining a high recruitment rate for the black rhino. Black rhino and buffalo *Syncerus caffer* are managed whenever it is deemed that there is a surplus and the population is reaching an asymptotic population growth rate. Currently they may, however, not be removed alive because of the presence of bovine tuberculosis in Madikwe. Predation pressure is quite high within the reserve, which negates the necessity to manage other herbivore populations. The predator populations are closely monitored and the population is controlled as and when needed by either euthanasia or live removals. The herbivore population is monitored annually with triplicate aerial counts.

3.6. Preferred management density

An adaptive approach is followed and follows the fluctuation in the predator-prey ratio.

SECTION C

4. Information pertaining to elephants

4.1. Purpose of introduced elephant

Elephants were first introduced into Madikwe Game Reserve as one of the charismatic mammalian species that would draw in tourists, while it is acknowledged that they also historically occurred in the area. There is no conservation status applied to these animals and they are not regarded as source populations for elephants though potentially they could, given

the large size of the population. The management objectives for elephant in the reserve are therefore:

- Manage to optimize their value as a tourist attraction
- Maintain the population in a state where the elephant associated ecological processes are maintained
- Consumptive use where allowed under current legislation
- Manage to enhance the contribution of elephant newly incorporated areas and other partnerships and work towards integrated elephant management across boundaries

Recent research done on the elephants has shown that they become stressed during high tourist traffic periods, which suggest some form of refugia be provided (Szott *et al.* 2019a). This may be impractical, given the road density, but can be considered in future if an opportunity for reserve expansion arises. Furthermore, as tourist pressure increased, conspecific-directed aggression in elephants increased and male elephants were more likely to perform conspecific directed aggression compared to female elephants. Further, they found that elephant herds became increasingly likely to move away with increasing numbers of vehicles present. Results suggest that reserves should monitor elephant behaviour to identify when tourist pressure has potential effects on elephant welfare and train guides to monitor behaviour and adjust minimum distances flexibly to ensure high welfare standards and tourist safety (Szott *et al.* 2019b).

4.2. Public participation reports

Any major management decisions that are taken in terms of Madikwe Game Reserve are done under public scrutiny. Madikwe Game Reserve is managed under a tripartite agreement between the NWPB, the Concessionaires, and the surrounding Communities. Should any decision be made regarding elephants, as well as any other aspects of the reserve, all three parties will be called to the table. The Madikwe Management Forum is one such forum where management decisions are subject to public scrutiny.

This plan was presented to the Madikwe Management Forum and concerns and comments were incorporated.

4.3. Specifications for the release camp

Not applicable for now, as the elephants were released in 1994. However, there is an operational boma in the reserve suitable for elephants should they need to be handled for one or other reason, which and serves to keep other species too.

4.4. Control of elephant population size

Over the years, various elephant management options have been considered, but the implications and unintended consequences of certain interventions are uncertain and risky in terms of the objectives of the reserve. The Board has entrenched the principle of adaptive management into its policies and this should be the guiding principle in elephant management in the reserve.

All actions will be according to the approved elephant management plan and standing permit and any additional permits that may be required according to the nature of the restricted activities may be applied for on *an ad* hoc basis.

When attempting to control elephant population size, the following options are available:

a) Translocation

Over and above the various removal methods, translocation of family groups or individuals is still the preferred option. The Madikwe elephants are habituated to mass tourism and they are fence "trained", thus their potential as founding populations in other tourist areas is still very high.

Translocation to pre-approved free roaming areas will be encouraged. As far as possible, known family groups identified as per request or individual bulls will be moved. Given South Africa may be approaching saturation with elephant-containing reserves, restocking other

African reserves where they have been depleted does hold promise, and such will be considered when such opportunities and interest avail.

b) Contraception using pZP

Immunocontraception has been proven effective in controlling elephant population growth (Fayrer-Hosken *et al.* 2001; Perdock *et al.* 2007) and is the preferred option.

There is, however, currently no contraception of female elephant in Madikwe. Female contraception using porcine Zona Pellucida (pZP) has been applied with success in other conservation areas (see Delsink *et al.* 2006 & 2007; Druce *et al.* 2011), and the protocol developed in these areas, especially Makalali, will also be applied in Madikwe as a long-term management population strategy.

The strategy for applying pZP contraception will be to allow for natural age-related mortalities in future. As mentioned, it would be a precautionary approach, slowing down the population growth to thwart the need to have to consider less favoured, lethal management (i.e. culling) of the population in the years to come, which would be in line with the flow chart approach to decision making in Appendix VI of the Elephant Norms and Standards.

Aerial vaccinations of pZP contraception will be applied and can be funded by NPO's that have pledged their support already. Cows older than 10 years will be vaccinated, and a booster application will be administered 3 weeks later. The matriarch animals will be collared with VHF collars (or satellite collars) to reduce flying time for the future annual contraception operations (see Delsink *et al.* 2007), and other monitoring requirements (known group counts and identification updates etc.) will be done at the same time.

With a 100% contraception rate achieved (i.e. no calves in the population ever), the population is likely to stabilize at around current levels for at least another 15-20 years, before age related mortalities will commence after which the population will start declining.

c) Culling

Culling is not a preferred option in the Madikwe situation, especially given the emotional sentiment afforded to the species, and reputational risk associated with this. It will however be considered only if other management population limitation options are not feasible or unsuccessful. Culling is the last option where translocation, contraception and even range manipulation have been considered and failed, and this would be in line with the framework of Annexure VI of these same Norms and Standards. An independent culling plan must be submitted for approval.

d) Hunting

Selective hunting may be used to limit the number of adult bulls. Hunting will be according to the elephant Norms and Standards, which can even be considered for escaped bulls. Hunting is not advocated and would only be considered under exceptional circumstances. Trophy hunting is not efficient at population control, and it would be more tied to economics and problem animal control.

e) Reintroductions

Although further introduction of elephants appears to be superfluous in the control and management of elephant population in the reserve, it may be required for a few reasons:

- To enhance the genetic diversity of the population
- To enhance the tourist product by reintroducing tourist- friendly animals
- To provide a possible refuge for abandoned or orphaned animals
- To alter or modify when necessary, sex and age structure through the reintroduction of adult bulls/females. The reintroduction of adult bulls has proven to be successful in suppressing aberrant behaviour by adolescent bulls (Slotow *et al.* 2000).

If ever other genetics are to be considered, in the spirit of metapopulational management, these may be from northern Kwazulu-Natal, i.e. Tembe Elephant Park, since the founders are from Addo Elephant National Park and Kruger National Park stock.

Aspects such as the objective of the reintroduction, the history of the elephants and the process of reintroduction will be carefully considered before a firm decision on further reintroductions will be made.

f) The sterilization of adult elephants

The sterilization of adult elephants is a recent development; however, great strides have been made in the development of surgical protocols for the successful and relatively stress-free sterilization of males and females. The application of laparoscopic vasectomy techniques for sterilizing males has proven to be very successful and had little trauma or side effects on elephant populations in which it was implemented (Bokhout *et al.* 2005; Doughty *et al.* 2014).

A fair number of bull elephants have had the laparoscopic procedure done since 2006, assisted by surgeons from the Faculty of Veterinary Science of the University of Pretoria. The vasectomy effectively sterilizes the bull elephants while maintaining normal hormone levels and normal elephant social behaviour.

Wildlife scientists and rangers used telemetry tracking collars placed on the elephants during the procedure, to closely monitor the animals and ensure there are no post-operative complications. All bull elephants that have had this procedure have fully recovered and shown no side effects from the procedure.

The procedure entails the following:

- Under anaesthesia a trans-rectal ultrasound is done to determine reproductive health status
- After cleaning and disinfection of the rectal mucosa, a needle is inserted through the rectal mucosa
- Trans-rectal ultrasound guided access to the lumen of the ampulla and *ductus deferens* by 14G specific catheter system

- Aspiration of sperm stored in ampulla with subsequent harvest and cryopreservation
- Flushing of ampulla and duct
- Fusion, ablation, obstruction of both *ductus lumina* over a length of 15 cm

Follow-up assessment of the success of the procedure entails trans-rectal ultrasound (under anaesthesia) for evaluation of the treated *ductus deferens* in the area of ablation and obstruction. An ejaculate will be collected by standardized electro-ejaculation to ascertain aspermatic ejaculate.

This technique does not require invasive and complex surgical procedures and can be done at relatively low costs.

This option will be applied on male elephants in a reproductive state. The number of bull elephant to be sterilized will be dependent on costs.

This has been hailed as useful to calm the behaviour of males (Du Toit 2010), and for managing populations between 100 – 200, where 2 % of the population can be vasectomized, even with natural growth rates, populations can still stabilize at desired levels (Bokhout *et al.* 2005). This typically does not involve testes removal, which affects the onset of musth in males, and it simply involves the ducts, specifically the *Ductus deferens.* Males destined for removal as problem animals or those selected for hunting, should be side-lined for such sterilization.

g) GnRH application to adult elephants

Contraception in males is also achievable, by the use of Gonadotropin – Release Hormone (GnRH) treatment (Doughty *et al.* 2014). Treating male elephants rather than female elephants may be more efficient as fewer bulls reach breeding age, as it is thought that only 39% of bulls reach the ages where they regularly enter musth, as opposed to 82% of females reaching reproductive age (Moss 2001, In: Doughty *et al.* 2014). GnRH treatment inhibits the release of testosterone. The suppression of this hormone prevents the bull from entering musth, that period of heightened sexual activity, and therefore has a direct effect on the animal's overall sexual behaviour (Bertschinger *et al.* 2004, In: Doughty *et al.* 2014). This may, however, compromise the capability of the mature bulls in the reserve in their duty to control the onset of

musth in young males in the reserves (see Slotow *et al.* 2000), which indirectly is a 'stop gap' to control breeding in a natural way.

This method is a tertiary approach to contraception of elephants and must be carefully evaluated if this option is ever availed and considered.

4.5. If and how sex and age ratios will be manipulated

As discussed in the previous section, the strategy for applying pZP contraception will be to allow for natural age-related mortalities in future, but will not impact on sex ratios.

4.6. Measures to prevent poaching

Madikwe Game Reserve has been plagued by poaching of specifically rhino. Elephant poaching has not occurred yet, but the reserve has developed a comprehensive and detailed response plan for combatting of poaching. The plan is being implemented over the past 5 years with installations of advanced technology at strategic security risk points, acquisition of equipment and vehicles, development of Standard Operating Procedures (SOPs) and closer collaboration with other security structures, including private landowners and national departments.

Patrols are undertaken daily and the road density in Madikwe Game Reserve, in conjunction with the number of vehicles with more surveillance is in itself prohibitive to poaching. There are people present all over the reserve to such an extent that little opportunity exists for clandestine operations. In addition to this, the following are also done, a lot of this coming off the back of rhino protection strategies:

- Cooperation with the South African Police Service (SAPS) in patrolling roads inside and outside of Madikwe Game Reserve
- Installation of security cameras at the gates and strategic points across the reserve, all linked to a central control room
- Nights patrols were increased and the whole reserve is put on high alert during periods of full moon

- All field rangers have been on a Field Ranger course presented by the South African Wildlife College, during which anti-poaching responses and patrolling were specifically covered
- The reserve continuously pursues good relations with the community in order to secure intelligence on potential problems
- The field guides in Madikwe Game Reserve have established amongst themselves a Ranger Action Team (RATs) through which day and night patrols are coordinated

4.7 Provision for adequate insurance

As a state entity, the NWPB has adequate public insurance

4.8. Contingency plans to deal with elephant problems

a) In the case of the fence being unable to contain the elephants

Contact details of responsible manager, veterinary practitioner and capture operator/s:

- Moremi Keabetswe, Acting Reserve Manager – 018-350 9932
- Dr Andre Uys, Wildlife Veterinarian - Conservation Solutions (0823726796)
- Dr Gerhardus Scheepers Wildlife Veterinarian : +27 82 785 1593
- David Banda; Resource Security Manager; NWPB (0829350007)
- Ms. Sindi Zwane, Regional Manager: Ngaka Modiri Molema district, DEDECT (082 662 7787)

Elephants will be shot if they have killed or injured someone that are legitimately supposed to be there (i.e. exclusion of poachers). Problem animal status will also be assigned to those that threaten livelihoods of communities should they escape, or the lives of those on the reserve, whether in staff impoundments or lodges. Elephants that do not refrain from damage to infrastructure in camps, lodges or fences will be singled out for destruction.

Reserve management or skilled Honorary Officers will assist in the role of destroying offending elephants with minimum calibre rifles of .375. We will update a register of all problem animals destroyed.

b) In the case of the alteration of the habitat beyond acceptable limits.

See control of population. There is a very real possibility of damage to large tracts of habitat and the population, and its use of landscapes will be monitored closely.

4.9. Feeding scheme in case of natural food supply shortfall

No feeding scheme is considered, as a population control program is in place to prevent a food shortfall.

4.10. Threat analysis and security plan

There are approximately 30 lodges in Madikwe Game Reserve (Figure 14). Each lodge has traversing rights over the entire reserve, which implies a significant coverage of the reserve by vehicles on game drives. The field guides are in constant communication with reserve staff and any irregularities are reported immediately. In addition to the reserve staff, a centralized control room also records any incidents for further action.

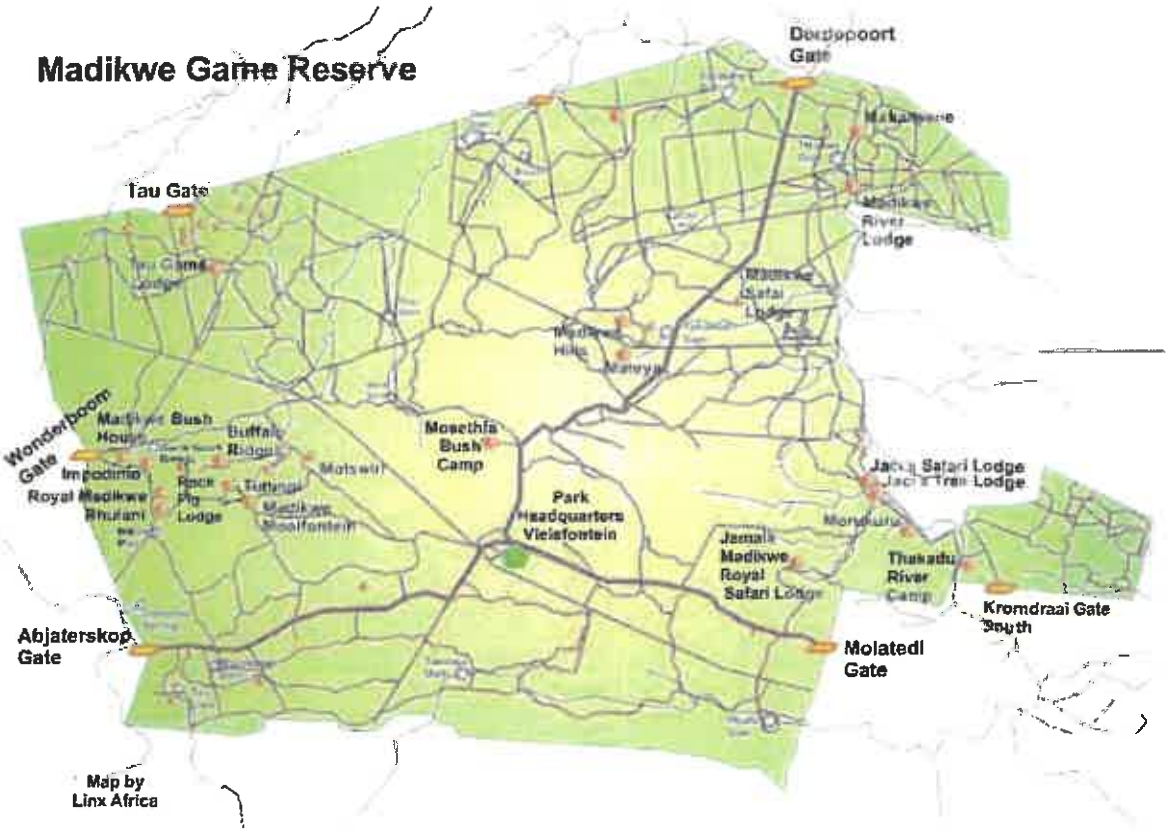

Figure 14: Distribution of lodges within Madikwe Game Reserve

Section C Information to be provided after approval for the introduction of elephants, but before a permit may be issued

Not Applicable

5. Details of the introduced elephants

In 1992, 25 orphaned juvenile elephants from the Kruger National Park were introduced to the Reserve (Szott et al. 2019, In Van Aarde et al. 2021). In 1993, 194 elephants, made up of entire family groups, were introduced from Gonarezhou National Park in Zimbabwe (Garaï et al. 2004 In Van Aarde et al. 2021; Szott et al. 2019). Two groups of adult bulls were brought in from Kruger (six in 1998 and two in 1999) (Szott et al. 2019).

Also, refer to Section 2.5 in this document.

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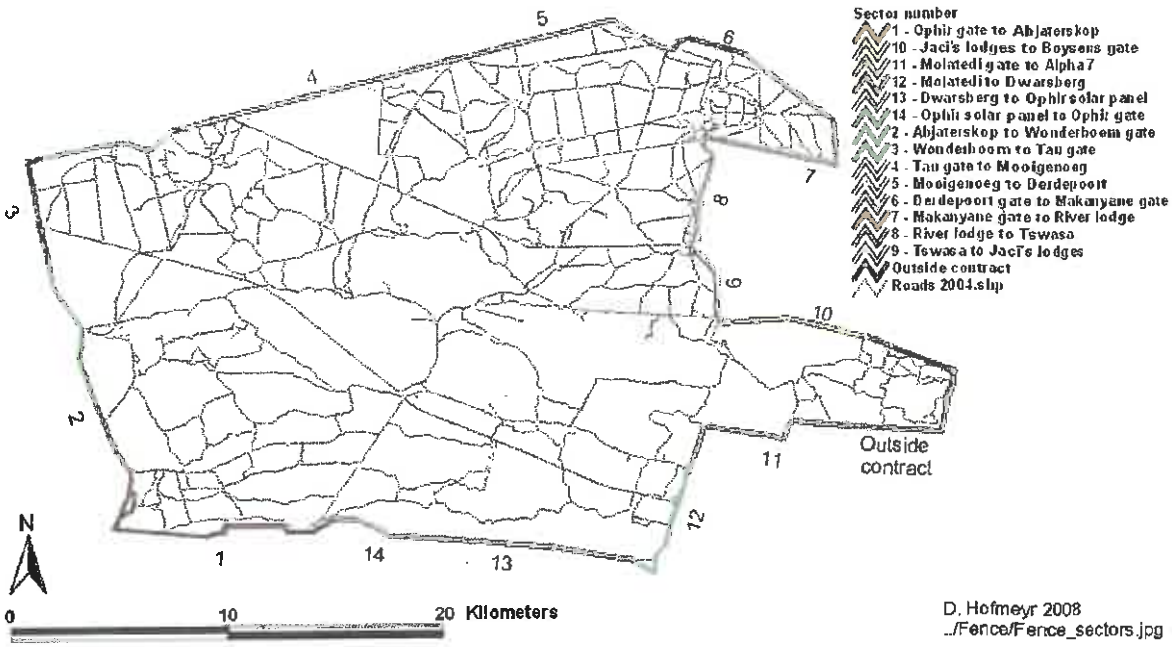
Madikwe fence sector map



Appendix II

NW Department: Rural, Environmental and Agricultural Development approval in terms of the fencing of Madikwe Game Reserve being compliant with TOPS regulations

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Department:
Agriculture, Conservation,
Environment and Rural Development
North West Provincial Government
REPUBLIC OF SOUTH AFRICA

630

Directorate: Biodiversity Management & Conservation
(Daily Activity Report)

Name of Official: L. E. Vilane and M.A. Mokgwadi

Station: Swartruggens

Name of place visited: Madikwe Game Reserve

Address: Madikwe

Telephone & Fax No.: 018 350 9731/2 / 018 350 9735

Location/GPS: East: ..... South: .....

X	Game Farm Inspections		Taxidermy Inspection
	Predator Farm Inspections		Pet Shops
	Keeping farms with Ordinary Game		Nurseries
	H/O Facility Inspection		Muti Shops
	Investigations		Butcheries
	Dam Inspections		Port of Entry
	Complaints		Road Blocks
	Routine Inspections/Farm Visit		
	Dams Inspections		

Time of arrival on Farm: 10h00

Time of Departure from Farm: 16h00

Outcome: The inspection has been done from Sector 1-7 for tagging of TOPS species, the inspection continues tomorrow.

Distance Travelled: .....

M.A. Mokgwadi, L.E Vilane — Name of Official

Signature of Official

ANDREW MOLEFOBI — Name of Facility Owner / Rep

ANDREW — Signature of Facility Owner / Rep

Date: 04-03-2011

Date: 04/03/2011

(Original copy to the Game Manager, Duplicate to Supervisor, Triplicate remains in the book)

631

the dacerd
Department:
Agriculture, Conservation, Environment and Rural Development
North West Provincial Government
REPUBLIC OF SOUTH AFRICA

Directorate: Biodiversity Management & Conservation
(Daily Activity Report)

Name of Official: M.A. Mokgomadi
Station: Swartruggens

Name of place visited: Madikwe Game Reserve
Address: Madikwe Game Reserve
Telephone & Fax No.: 018 350 9931/2 / 018 350 9937
Location/GPS: East: .... South: ....

	Game Farm Inspections		Taxidermy Inspection
X	Predator Farm Inspections		Pet Shops
	Keeping farms with Ordinary Game		Nurseries
	H/O Facility Inspection		Muti Shops
	Investigations		Butcheries
	Dam Inspections		Port of Entry
	Complaints		Road Blocks
	Routine Inspections/Farm Visit		
	Dams Inspections		

Time of arrival on Farm: 8h00
Time of Departure from Farm: 16h00

Outcome: The inspection was complected today Sector 8-16 for TOPS species. The fence do comply with department fencing specification for game.

Distance Travelled: ....

E.L. Vlore / M.A. Motgomadi — Name of Official
Moatshadi Samuel Mmesi — Name of Facility Owner / Rep

M.A. Mokgomadi — Signature of Official
[signature] — Signature of Facility Owner / Rep

Date: 05/03-2011
Date: 05-03-2011

(Original copy to the Owner/Manager, Duplicate to Supervisor, Triplicate remains in the book)

Appendix III

Vegetation condition assessment methodology

DETERMINING VEGETATION STATUS FOR MANAGEMENT PURPOSES

PETE ZACHARIAS, GREG STUART-HILL & BRUCE BROCKETT

JULY 1994

RATIONALE

The method for vegetation monitoring described below is based on the following objectives.

1) The need for a rapid field procedure;
2) Limited inputs of expertise and time;
3) Suitability for both grass and tree components;
4) Suitability to gross changes in community structure; and
5) Have a quantitative and qualitative element

With these objectives in mind, a semi-quantitative approach was adopted and includes the use of fixed point photography. The success of the approach will depend on frequent (annual) recording of sites as many of the measures taken are imprecise.

SITE LOCATION AREA MARKING

Location

The location of sites requires careful planning. As the technique is employed for monitoring purposes and the location of sites is a critical element. The location of sites therefore should be along roads or tracks that are likely to be permanent. Permanent fence lines, regular fire breaks and arterial roads are good routes to choose. Permanent water points and structures (e.g. bridges) are useful reference points. As the technique is designed to be rapid, this should not be thwarted by long searching times.

The density of sites depends on the specific objectives for the monitoring programme as well as the diversity of the vegetation. Financial and manpower constraints will have a major influence on the decision but a **minimum of one site per 1000 ha is recommended** and these should be distributed as evenly as possible across the reserve. It is important to have at least two sites in each major vegetation unit. Care must be taken to ensure that sites are representative of the vegetation unit or type and must not fall in 'bush-clumps', termitaria or on other non-representative features. Any specific features, with particular conservation value, should form a 'site' and be recorded separately. In such cases, some modifications of the method described here are necessary.

Marking

The physical position of each site is marked with the use of a concrete marker block (kern) secured with a stout peg driven through the center. The blocks are square and the faces are orientated to form the points of the compass to facilitate positioning of photo points (see later). The block is placed in the center of the site and the radii of 10 m and 20 m respectively form the bounds of the site for GRASS and TREE descriptions. Because of the requirements for a 20 m radius the site should be at least 25 m (paces) from the road or track at right angles to the direction of the track, to reduce to road edge bias.

DATA RECORDING

Given that the technique has the principal purpose of long-term monitoring, some form of retrieval system is essential. Data sheets are therefore of two forms; 1) **Cover sheet** and 2) **Field sheet**

These are linked to a catalogued photograph album.

Cover sheet

The cover sheet records the basic details of the site and is used only when the site is first located. Details of the site relocation are placed in the 'DIRECTIONS TO SITE' field.

The main function of the cover sheet is to provide the catalogue information for the photographic and field sheet records. The following fields are required:

1) SITE NUMBER – unique number to identify each site and it has two parts; a) three letter code to identify the reserve and b) a numerical identifier for each site *e.g. MAD 24* is the twenty fourth site in Madikwe Game Reserve.
2) PLACE – the name of the reserve e.g. Madikwe Game Reserve.
3) LOCATION – the sub-unit or region of the reserve e.g. Abjaterskop.
4) GPS ROAD – grid position of LONGITUDE and LATITUDE taken from a geographic positioning system (GPS) and recorded digitally to five decimal places. The position is at the road track position closest to the site location as described in the DIRECTIONS TO SITE field.
5) GPS SITE – the position of the marked block on the site. This locates the center of the monitoring site and is permanently marked (plate 1)
6) DATE – date of placement of the site.
7) OBSERVERS – names of the observers involved in data recording.
8) MAP SHEET – the reference sheet number of 1:10 000 surveyor general orthophotos of 1:50 000 topocadastral sheets. *E.g. 2426 CB21 or 2426 CC GA-SUPING.*
9) DIRECTIONS TO SITE – a detailed description to aid relocation. Care must be exercised here and reference to permanent landmarks or structures (e.g., bridges) should be used wherever possible. Remember that vehicle speed readings vary from vehicle to vehicle and that trees die and tracks disappear. The use of GPS equipment should greatly improve relocation but must not be relied on entirely.
10) SITE DESCRIPTION – general physical description of the site and the area it represents.
    1. TOPOGRAPHY – describe the major features of the site *e.g. flat, undulating, steep, north facing slope, etc.*
    2. ROCKINESS – estimate and describe the degree of rockiness of the area *e.g. Stone free, several small stones, gravelly, large exposed rocks, etc.* If possible, estimate the proportion of ground covered by rocks. Be aware that in situations of old farms that the

site may be on a man-made rock pile (e.g., from land clearing) so the description should be for the area as a whole. Monitoring sites should normally not be placed on man-made features which are aberrant.

3. SOIL TYPE – general description of the soil *e.g., yellow/red sand, heavy clay, loose red sand, etc.*

11) PHOTOGRAPH CATALOGUE INFORMATION –details of the retrieval information for photographs taken at each site.

1. YEAR – year of record.
2. FIELD SHEET REF – site number from field sheet and date.
3. ALBUM VOLUME – the volume of the photograph album containing that year's photographs. There should be one album per year (see later).
4. OBSERVERS – name of the observers from the field sheet.

The cover sheet will act as divider in the ring file housing the data sheets. They are printed on colored board to distinguish them from field sheets which will usually be on blue paper (this reduces eye fatigue in sunny conditions).

Field sheets

The field sheet contains the data recorded on each occasion that the site is visited. Sites should be visited at the same time each year to ensure that the photographs are taken under the same conditions as these will be interpreted visually – *this is of extreme importance.* For uniformity of the photographs, it is desirable to visit the sites at the same time of the day, but this is unlikely to be practicable.

To ensure adequate cross-referencing to the COVER SHEET some information is duplicable. The GPS coordinates with today's technology should bring the observers within 3-4m from the site, but **it is important to note that the photographic record may be helpful with the relocation of sites.** Care must be taken not to damage the plate in the field.

The following field are required.

1) SITE NUMBER – as per cover sheet.
2) PLACE – as per cover sheet.
3) GPS ROAD – as per cover sheet
4) GPS SITE – as per cover sheet and road GPS.
5) DATE – date the site is visited and photographed for that year's record.
6) OBSERVERS – names of observers recording data for that year.

7) PHOTO INFORMATION – once all other recording is completed the site is photographed with five views. A number board is used to reference the site.

1. Photographs are taken as *site (pan) views and ground views as follows:*

SITE VIEW –designed to gauge the structure of the vegetation. This is a pan view of the site and is taken with the camera placed at the concrete kern marking the site and facing three compass directions WEST, EAST, SOUTH (Plates 2 to 4). The camera (or cell phone) is placed on a monopod 1500 mm from the ground and held level. A marker board with the site number and camera direction is held by an assistant 10 m (paces) from the camera. The board is held high but care must be taken to ensure the marker board is not obscured by vegetation. Its visibility and distance from the camera are important and should be considered first.

GROUND VIEW – designed to gauge the conditions of the ground cover at the site. Two photographs are taken from two aspects SOUTH and WEST (plates 5 & 6). The marker board is placed at the kern with information referring to the direction of the photograph and site number. The camera is moved 5 m (paces) from the kern and held 1500 mm from the ground on the monopod. The camera is then tilted towards the ground until the kern is in the top right hand corner of the frame. Pragmatics may dictate that the marker board be positioned elsewhere in the frame in which case it should be at the top edge of the frame and close to the top right hand corner. Situations where this may be necessary include shadows and large bare rocks. Fallen trees and other debris should be included as they are subject to change due to fires and animal activity e.g. Termites or elephants.

To ensure efficient field procedure and easier posy-printing cataloguing of photographs the following order should always be followed; WEST, EAST, SOUTH pan views, followed by the SOUTH and WEST ground views. This minimizes board changes and movement over the site.

LENS SIZE –the size (focal length) of the lens used. This must be consistent from year to year. A 28 mm lens has been used, in the initial survey at Madikwe Game Reserve, as this gives the widest view with least distortion.

VEGETATION DESCRIPTION – This section forms the basis of the qualitative information gathered at each site. Use is made of rankings into classes with little detailed measurement.

The description of the vegetation is recorded from the two components separately viz: GRASS and WOODY PLANTS. A site with a c. 10 m radius is used for grasses, and a *c.* 20 m radius is used for woody plants.

GRASS COMPONENT – For the grass components of the site the following parameters are recorded:

1. Species – record the first 10 most abundant species. It is not essential, but these should be recorded in order to ensure the most abundant species as well as those contributing the bulk of the biomass are recorded. The species names are recorded as eight letter codes (first four letters of the genus and species names respectively e.g. *Enneapogon scoparius =ENNE SCOP)*
2. Density and MD rank