CHAPTER 1

INTRODUCTION

Wildlife management and private game farming have been practised for a number of years in southern Africa. However, wildlife management decisions have often been based on knowledge gained in the agricultural sector, with little attention having been given to sound ecological theory. Ecological theory should form the basis of all ecosystem management, including the savanna ecosystem.

The savanna ecosystem covers around 20% of the world's terrestrial ecosystems, including some 40% of Africa and approximately 35 % of the land surface of South Africa (Scholes & Walker 1993). Savannas are second to tropical forests in terms of their contribution to primary production, and represent a large portion of the terrestrial carbon pool (Atjay, Ketner & Duvigneaud 1987; In: Scoles & Walker 1993). The distribution, structure and function of savannas around the globe are determined by the availability of water and nutrients and through complex interactions between climate, soils, fire and herbivory (Frost 1984, O'Connor 1994). The African savanna ecosystem can be divided into moist and arid savannas (Huntley 1989).

Land use activities in the savanna region are dominated by cattle ranching, crop production and wildlife-related tourism. Protected areas within the arid savanna represent 49% of the total number of protected areas in southern Africa, and cover 12.1 % of this biome. The area covered by protected areas within the moist savanna is much lower and only covers 5. 0 % of the biome, representing only 8.7 % of the total number of nature reserves within southern Africa (Huntley 1989).

The Cinergy Game Farm is situated within the mixed bushveld area of the Springbok Flats, situated within the moist savanna. The Springbok Flats covers an area of 66 647 km^2, 60 % of which has been transformed, mainly through agricultural practices, mining activities and infra structural development. Only 3.1 % of the mixed bushveld's land surface area has been set aside for conservation (Van Rooyen & Bredenkamp 1996).

The Cinergy Game Farm has been exposed to agricultural activities for some 30 years prior to its establishment. At the onset of the present study the owner wished to change the management approach of the area to game ranching. The reintroduction of indigenous animals to Cinergy Game Farm is central in establishing a game farm operation. These re-introductions, whether natural or artificial, also serve to promote the conservation of biodiversity. According to the International Union for the Conservation of Nature and Natural Resources (IUCN), biodiversity can be defined as 'the variety and variability of all living organisms' (Bond 1989). This includes the genetic variability within species and their populations, the variety of species and their life forms, the diversity of the complex associations between species and their interactions with the environment, and the ecological processes which they influence and perform.

The transformation from agricultural farmland to game farming should be based on ecological restoration. Ecological restoration entails the return of a damaged ecosystem towards its pre-disturbance condition, i.e. the reestablishment of ecological attributes (structural and functional) and related physical, chemical and biological characteristics (Pywell & Putwain 1996).This management plan uses sound ecological theory to formulate the management actions needed to achieve this transformation. All management actions should also be in accordance to those dictated by the legislation of the Northern Province. This legislation has been laid out in the Nature Conservation Ordinance 12 (1983) of the former Transvaal Province.

The present management plan is directed at achieving the objectives set for the Cinergy Game Farm. Here I present the background to the area and describe the floral and faunal elements currently present on the Conservation Unit. This will be followed by a review of the ecological theories underlying the objectives that have been designed for the Cinergy Game Farm. The management actions that need to be taken to fulfil the required objectives for the Cinergy Game Farm, will be based on the described ecological theory, and applies this within an hierarchal management framework. Monitoring the process, and measuring that against the initial ground surveys will determine whether the right management techniques have been applied, and to implement any changes either to the predetermined objectives of the Cinergy Game Farm, or the management actions described for the Conservation Unit. This management plan is valid for a five year period. Thereafter it should be revised against the results of the monitoring program.

CHAPTER 2

OBJECTIVES

The objectives for the management plan have been compiled through discussions held between Dave Alexander, the owner of the Cinergy Game Farm and Rudi van Aarde of the Conservation Ecology Research Unit of the University of Pretoria (Appendix 1). The following objectives have been set for the Cinergy Game Farm:

- To contribute to the conservation ethic by consolidating land previously exposed to land use practises other than conservation into a unit with characteristics typical of an indigenous, self-sustaining natural system.
- To restore the consolidated land into a singular unit, where natural and indigenous processes with faunal and floral elements typical of the region prior to disturbances evoked by man, dominate.
- To develop a conservation ethic amongst all stakeholders so as to enhance and maintain biological diversity through a pro-active conservation management operation.
- To develop a self-sustaining game breeding enterprise which will supply for some of the needs of other animal breeders and conservationists.
- To enact and maintain some self-sustaining leisure activities to the benefit of the owner and his family.

The specific operational objective for the Conservation Unit of the Cinergy Game Farm has been set out to establish :

'a singular fenced in unit adjoined by other conservation units and cattle ranging enterprises development of this land in line with the overall objectives of the Cinergy Farm. The unit will be developed as a self-sustaining Conservation Unit within the modern paradigm of conservation, reflecting on the maintenance of local biological diversity. As part of this the existing biological diversity is to be assessed and where needed, be enhanced through ecological restoration within the limits set by spatial configuration and sensible temporal and economic variables'.

The aims of this management plan for the Conservation Unit of the Cinergy Game Farm are as follows:

- To determine and evaluate the distribution and relative abundances of selected plants and animals on the Unit.

- To construct a vegetation map of the Unit, with emphasis on habitat condition and suitability for the relocation of large herbivores on to the Unit.
- To determine the economic carrying capacity of the Unit.
- To develop an adaptable management plan that will give rise to the recovery of suitable habitats through the restoration of ecological processes typical of the region.

CHAPTER 3
THE STUDY AREA

Geology, Topography and Soils

The present study was conducted on the Cinergy Game Farm which is situated in the Northern Province of South Africa, in the area demarcated as Voordeeel (559 KR) in the Potgietersrus Magisterial District (Figure 1). The area is 11 km east of Naboomspruit (24°38' S and 28°45' E) and falls within the north-western region of the Springbok Flats. The Cinergy Game Farm is sub-divided into a Conservation Unit, Game Farming Unit and a Farm Yard (Figure 2). The Conservation Unit extend over an area of 753 ha. The Game farm is situated adjacent to the Nylsvley Nature Reserve and Mosdene, a private nature reserve. The Nyl river is the nearest natural water source and flows in a north-easterly direction through Nylsvley Nature Reserve and the adjacent properties to the north of the Cinergy Game Farm. The Conservation Unit of the game farm is situated on the Clarens formation of the Karoo geological sequence. Here medium to fine-grained, red to cream sandstones have been overlain by younger volcanic basalts of the Letaba formation (CSIR 1998). The sediments and volcanic soils have no structural dip, with a horizontal bedding in the sandstones.

The Springbok Flats is characterized by a flat topography with a surface gradient of 1 in 100 metres to 1 in 200 metres with no marked surface drainage system. The area surrounding the Conservation Unit comprises mostly of undulating to flat plains at an altitude varying between 700 to 1100 m above sea level. The flat topography is a direct result of the sediments and volcanic soils in the vicinity of the conservation area having no structural dip, with horizontal bedding in the sandstones. There are no drainage lines within the area. Two major groups of soil types identified for this study are given as nutrient poor and nutrient rich soils. They both are very sandy and derived from sandstone. Both soil types are approximate one metre deep. The nutrient rich soils have a higher clay content and are characterised by fine-leaved trees and shrubs such as *Acacia nilotica* and *A. tortillis*. The sandy nutrient poor soils are characterised by the broadleaved trees and shrubs such as *Burkea africana* and *Ochna pulchra*.

Climate

The climate of the region is typical of the savanna biome with, hot wet summers followed by

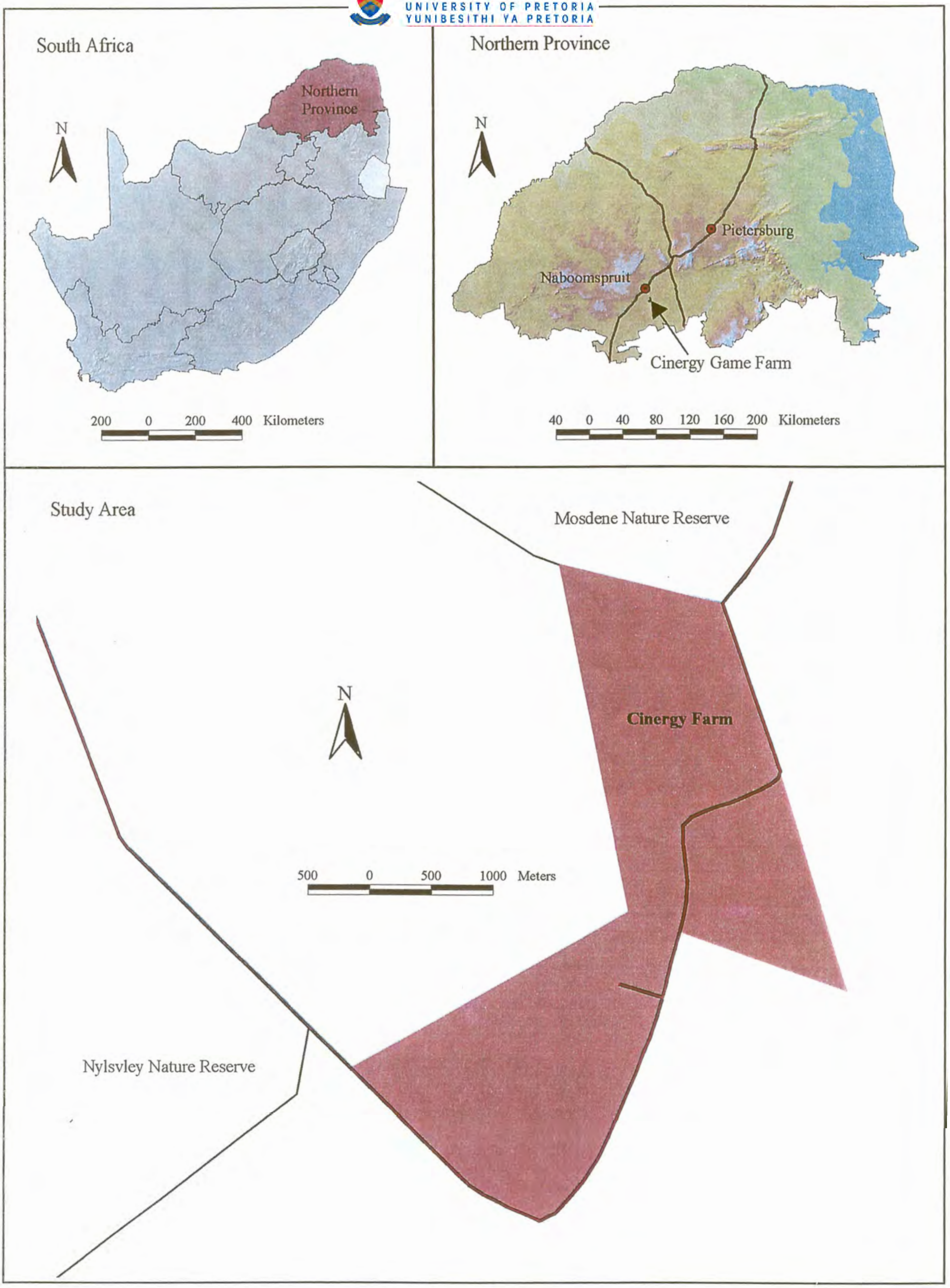

Figure 1: Location of the Cinergy Game Farm, Northern Province

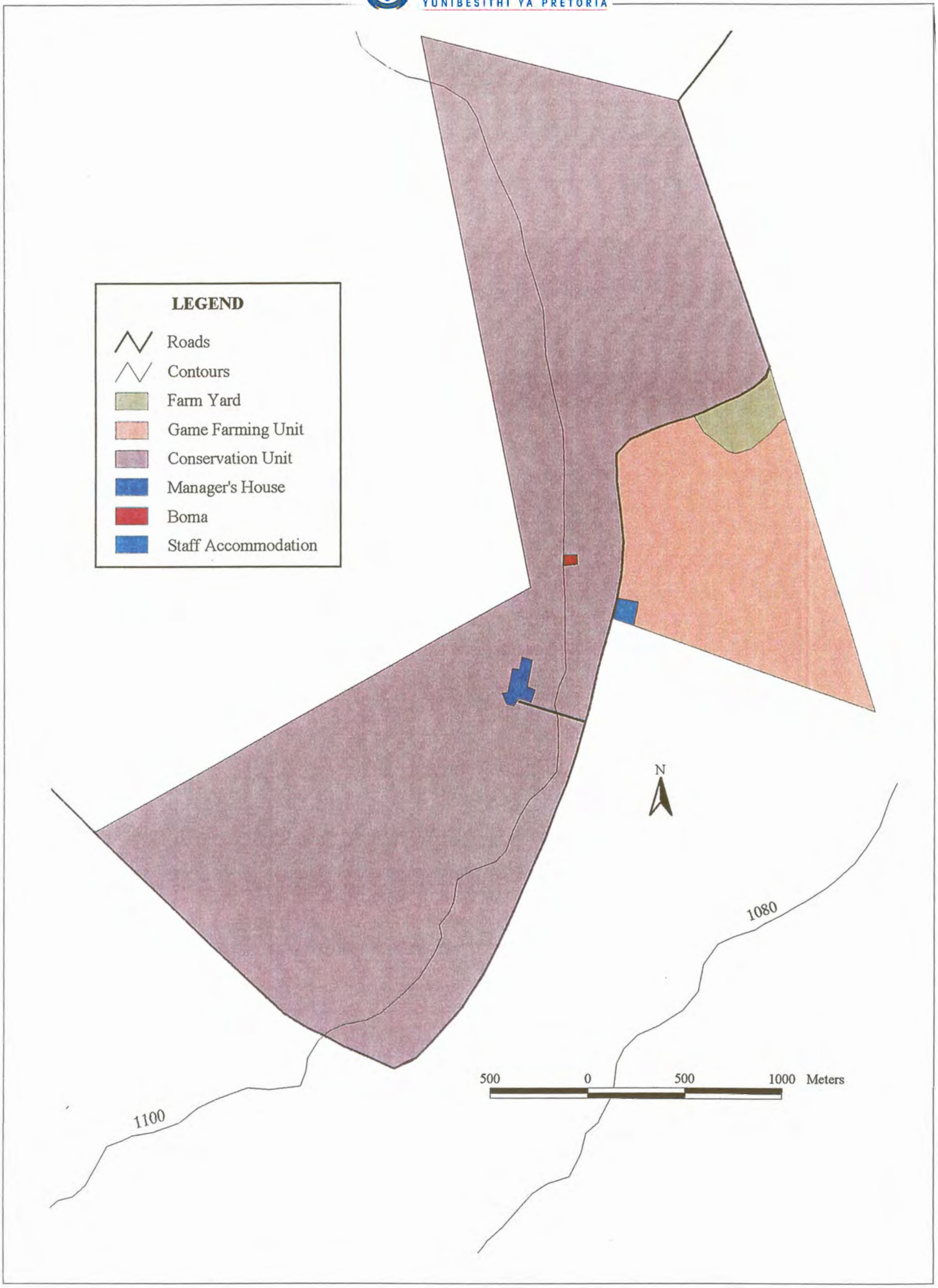

Figure 2: The Layout of the Cinergy Game Farm, Northern Province

warm dry winters. Savanna ecosystems are some of the sunniest areas in the world and the Nylsvley Nature Reserve abutting the farm receives at least 75 % of its potential annual total of 4371 sunshine hours (Harrison 1984, In: Scoles & Walker 1993).

The atmosphere is relatively dry throughout the year, particularly so during the winter season. Relative humidity (RH) varies between 40 % in July to 58 % in January, with an annual mean of 50 %. The mean annual wind speed measured at 2 m above ground level is 1.45 $m.s^{-1}$ (with 50 m diameter clearing). Typically, savanna vegetation experiences an average above canopy wind speed of 2.99 $m.s^{-1}$ (measured at 11.5 m). At a height of 2 m wind speeds are reduced to 1.08 $m.s^{-1}$. Winds associated with thunderstorms and whirlwinds can reach speeds of up to 22 $m.s^{-1}$ (Harrison 1984, In: Scoles & Walker 1993).

Temperature data extracted from ArcInfo® raster grids supplied by the Computing Centre for Water Research, University of Natal, Pietermaritzburg suggest an annual mean temperature for the Cinergy Game Farm of 18.4 °C, with an annual range of 10.7 °C between the warmest and coldest months (Table 1). December, January and February are the warmest months, with mean daily maximum temperatures reaching 28°C and June and July the coldest, with the mean daily minimum temperatures as low as 3.5°C. Frost may occur within the area, but is rare because of the relatively dry conditions prevailing during winter. Severe frost occurs every 5-10 years. Extreme low and high temperatures are stochastic events causing natural disturbances within biological communities. Annual soil temperature averages around 22°C at all depths between 0.1 m and 1.2 m. Daily and seasonal variation is however highest in the surface horizons. Exposed soil surfaces will experience higher daily soil temperature fluctuations than areas covered by natural vegetation. Higher air temperatures leads to higher soil temperatures within the upper layers. The lowered moisture levels within these exposed soil areas will result in topsoil being blown away.

The Cinergy Game Farm is situated within the summer rainfall area of southern Africa. The rainfall season lasts from October until April. The mean annual rainfall for the Nylsvley Nature Reserve is given as 629 ± 118 mm rainfall per year (Figure 3*a* & Figure 3*b*). Most rain falls between November and February. The dry period occurs mainly during the colder months of the year from May to August, with small isolated events within the dry period (Harrison 1984).

Table 1. Mean daily minimum temperature (°C), mean daily maximum temperature (°C) and mean daily temperature (°C) for the Cinergy Game Farm, Northern Province (Computing Centre for Water Research, University of Natal, Pietermaritzburg).

Month	Mean daily minimum temperature (°C)	Mean daily maximum temperature (°C)	Mean daily temperature (°C)
January	16.7	28.9	22.8
February	16.4	28.5	22.5
March	15.1	27.5	21.3
April	11.7	25.5	18.6
May	7.1	23.2	15.2
June	3.6	20.5	12.1
July	3.5	20.7	12.2
August	5.9	23.2	14.6
September	10.2	26.0	18.0
October	13.1	27.5	20.3
November	14.9	27.8	21.3
December	16.1	28.5	22.3

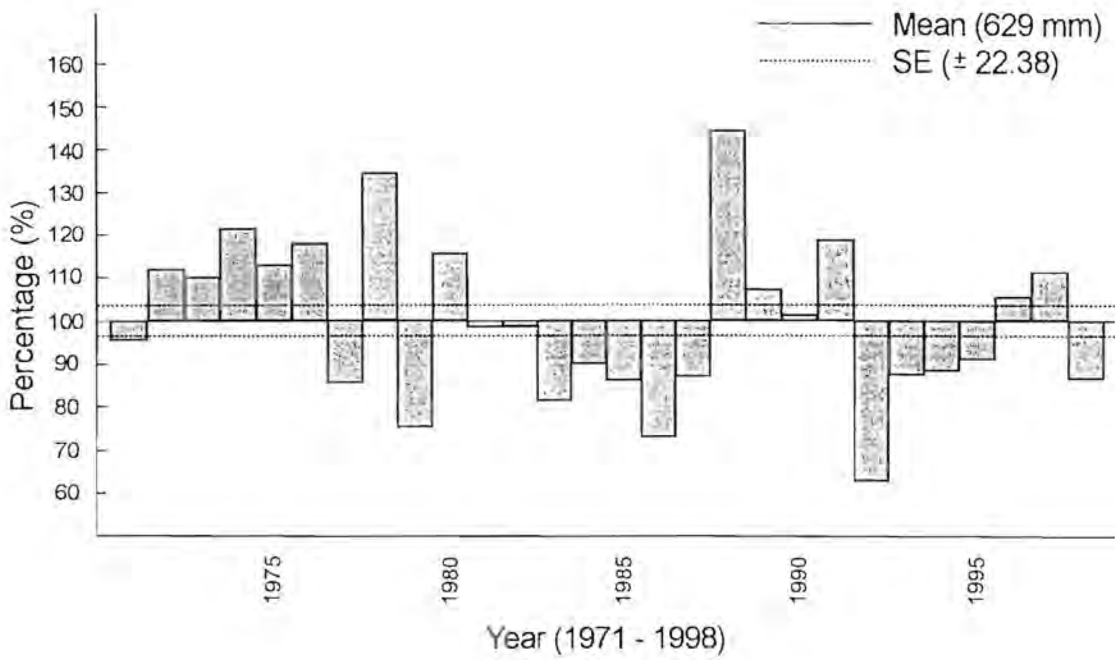

Figure 3*a*. Annual rainfall (mm. annum^{-1}) for the Nylsvley Nature Reserve, Northern Province from 1971 until 1998, expressed as a percentage of the mean (DEAT 1999).

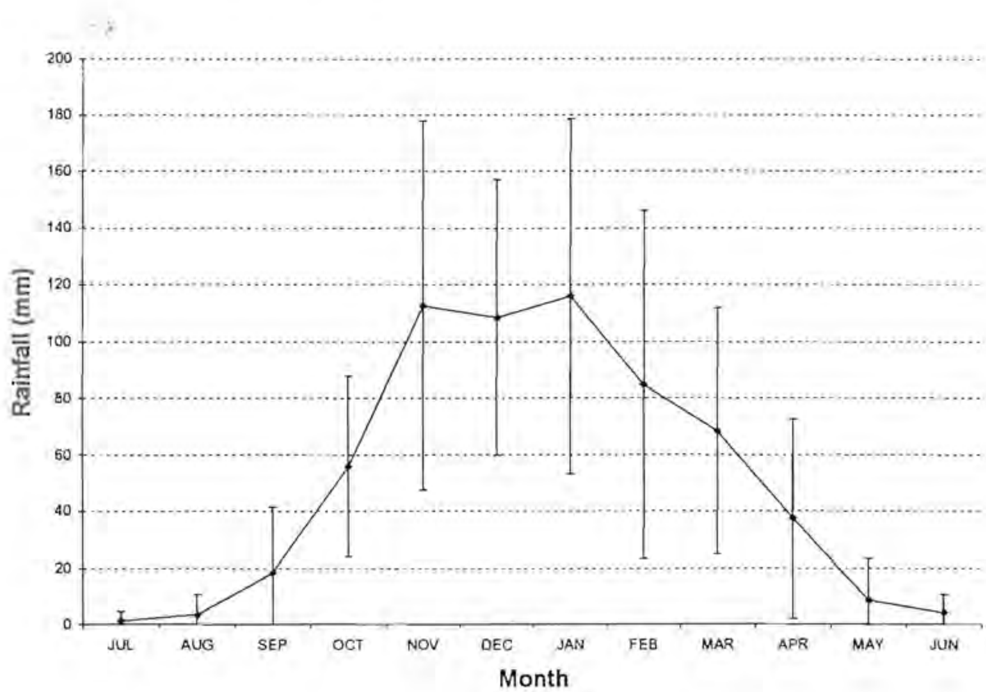

Figure 3*b*. Mean monthly rainfall (mm) ± SD recorded for the Nylsvley Nature Reserve, Northern Province from 1971 until 1998 (DEAT 1999).

Rainfall occurs mainly as high intensity convective storms. This leads to soil-surface characteristics such as capping and erosion through rain splash. However, the amount of rainfall for an average storm is relatively low, less than 20 mm, resulting in high proportional interception losses. High evaporation causes the water of a rainstorm of less than 20 mm to disappear within five days (Harrison 1984, In: Scoles & Walker 1993).

The area experiences extended periods of below average annual rainfall with a cyclic pattern of about 18 years. This cycle appears to be consistent for the summer rainfall interior region of southern Africa (Tyson 1986). This cyclic pattern, however, only accounts for some of the annual rainfall variation and can not be used for long term predictive purposes as may be required for conservation management. Ecosystems are event driven and climate extremes are an important variable when determining management strategies.

Vegetation

This area is classified as Mixed Bushveld (van Rooyen & Bredenkamp 1996) and is characterized by red bushwillow, *Combretum apiculatum,* on shallow soils, with scented thorn, *Acacia nilotica*, sweet thorn, *A. karroo* and sickle bush, *Dichrostachys cinerea* dominating the clay soils. The deeper sandy soils are dominated by silver clusterleaf, *Terminalia sericea*, peeling plane, *Ochna pulchra*, weeping wattle, *Peltophorum africanum* and wild syringa, *Burkea africana*. Grasses common to the area include *Eragrostis heteromera* and *Aristida bipartida* on the clay soils, and *Panicum maximum*, *Eragrostis pallens* and *Perotis patens* on the sandy soils.

The Conservation Unit has been exposed to a range of agricultural activities for some 30 years prior to the present study. At least 65% of the property has been under maize (*Zea mays*), wheat (*Triticum vulgara*), watermelon (*Citrullis rehmii*), cotton (*Gossypium herbaceum*) and peanut (*Arachis hypogea*) cultivation. The remaining areas were exposed to various levels of grazing and browsing by domestic animals.

Materials and Methods

The Conservation Unit has been divided into 23 management units, based on former land use practices. Interpretation of recent 1:10 000 aerial photographs, supplemented by information obtained from previous landowners, allowed the delineation of each of these units. Twenty three 10X10 metre sample plots were randomly selected and surveyed for species presence and density during April 1999. The Braun-Blanquet method of sampling and synthesis was followed as described by Westhoff & Van der Maarel (1973) and Werger (1974a). A description of the topsoil layer and type of disturbance was noted for each survey plot. Trees (>2 m) and shrubs (<2 m) were identified, separated into two height classes and counted within each sample plot. The grass layer was surveyed using the line intercept method, with grass species identified and recorded at one pace interval. Transects were 100 point long, with each point being about one metre apart. Other characteristic plant species not encountered along the transects within each of the predetermined vegetation units were recorded separately. Cover-abundance was estimated and recorded for each vegetation layer, using the scale of Westhoff & Van der Maarel (1973; adapted by Werger 1974a). In this scale (r) denotes one or few individuals; (+) denotes occasional and less than 1% of total area; (1) denotes abundant and with very low cover, or less abundant but with higher cover (<5% of total cover); (2a) indicates 5-12.5% cover, irrespective of number of individuals and (2b) indicates 12.5-25% cover, irrespective of number of individuals, (3) denotes 25-50% cover of total plot area, (4) denotes 50-75% cover of total plot area, and (5) indicates 75-100% cover of total plot area, irrespective of number of individuals.

The vegetation types of the Conservation Unit were classified using the computer program TWINSPAN (Hill 1979a) and refined by Braun-Blanquet procedures, using TURBOVEG (Hennekens 1996a) and MEGATAB (Hennekens 1996b). Vegetation unit gradient analysis for soil type, age of old fields and vegetation composition were determined through DECORANA (Hill 1979b).

ArcView® and ArcView Spatial Analyst® were used for all mapping purposes. The boundaries of the different units of the Cinergy Farm as well as distinct roads were manually digitised from 1:50 000 topographical maps (South Africa; 1985, 1986) using a Transverse Mercator projection from the Clarke 1880 spheroid and taking 29° longitude as the central meridian. The aerial photograph (Fotogramensura, Pretoria, 25-02-1999) was scanned and utilised in JPEG format. This image was geo-referenced in ArcView® using an Avenue® script supplied with the software. Vegetation types, management units and farm roads were manually digitised from the geo-referenced JPEG image. The sizes of the management units were calculated using an Avenue® script supplied with ArcView® software.

The economic carrying capacity for each of the management units was determined by combining the ecological index method (Vorster 1982) and the veld condition score index

(Trollope, Potgieter & Zambatis 1989). The results were added to the model proposed by Coe, Cumming & Phillipson (1976) to calculate the biomass and production of large herbivores in relation to rainfall and primary production. The optimal rainfall figure was taken as 500 mm / rainfall season, and below average rainfall as 80 % of the optimum value. The figures were then converted to large stock units for game species from domestic animal calculations (Meissner, Hofmeyr, van Rensburg and Pienaar 1983). Economic carrying capacity is expressed in Large Stock Units (LSU). One LSU has been defined as the equivalent of a single cow with a mass of 450 kg which gains 500 g / day on a grass pasture with a mean Digestible Energy (DE) of 55% (Meissner *et al.* 1983). The calculations for determining the economic carrying capacity were based on conservative estimates, due to the agricultural disturbances to which the Conservation unit has been exposed.

Description of the vegetation types

Twenty three management units were identified (Figure 4). The management units were identified based on the historical exposure to different agricultural practices (Table 2). The management units were grouped into four vegetation types, with one of these vegetation types subdivided into five plant community variations (Figure 5). The upper soil layer characteristics, the characteristic and dominant species for the woody layer, grass layer and forbs occurring within the plant communities of the various vegetation types, are described separately. The Braun-Blanquet table for the vegetation classification is given in Appendix 2.

A *Acacia tortillis* - *Acacia nilotica* thorny woodland on vertic clay.

Management units 1 and 2 consist of the *Acacia tortillis* - *Acacia nilotica* thorny woodland. The age of the non-herbaceous vegetation, except for the edges, is 24 years or younger. These plant communities occur on black vertic clay with a loamy layer on top. Several natural depressions where rainwater collect during the rainy season also occur within this area.

The plant community is dominated by 3 to 6 metre high *Acacia tortillis* and *Acacia nilotica* trees. *Panicum coloratum*, *Eragrostis heteromera* and *Aristida bipartida* are the dominant grass species in both units 1 and 2. On unit 1 *Brachiaria nigropedata* and *Brachyleana neriifolia* also occur commonly while *Sporobolus ioclados*, *Eragrostis curvula* and *Tragus berteronianus* occur commonly on unit 2. Unit 2 has large numbers of *Aloe transvaalensis* and

Asparagus suavolens. The presence of *Aristida bipartida* suggests high grazing pressure.

B *Sporobolus africanum* - *Acacia karroo* thornveld on vertic clay.

Management units 16, 17 and 19 consist of the *Sporobolus africanum* - *Acacia karroo* thornveld plant community. The substrate consists mainly of dark black vertic soils going over into red sandy loam soils with high a clay content. Ploughing and the clearing of trees over a period of nearly 30 years resulted in mixing of the O-, A- and B mineral horizons.

Within the red loamy clay areas the tree layer is dominated by *Acacia karroo* and *Acacia nilotica* and *Acacia tortillis* in the vertic clay soils areas with a higher clay content. Trees on unit 17 were less than 2 m high and sparsely distributed at the time of the study. *Sporobolus africanus* characterises the herbaceous layer of the community within all three the units. *Cynodon dactylon* and *Urochloa mosambicensis* are the dominant grass species. Other grass species commonly occurring here include *Aristida canescens*, *Eragrostis lehmanniana* and *Heteropogon contortus* in the vertic clay soils and *Melenis repens* and *Aristida congesta* in the red loamy clay areas.

C *Tagetes minuta* - *Cynodon dactylon* old fields on clay.

At the time of the study the *Tagetes minuta* - *Cynodon dactylon* old fields were the most recent ploughed areas on the Conservation Unit. Management units 3, 7, 9 and 18 consist of the *Tagetes minuta* - *Cynodon dactylon* old fields vegetation type. The soils of these units vary from vertic clay with a loamy layer on top, to a red basalt covered with a loamy clay layer. Ploughing resulted in the mixing of the O-, A- and B mineral horizons. There are very few woody species within the plant community due to recent agricultural activities. The vegetation is dominated by various exotic weedy species.

Unit 3 has a small stand of *Acacia gerrardii* of less than 2 m high in the north- eastern corner of the ploughed field. The herbaceous layer consists mainly of *Cynodon dactylon*, with *Digitaria argyrograpta*, *Chloris virgata*, *Melinis repens* and *Eulisine coracana* also present.

Units 3, 7 and 18 are also covered with *Tagetes minuta*. Units 7 and 9 are dominated by *Crotolaria* sp.. Unit 18 is the most recently ploughed field and the vegetation consists of *Datura ferox*, *Datura stramonium*, *Xanthium spinosum*, and *Xanthium strumarium*. Very few forbs, apart from *Hibiscus trionum* and *H. pusillus* occur within this plant community.

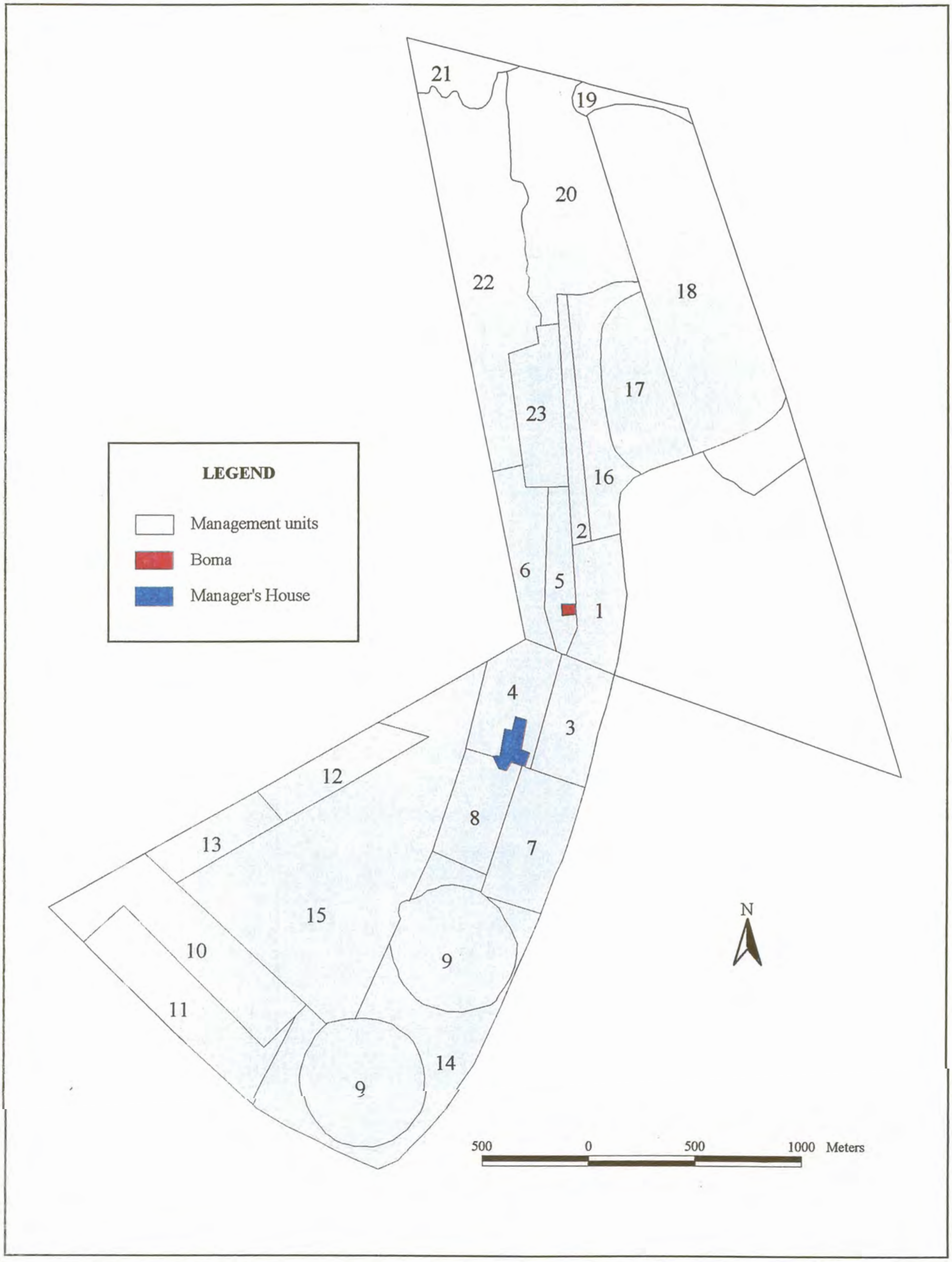

Figure 4: Management Units of the Conservation Unit, Cinergy Game Farm, Northern Province

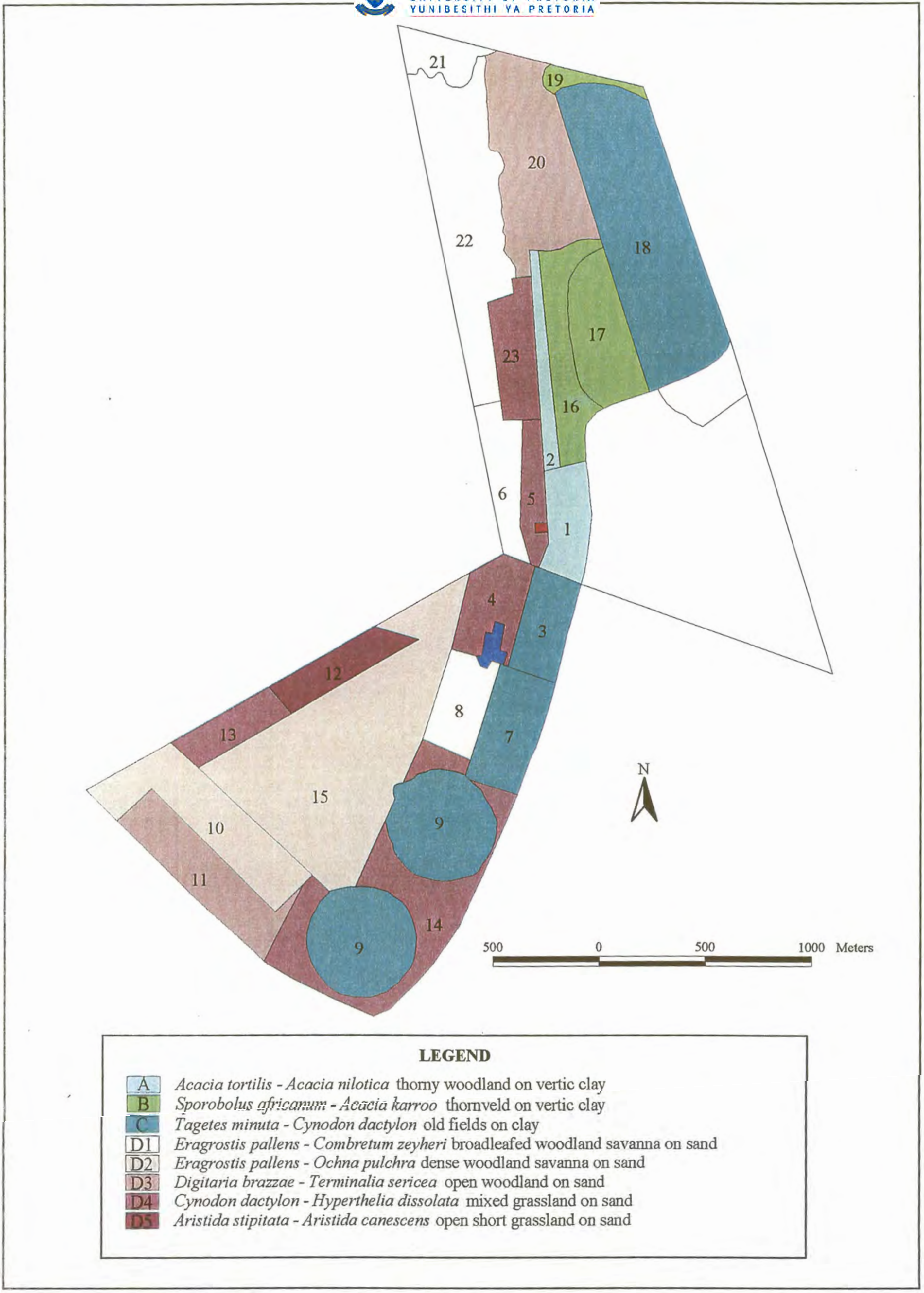

Figure 5: Vegetation Types of the Conservation Unit, Cinergy Game Farm, Northern Province,

Table 2. Management unit number (Figure 4), date and history of agricultural disturbances for the Conservation Unit, Cinergy Game Farm, Northern Province.

Management unit number	Date	History of agricultural disturbance
1	1973	All vegetation removed except along a narrow strip to the southern and western edges of the ploughed field.
	1975	Attempt to establish a permanent grass layer by eliminating the woody components.
	1976	The management unit was used for cattle and sheep grazing until 1998.
2	1970	Management unit has been exposed to cattle and sheep grazing for some 30 years prior to the present study.
3	1970	Three different sections. The western region was used as maize fields, while the southern part of the eastern section was used for wheat production and the northern section for sheep grazing.
4	1980	Cleared for watermelon production.
	1981	Grass layer was mown annually to stimulate grass growth for cattle and sheep grazing.
5	1984	Cleared for watermelon production.
	1985	Grass layer was mown annually to stimulate grass growth for cattle and sheep grazing.
6	1970	Fenced off and exposed to cattle grazing for some 30 years. Housing the farm labourers during the time of previous agricultural activities within the Conservation unit.
7	1970	Extensively cultivated for 30 years with maize and peanut cultivars, alternating between the two species.

8	1970	Fenced off and exposed to cattle grazing for some 30 years. Woody elements randomly removed, resulting in small open grass patches within the mature tree stand. A similar approach was followed in units 21 and 22, but on a much smaller scale. Unit 6 used for the housing of farm labourers during the time of previous agricultural activities within the Conservation unit.
9	1970	Unit 9 used to cultivate a combination of maize, cotton, peanuts and watermelons for 27 years.
10	1970	Cleared for cultivating watermelons.
	1971	Kept clear of all woody elements through mowing.
	1982	Used for maize and peanut farming for two years.
	1985	Mowed annually to stimulate grass growth for cattle and sheep grazing.
11	1970	Cleared for watermelon cultivation.
	1971	Subsequently been mowed annually for a unknown number of years to stimulate grass growth.
12	1982	Cleared in and cultivated with maize and peanuts.
	1988	Kept clear of woody elements through annual mowing.
13	1982	Cleared for watermelon production.
	1983	Grass layer was mown annually to stimulate grass growth for cattle and sheep grazing.
14	1970	Extensively cultivated with maize, cotton and peanuts.
	1982	Mown annually to stimulate grass growth.
15	1970	Used for temporary grazing for cattle during the dry season due to the presence of *Dichapetalum cymosum*.

16	1970	Cleared of natural vegetation to establish wheat fields but was unsuccessful, due to high clay content
	1971	Used as graze lands for cattle and sheep.
17	1970	Cleared through ploughing for maize and wheat cultivation.
	1975	Irrigated through a central pivot system for a 20 year period.
	1995	Kept clear of woody elements through annual mowing to promote grazing for sheep and cattle.
18	1970	Annual maize and wheat cultivation for 30 years.
19	1970	Woody elements cleared but allowed to reestablish, and has been exposed to sheep and cattle grazing.
20	1970	Exposed to grazing by cattle for some 30 years.
21	1970	Fenced off and exposed to cattle grazing for some 30 years. Woody elements randomly removed, resulting in small open grass patches within the mature tree stand.
22	1970	Fenced off and exposed to cattle grazing for some 30 years. Woody elements randomly removed, resulting in small open grass patches within the mature tree stand.
23	1985	Cleared for watermelon production.
	1986	Grass layer mown annually to stimulate grass growth for cattle and sheep grazing.

D *Eragrostis pallens - Burkea africana* broadleaved woodland savanna on sand.

The *Eragrostis pallens - Burkea africana* vegetation type occurs on well drained and highly leached sandy soils of varying depths. The area is covered with the shallow diggings and burrows of various animals. Several management units within this community have been cleared and ploughed for the cultivation of watermelon, and then kept clear of all woody elements through the annual mowing of the grass layer. Some of the management units within the vegetation type are fenced off, due to the presence of *Dichapetalum cymosum*, thus withholding grazing pressure within this area during the growing season. These areas are encroached by *Ochna pulchra* and *Strychnos pungens*. This vegetation type is characterised by *Burkea africana* and *Securidaca longipendiculata* in the tree layer, *Eragrostis pallens* and *Aristida stipitata* in the grass layer, and *Vernonia poskeana* in the herb layer. This vegetation type can be subdivided into five plant community variations based on the type and intensity of the agricultural disturbance and the time of vegetation regeneration.

D1 *Eragrostis pallens - Combretum zeyheri* broadleaved woodland savanna on sand.

Management units 6, 8, 21 and 22 consist of the *Eragrostis pallens - Combretum zeyheri* plant community. The plant community is characterised by mature trees and shrubs with long grasses. *Combretum zeyheri, Combretum molle, Strychnos pungens* and *Ochna pulchra* dominate the tree layer. *Grewia flavescens* and *Ehretria rigida* characterise the shrub layer. *Triraphis andropogonoides* characterises the grass layer, but *Eragrostis pallens*, *Panicum colloratum* and *Digitaria brazae* dominate the grass layer. *Asparagus laricinus* and *A. suavolens* dominate the herb layer.

D2 *Eragrostis pallens - Ochna pulchra* dense woodland savanna on sand.

Management units 10 and 15 occur within the *Eragrostis pallens - Ochna pulchra* dense woodland plant community. Due to different histories of agricultural practices these two units differ in vegetation structure. Unit 10 is dominated by stands of the grasses *Eragrostis pallens, Digitaria eriantha, Eragrostis lehmaniana, Pogonarthria squarrosa, Cynodon dactylon* and *Aristida canescens*. The tree layer is dominated by *Terminalia sericea, Securidaca longipendiculata* and *Ochna pulchra*, all standing less than 2 m high, whilst *Maytenus senegalensis* dominates the shrub layer.

Unit 15 consists of a mature tree stand, with a dense *Ochna pulchra* and *Strychnos pungens* (<2 m) shrub layer and a sparse grass layer. The tree layer consists of mature *Ochna pulchra*, *Burkea africana*, *Terminalia sericea*, *Strychnos pungens* and *Securidaca longipendiculata*. The dense growth of trees and shrubs can be attributed to the encroachment of *Ochna pulchra* and *Strychnos pungens*. Bush encroachment is mediated by an increase in the number of individuals within the vegetation stand. In contrast, bush thickening describes the increase in individual size of the tree or shrub, usually in semi-arid and arid savanna regions. The grass layer is dominated by *Eragrostis pallens*, *Eragrostis heteromera* and *Aristida stipitata*. The herb layer consists mainly of *Indigofera* spp. and *Cucumus hirsutus*.

D3 *Digitaria brazzae - Terminalia sericea* open woodland savanna on sand.

Management units 11 and 20 consist of *Digitaria brazzae - Terminalia sericea* plant community. The vegetation in unit 11 consists of an open long grass field and is dominated by scattered mature *Terminalia sericea* trees. The mature *Terminalia sericea* trees were kept intact during the period of agricultural activity to provide shade for domestic farm animals. *Digitaria brazzae*, *Perotis patens* and *Cynodon dactylon* are the dominant grass species of this plant community, together with *Eragrostis pallens* in unit 11 and *Heteropogon contortus* in unit 20. *Dichrostachys cinerea*, *Acacia tortillis* and *Acacia nilotica* (<2 m) dominate the shrub layer in unit 20.

D4 *Cynodon dactylon - Hyperthelia dissolata* mixed grassland on sand.

Management units 4, 5, 13, 14 and 23 consist of *Cynodon dactylon - Hyperthelia dissolata* mixed grassland plant community. Mature *Burkea africana* trees were kept to provide shade for the domesticated animals in unit 4. Management units 9 and 14 are assigned to different vegetation types due to the mixing of the topsoil horizons and the historical differences in agricultural exposure. Pioneer species and exotic weeds are generalists and do not distinguish between the vertic clay soils and the soils containing loamy red basalts. The plant community is characterised by the presence of *Hyperthelia dissolata* in the grass layer but dominated by *Cynodon dactylon*, *Aristida congesta*, *Eragrostis heteromera*, *Pogonarthria squarrosa* and *Perotis patens* within all the units. *Waltheria indica* characterises the forb layer. *Dichrostachys cinerea* is the dominant woody element, though still less than two metres tall together with other tree species including *Terminalia sericea* and *Strychnos pungens*.

D5 *Aristida stipitata - Aristida canescens* open short grassland on sand.

Management unit 12 is the only management unit within the *Aristida stipitata - Aristida canescens* short grassland. The vegetation of the management unit is dominated by an open short grass field consisting of *Cynodon dactylon* and *Aristida canescens*. The shrub layer (<1 m) consists of *Terminalia sericea*, *Dichrostachys cinerea* and *Maytenus senegalensis*.

Carrying capacity and stocking rates

The total grazing capacity under average rainfall conditions for the Conservation Unit is 13.8 ha / LSU. The economic carrying capacity for the Conservation Unit, based on the total grazing capacity, converts to a total of 49 LSU game during years of average rainfall. Under poor rainfall periods (< 80% of the mean annual rainfall), the economic carrying capacity decreases to 20 LSU.

Fauna

The preselected macro-fauna surveyed for this study includes birds and mammals. The majority of wildlife including birds, small mammals and smaller ungulates, for example steenbok (*Raphicerus campestris*) were present within the Conservation Unit during the time of agricultural activity. Re-introductions of the larger ungulates such as Cape buffalo (*Syncerus caffer*), white rhinoceros (*Ceratotherium simum*), Burchell's zebras (*Equus burchelli*), red hartebeest (*Alcelaphus buselaphus*) and eland (*Taurotragus oryx*) have been undertaken over the time period of the present study.

Materials and Methods

Birds

The bird survey was conducted over a four day period during September 1999. Only diurnal birds were recorded. The survey was conducted along transect lines (Bibby, Burgess & Hill 1992), which covered the whole Conservation Unit and were laid out systematically at 250 m intervals in an east-west direction. The transect lines crossed through all habitat types on the Conservation Unit. The survey was conducted walking at a speed of two km.h^{-1} and observing the birds through 8X40 binoculars. All stationary birds seen in front of the observer and within about 50 m either perpendicular to the transect line were identified, counted and recorded. Birds that were stationary within the set range, but which were disturbed due to the observer's presence, were also identified, counted and recorded. Species richness, the number of species and the Shannon-Wiener's diversity index were calculated as measures of assemblage characteristics (Clarke & Warwick 1994). Hierarchical agglomerative clustering by using the program CLUSTER of the PRIMER software package (Clarke & Warwick 1994) produces a dendogram of the similarity matrix. Non-metric multidimensional scaling (MDS) was used to do determine community assemblages. An analysis of similarity, through non-parametric procedures (ANOSIM, PRIMER, Clarke & Warwick 1994), were performed to test for similarity and dissimilarity of the different bird assemblages between the different habitats.

Small mammals

The small mammals survey was conducted in May 1999. The Conservation Unit was stratified into two habitat types, based on the presence of predominantly sandy or clay soils. Six trapping grids were placed within each of these habitat types. Each grid (100 X 100 m) comprised 100 trapping stations at 10 m intervals. Sherman live traps (8 X 9 X 23 cm) were set in the afternoon and baited with a mixture of peanut butter, raisins and oats. The traps were checked and closed every morning. Trapping was done over four consecutive days for each grid. Trapped individuals were checked for identification marks, identified, sexed and marked through toe-clipping. The grid number, station number, species, sex and mark number were recorded at each capture and the individual released at the capture sight. The densities for each species per grid were determined as the minimum number alive (MNA) (Chitty & Phipps 1966). Species richness was calculated from the MNA results, using the software program ECOLOGICAL METHODOLOGY (Krebs 1997).

Other Nocturnal Mammals

The survey to identify other nocturnal mammals on the Conservation Unit was conducted from April to September 1999, at intermittent time intervals, for periods up to four days at a time. Animal burrows, waterholes, animal carcasses and game trails were surveyed for the presence of nocturnal species such as the porcupine (*Hystrix africaeaustralis*), aardvark (*Orycteropus afer*) and brown hyaena (*Hyaena brunnea*). A single infra-red triggered 35mm camera setup was used over a total of 36 days, covering nine preselected areas over a four day period. The areas chosen for setting up the camera were investigated for recent animal activities such as fresh tracks, dung, etc. The waterhole closest to the northern boundary with the Mosdene Nature Reserve, as well as one of the active porcupine burrows, were covered on two separate occasions. All the other sites were covered on a single occasion. A complete description of the techniques, technical difficulties encountered and possible solutions to these problems are provided in Appendix 3.

Results

Birds

A total of 72 bird species were recorded during the bird survey. The total species number and the Shannon-Wiener diversity index estimated for the survey are given in Table 3. The mean species number for the Conservation Unit is 5.84 ± 0.67 bird species per transect. The MDS ordination of the 44 transects based on the square root transformed abundances and Bray-Curtis similarities, indicated a stress value of 0.22. The stress value falls within the 0.2 - 0.3 range and should therefore be interpreted with scepticism (Clarke & Warwick 1994).

Small mammals

Four rodent species and three insectivore species were captured during the trapping survey. The two shrew individuals (either *Crocidura* or *Mysorex*) could not be identified to species level and the tree squirrel (*Paraxerus cepapi*), a diurnal species, was excluded from the data base when calculating rodent species richness and diversity. The estimated minimum number alive (MNA) for rodents within the Conservation Unit is presented in Table 4.

Other nocturnal mammals

The camera and infrared data loggers were set up for a total of 448 hours, during which the infrared beam was triggered on a 105 occasions. A total of 25 photographs were taken, of which 12 were taken when testing the camera equipment after the setup was completed. Thirteen photographs of four different species were taken on five separate occasions. These included five photographs of two individual white rhinoceros (*Ceratotherium simum*) of unknown sex on two occasions at the same waterhole. A single photograph was taken of a brown hyaena (*Hyaena brunnea*) at the same waterhole, one photograph of a single honey badger (*Mellivora capensis*) of unknown sex entering what appears to be an abandoned porcupine burrow, and a total of six photographs of an unknown number of porcupines on two occasions at two different burrows.

Discussion

Birds

A total of 325 bird species have been recorded for the region (Tarboton 1977). This figure includes 64 species known as summer migrants and 64 species which are vagrants and sporadic visitors. The total figure also includes raptors, nocturnal birds and winter migrants, enumerated through surveys done over extended periods of time. Of the 325 bird species for the region, only 176 birds species occur within the terrestrial savanna.

Ninety two species of birds documented were noted on the Conservation Unit during the study period (Appendix 4). These do not include most nocturnal birds, the Egyptian Goose (*Alopochen aegyptiacus*) and Spurwinged Goose (*Plectropterus gambensis*) that were associated with newly established wetlands on the Unit. The three nocturnal birds of prey typical of the area, i.e. the Whitefaced Owl (*Otus leucotis*), Pearlspotted Owl (*Glaucidium perlatum*) and Spotted Eagle Owl (*Bubo africanus*) were seen during the day and thus are included in Appendix 4.

The bird transect surveys resulted in 72 bird species being recorded. Recent agricultural activity, along with the time of year when the single bird survey was conducted, contributes to the relatively low number of species recorded at the time. The multivariate statistical analysis suggests that all birds occurring on the Unit can be placed into a single community. Discriminant species for each of the habitat types could however be identified.

The Scaly-feathered Finch (*Sporopipes squamifrons*) is a discriminant species for habitats on clay soils, whether shrubs and/ or trees were present or not. The Grassland Pipit (*Anthus cinnamomeus*), Crowned Plover (*Vanellus coronatus*) and Swainson's Francolin (*Francolinus swainsonii*) are consistently discriminant for habitats on clay soils with no woody elements present. These are mainly the old cultivated fields within the *Tagetes minuta - Cynodon dactylon* old fields. The Blue Waxbill (*Uraeginthus angolensis*) and Rufous-vented Titbabler (*Parisoma subcaeruleum*) are discriminant species for the clay soils with only trees and shrubs present, for instance within the *Acacia tortillis - Acacia nilotica* thorny woodland and *Sporobolus africanum - Acacia karroo* thornveld.

The Fork-tailed Drongo (*Dicrurus adsimilis*) is the discriminant species for open vegetation (open grassland and open tree veld) on both the clay and sandy soils. No discriminant bird species were identified for the sandveld with dense stands of shrubs and trees. The Southern Black Tit (*Parus niger*) and Arrow-marked Babbler (*Turdoides jardineii*) are discriminant species

Table 3. The total number of bird species (mean ± standard error) and Shannon-Wiener diversity index (mean ± standard error) for the Conservation Unit and for four different habitat types on the Conservation Unit, Cinergy Game Farm, Northern Province.

Habitat Type	Number of transects	Total number species Mean ± SE	Shannon Diversity Index Mean ± SE
Conservation Unit	44	5.84± 0.67	1.27 ± 0.11
Habitats on clay and sandy soils with no trees and shrubs	20	8.10 ± 1.44	1.38 ± 0.14
Habitats on clay and sandy soils with trees and shrubs	24	5.08 ± 0.99	1.16 ± 0.16
Habitats on clay soils whether trees and shrubs present or not	24	8.13 ± 0.99	1.64 ± 0.11
Habitats on sandy soils whether trees and shrubs present or not	20	3.41± 0.51	0.88 ± 0.14

Table 4. MNA for small mammals captured within habitats on sandy and clay soils for the different management units (number in brackets indicates the time since agricultural disturbance has elapsed) during the small mammal survey on the Conservation Unit, Cinergy Game Farm, Northern Province.

Habitats on sandy soils						
Species — Management unit number	21 (>30)	22 (>30)	6 (>30)	10 (16-20)	4 (16-20)	13 (10-15)
Mastomys coucha	0	0	0	0	1	1
Dendromys melanotis	0	0	0	4	3	4
Elephantulus branchyrynchus	0	0	0	0	0	0
Tatera leucogaster	0	0	0	0	0	0
Tatera brantsii	1	2	3	6	7	2
Habitats on clay soils						
Species — Management unit number	1 (>30)	16 (30)	19 (30)	14 (16-20)	17 (5-10)	20 (1-4)
Mastomys coucha	1	3	12	16	4	17
Dendromus melanotis	0	0	0	0	0	0
Elephantulus brachyrynchus	4	0	0	0	0	0
Tatera leucogaster	2	0	0	0	0	0
Tatera brantsii	4	0	0	0	0	0

within the open sandveld vegetation types, like the *Eragrostis pallens* - *Combretum zeyheri* and the *Digitaria brazzae* - *Terminalia sericea* which consists of open long grass, shrubs and trees.

The broadleaved savanna of the mixed bushveld are characterised by generalist bird species that congregate into bird parties. These bird parties consist of species such as the Fork-tailed Drongo, Southern Black Tit and Chin-spot Batis (*Batis molitor*) which tends to attract other species including the Arrow-marked Babbler, Red-billed Woodhoopoe (*Phoeniculus purpureus*), Long-billed Crombec (*Sylvietta rufescens*) and White helmet Shrike (*Prionops plumatus*). This phenomena explains the high standard deviation around the mean for both the species number and species diversity for the transects covering the habitats on the sandy soils (Table 3).

Small mammals

The Nylsvley Nature Reserve supports 35 rodent and insectivore species, of which 15 species are terrestrial. The present trapping survey was, however, not designed to include species such as Juliana's golden mole (*Amblysomus julianae*), southern African hedgehog (*Atelerix frontalis*), porcupine (*Hystrix africaeaustralis*) and springhare (*Pedetes campesis*). Several terrestrial rodent species typical for the region, including *Aethomys chrysophilus*, *Lemniscomys rosalia*, *Mus minutoides* and *Rhabdomys pumilio*, and more uncommon rodents species including *Saccostomus campestris*, *Dendromus mystacalis* and *Graphiurus murinus*, were not captured during the trapping survey. However, *Lemniscomys rosalia* and *Rhabdomys pumilio* are crepuscular and diurnal and thus would not have been trapped during the present survey (see Skinner & Smithers 1990).

Eight small mammal species were caught during the small mammal survey. The tree squirrel (*Paraxerus cepapi*), two shrew individuals along with the four rodent species and a single elephant shrew species were captured, and are used in the species richness calculations for small mammals on the Conservation Unit. *Mastomys coucha* (sensu lato) was the most common species trapped, especially on recently disturbed habitat types such as the *Tagetes minuta* - *Cynodon dactylon* old fields, *Cynodon dactylon* - *Hyperthelia dissolata* mixed grasslands as well as on management unit 19 which is part of the *Sporobolus africanum* - *Acacia karroo* thornveld.

Sections of the *Acacia tortillis* - *Acacia nilotica* thorny woodland had been left undisturbed by the agricultural activities, resulting in a more complex vegetation structure for feeding guilds and niches to be filled by the small mammals for this vegetation type. The *Acacia tortillis - Acacia nilotica* thorny woodland (Management unit 1) supported more rodent species than the other vegetation types on clay soils (Table 4). The rodents occurring here include *Mastomys coucha*, *Tatera leucogaster* and *T. brantsii*, as well as the elephant shrew *Elephantulus branchyrynchus*.

The *Eragrostis pallens - Burkea africana* vegetation types accounted for three different rodents being captured. The *Eragrostis pallens - Combretum zeyheri* plant community variation of the *Eragrostis pallens - Burkea africana* vegetation type only produced a low number of *Tatera leucogaster*. Within management units 4 and 13 of the *Cynodon dactylon - Hyperthelia dissolata* mixed grassland and management unit 10 of the *Eragrostis pallens - Ochna pulchra* dense woodland all three rodents, *Tatera leucogaster*, *Dendromys melanotis* and *Mastomys coucha* were recorded.

Mastomys coucha dominated recently disturbed habitats on the clay soils, whereas the habitats within the *Acacia tortillis - Acacia nilotica* thorny woodland contain two additional rodent species (*Tatera leucogaster* and *T. brantsii*) and the elephant shrew (*Elephantulus branchyrynchus*). The habitats within the *Eragrostis pallens - Burkea africana* vegetation types, support a larger number of species within the younger vegetation stands, i.e. the *Cynodon dactylon - Hyperthelia dissolata* mixed grassland dominated by the grass layer, than the habitats situated within the *Eragrostis pallens - Combretum zeyheri* plant communities.

Other nocturnal mammals

On the first occasion of photographing the porcupines, at least one male and one female could be identified entering and exiting the burrow entrance. The sequence of events could be followed by arranging the photographs according to the date and time. After the initial success, the first porcupine burrow was monitored for a second four day period but no further photographs of any animals were taken. This second occasion at the burrow, along with a setup at a red hartebeest (*Alcelaphus buselaphus*) carcass, an active aardvark burrow, and at the original waterhole where the first white rhinoceros photos were taken, but at a different access game path, resulted in no photographs being taken.

Summary of the plant and animal surveys

The vegetation of the Conservation Unit corresponds well with the general description for mixed savanna vegetation types based on broad-leaved savannas on well drained sandy soils, and microphyllous thorn savanna on the clay rich soil areas, similar to the study done in the Nylsvley Nature Reserve (Coetzee, Van der Meulen, Zwanzigar & Weisser 1976). The vegetation on the sandy soils was exposed to disturbances varying from exclusion of grazing and browsing, removal of aboveground natural vegetation through deep ploughing, and the continuous disruption of woody species development through annual mowing of the grass layer. The vegetation type is therefore subdivided into five variations, depending on the composition of the plant communities, and the response of the indigenous species to disturbances caused by agriculture practices.

The vegetation types on the clay rich soils were exposed to higher levels of soil disturbance. Disturbances included the removal of all aboveground natural vegetation through deep ripping and ploughing of the topsoil, the continuous mixing of the upper soil horizons through annual ploughing, the addition of various nutrients and minerals and the application of herbicides and pesticides on the established agricultural monoculture. The exotic weeds and other pioneer species that occur on the recently abandoned old fields on the clay rich soils do not seem to discriminate between the management units on the clay and the sandy soil areas. The management units that fall within this category have either black vertic clay soils with a loamy layer on top, or a red basalt with a sandy layer on top. The different vegetation types in these areas are classified, based on the age and level of successional development of the different management units, rather than on the soil characteristics.

The savanna bird community on the Conservation Unit is dominated by seed-eating birds both in density and species numbers. This bias could be credited to the amount of food available to the seed-eating bird species from the agricultural activities in the past. The ostrich is the only species that has been reintroduced onto the Conservation Unit since the agricultural practices were stopped.

There is an estimated total of 67 mammal species within the Nylsvley Nature Reserve (Jacobsen 1977). A total of 28 mammals were either observed, photographed or caught during the study period within the Conservation Unit. The multimammate mouse is the predominant species occurring within the most recently disturbed areas. Their numbers appear to decrease, whilst other small mammal number increase, in the areas either not disturbed by agricultural activity, or being restored from previous man-induced disturbances. The bushveld gerbil is the only species that occurs within all the sandy soil habitats, as opposed to the multimammate mouse and the grey climbing mouse which prefer the sandy soil areas with long grass and no tree or shrub cover. Bushveld gerbil numbers appear to decrease, however, with an increased presence of woody elements within their habitats.

The ground surveys enabled the construction of an inventory on which to base part of the management plan. Species lists of mammals, birds and plants encountered during the study period on the Conservation Unit are presented in Appendix 4.

CHAPTER 4

ECOSYSTEM MANAGEMENT

Introduction

Ecological principles relevant to the development of a Management Plan for the Conservation Unit of the Cinergy Game Farm are determined by the objectives stipulated for the Management Plan. A generic description of these ecological principles, as well as a description of the applicable management techniques, will be given for each objective. Chapter 5 will deal with the management operations in terms of the hierarchal management framework as a conceptual model, so as to advise on specific details for the application of the different ecological principles to fulfil the requirements set out by the objectives.

Objective 1

To contribute to the conservation ethic by consolidating land previously exposed to land use practises other than conservation into a unit with characteristics typical of an indigenous, self-sustaining natural system. Ecological principles underlying objective 1 apply to management level 2, 3, 4 & 6 of the hierarchal management framework. The ecological principles that apply to objective 1 are:

1. *Intermediate disturbances and the maintenance of diversity.*

Disturbances have been viewed as irregular and uncommon events that cause abrupt structural changes in natural communities, resulting in ecosystems moving away from their dynamic and / or static equilibriums (Parker & Pickett 1997). Principles of point equilibrium and static stability, characterised by equilibrium concepts, assume that ecosystems will return to a previous equilibrium after perturbation. However, in light of the changes in the ecological paradigm, disturbance is taken as a discrete, punctuated killing, displacement, or damaging of one or more individuals or colonies, that creates immediate opportunity for new individuals or colonies to colonise that area (Sousa 1984).

This management plan subscribes to the concept of non-equilibrium theory. Disturbance regimes vary considerably over temporal and spatial scales (Sousa 1984). Characteristics of disturbances are usually described as follows (for examples: see Sousa 1984):

1. Spatial extent - size of disturbance area.
2. Magnitude - two components.
    a. Severity - measure of the damage.
    b. Intensity - measure of strength.
3. Frequency - number of disturbances per unit time.
    a. Random point frequency - mean number of disturbances per unit time at random point in the an area.
    b. Regional frequency - total number of disturbances in an area per unit time.
4. Predictability - measure the variance in mean time between disturbances.
5. Turnover rate - mean time required to disturb the entire area.

Based on these principles, the highest level of biological diversity may be attained at intermediate levels of disturbance (Petraitis, Latham & Niesenbaum 1989). Intermediate disturbance implies varying the characteristics of disturbances as set out by Sousa (1984). Agents of disturbance can be either physical or biological processes. Examples of physical disturbances include fire, floods, drought, landslides and ice storms. Predation, digging by burrowing animals and grazing are seen as forms of biological disturbances. The management plan for the Conservation Unit is primarily concerned with bush clearing and fire as physical agents of disturbance, and grazing and simulated predation as agents of biological disturbance.

2. *Ecological succession induces environmental heterogeneity.*

Succession is defined as 'the non-seasonal, directional and continuous pattern of colonisation and extinction on a site by species populations' (Begon, Harper & Townsend 1990). Successional trajectories are typically defined from primary succession, i.e. soil formation and initial colonisation of weedy species. Initial secondary succession such as herbaceous perennials are then followed by mid- and late successional stages such as shrubs and mature old growth trees.

The classical definition of succession implies a directional, cumulative, non-random change in species composition that results in a static, climax community. Ecosystems have been regarded to reach stable successional endpoints, after which system processes maintain the ecosystem in a dynamic equilibrium. Ecosystems were seen as closed and self regulating, with internal control over the flow of minerals and energy. All the processes within the ecosystems were regarded to be deterministic, and any external process or event was considered a disturbance. As such, disturbances were considered as exceptional events (Parker & Pickett 1997).

The contemporary paradigm assumes that ecosystems are open, regulated by internal and external processes, and are subject to frequent natural disturbances. Multiple, alternating successional pathways result in community dynamics which include cycles, equilibria or chaotic trajectories (Pickett & Parker 1994). Ecological theory now also recognizes disturbance-induced discontinuous and irreversible communities, and the importance of stochastic effects in succession (Wyant, Meganck & Ham 1995). These concepts imply that the full recovery of an ecosystem is not always possible due to potential environmental and biological constraints.

Objective 2

To restore the consolidated land into a singular unit, where natural and indigenous processes with faunal and floral elements typical of the region prior to disturbances evoked by man, dominate. Ecological principles underlying objective 2 apply to management levels 3, 5 & 6 of the hierarchal management framework. The ecological principles that apply to objective 2 are:

1. *Demographic processes and maintenance of viable populations.*

The four demographic processes that are essential to the maintenance of viable populations are birth, death, emigration and immigration. Population dynamics, as determined by the demographic processes, include the number of individuals within the population, the sex ratio and the age class composition. Dispersal of offspring away from their place of birth, together with migration are important, but difficult to quantify demographic processes. Opportunities for dispersal by individuals from a population become limited if the conservation area is surrounded by areas exposed to habitat destruction and habitat transformation.

Fragmented habitats, resulting in unsuitable habitat surrounding protected areas, therefore inhibit the dispersal and migrational abilities of individuals from their birth place to surrounding populations. Dispersal of individuals ensures genetic vitality between populations, strengthens social structures and ensures healthy population dynamics. The majority of species within the Conservation Unit are able to disperse effectively. However, the larger game species introduced to the Conservation Unit will have to be exposed to artificial dispersal. This is achieved through simulating natural dispersal through active relocation programs and further re-introductions. These demographic processes are closely linked to the ecological theory applicable to the management of small populations within the meta-population theory discussed under objective four.

2. *Predation and competition increases and maintains diversity.*

Predation and competition are closely inter-linked with one another. Together they mould the structure of communities and are therefore important for the maintenance of diversity. Interspecific competition may determine which species can, and in what number they occur within the community. Selective or general predation also determines community structure, pending preference prey. Selective predation can lower the diversity if the preferred species are competitively inferior, but increase diversity if the preferred species are competitively superior.

Exploiter-mediated coexistence occurs where predation ensures the existence of species that would otherwise be excluded due to competitively dominant species. Generalist predators can increase the diversity within a community through the exploiter-mediated coexistence. The competitively dominant species will be the most abundant and therefore exploited at higher rates by predation. Predation, such as grazing, is a form of disturbance, and therefore linked to the intermediate disturbance hypothesis. Intermediate predation will increase diversity, since a low predator density will exclude competitively inferior species, and a high predator density could lead to over exploitation of the preferred prey species (Begon, Harper & Townsend 1990).

Objective 3

To develop a conservation ethic amongst all stakeholders so as to enhance and maintain biological diversity through a pro-active conservation management operation. Pro-active management involves all levels of the hierarchal management framework. Biodiversity is defined as the 'total variety of life on earth. It includes all genes, species and ecosystems and the ecological processes of which they are part' (ICBP 1992; In Gaston 1996). Enhancing and maintaining biodiversity (structure) involves the management (control) of the ecological processes (functions). The simulation of natural disturbances and predation at intermediate levels, along with the dispersal processes described for Objectives 1 & 2, are the main focus points for the pro-active management approach.

Facilitating the successional processes implies the management of induced disturbances, as opposed to awaiting natural disturbances. These management induced disturbances include actions such as bush clearing, slashing of weedy species and controlled burning. The disturbance regime for the Conservation Unit has until recently consisted mainly of agricultural activities directed at maximizing production. This included mowing the grass layer to eliminate woody elements for higher grass production and ploughing land for monocultural production. The suggested management actions to stimulate, facilitate and manipulate successional development of the various management units differ from those induced to maximise productivity, not only in scale, but also in frequency, magnitude and timing.

Simulating the demographic processes for the large game species includes the addition and removal of individuals from the various population. Stimulating and assisting the demographic processes for small mammals, medium-sized predators and other nocturnal animals within the Conservation Unit would include alleviating the constraints set by the game proof fence surrounding the area. The selection for addition and removal of individuals of the large game species will depend on species specific response to disturbance, their social structure and habitat requirements.

Objective 4

To develop a self-sustaining game breeding enterprise which will supply for some of the needs of other animal breeders and conservationists. The underlying ecological principles for Objective 4 applies to management level 4 of the hierarchal management framework. The ecological principles underlying Objective 4 are:

Minimum viable populations and the meta-population theory.

Minimum viable populations have several factors to consider such as genetic factors, demographic and environmental stochasticity, and social dysfunctions (Simberloff 1988). The management of small populations, such as those on the Conservation Unit, includes several of these genetic factors that could play a role in the viability of the different populations. These factors include the effective population size, inbreeding depression, genetic drift, loss of genetic variation and genetic bottlenecks. The different species within the Conservation Unit will be specific in their responses to these factors. An important aspect for conservation is to maintain as much variation as possible through unrestricted interbreeding in large populations (Simberloff 1988). The demographic and environmental stochasticity and social dysfunctions along with the different genetic factors, are mainly theoretical and the empirical proof of population persistence are not sufficient (Simberloff 1988).

Habitat fragmentation is said to be the single greatest challenge to conservation management (Simberloff 1988). The management of fragmented populations with no suitable habitat linking the different populations are complex. The meta-population theory, i.e. the management of small populations and linking of the fragmented habitats, gives the manager of any conservation area important underlying ecological principles on which to base their management decisions.

Objective 5

To enact and maintain some self-sustaining leisure activities to the benefit of the owner and his family. Management principles that underwrite Objective 5 are applicable to management level 5 of the hierarchal management framework. The leisure and ecotourism principle should be based on all activities that are non-intrusive to the wildlife and vegetation within the Conservation Unit. These include activities that limits noise or any other form of pollution, limits the physical damage to the environment and do not harass wildlife. Applying these principles will soon pay, with wildlife becoming habituated to the presence of man - increasing the photographic possibilities with the wildlife and the general enjoyment of nature.

CHAPTER 5

HIERARCHAL MANAGEMENT FRAMEWORK

Introduction

Several management decisions and actions have been taken for the Conservation Unit over the time period of this study. These include the removal of artificial structures (i.e. building rubble, concrete pipes, electric and fence cables), the removal of some exotic vegetation, the fencing of the Conservation Unit with a ten foot high electrified game fence, the establishment of an anti-poaching patrol unit and the reintroduction of some large ungulate species typical of the region.

Assisting the management actions to be taken on the Conservation Unit is the design of a hierarchal management framework. The hierarchal management framework is designed to alleviate the constraints of dealing with 23 managements units within the Conservation Unit of 753 hectares. It is essentially a conceptual framework, developed with respect to the scale against which the management actions should be applied.

The hierarchal management framework involves dividing the Conservation Unit into six different management levels. The Conservation Unit and the immediate surroundings are placed at the top level, followed by the Conservation Unit as an insular entity at the second level. On the third level the Unit is divided into two sections based on soil types, i.e. clay soils and sandy soils. The fourth level is based on the various vegetation types and plant community variations, and at the fifth level the 23 management units. The sixth level divide the different management units into smaller hectare blocks of varying sizes.

The management actions suggested for the Conservation Unit will have several implications for the different biological components within the area. Monitoring these components should indicate whether the management actions fulfil the requirements as set out in the Objectives for Cinergy Game Farm. Although the suggested management actions are based on ecological principles they may have unforseen consequences or outcomes, such as the inability of species to recolonise the Conservation Unit. Predicting the outcome of the management actions, as well as making the necessary recommendations with regard to potential changes is dependant on a good monitoring and evaluation system. An effectively designed monitoring and evaluation plan must be practical in its application, time and cost effective, deliver reliable and accurate results and be continuous, even with a change of managers. It is essential that the monitoring be handled by qualified ecologists.

Describing the different management actions in accordance to the hierarchal management framework will begin at the lowest level of the framework, i.e. where the management units are sub-divided, progressing through all levels until all the levels have been covered.

Management level 1

Management level 1 is designed to assist with the removal of all unnatural elements and exotic vegetation. Man-made structures, for instance pieces of fence wire, concrete boulders, fence poles, as well as the scars and leftovers of previous agricultural practices in the Conservation Unit. Although considerable time and effort has been spent to remove these structures, follow up operations need to be undertaken. These management actions are designed to fulfil the requirements of Objectives 2 & 3.

Each management unit must be subdivided into areas of a practical size for sweeping purposes. Sweeping involves individuals walking a predetermined distance apart, depending on the thickness of the vegetation, in a specific direction, keeping the distance between them as even as possible. The individuals participating in this exercise should then remove all the unnatural elements within the specified area, as well as point out and or mark the positions of exotic vegetation to the hacking team. Depending on the intensity to which these actions conducted, a single sweep should be sufficient for the removal of all the man-made structures.

The line of sweepers are followed by a hacking team(s). A hacking team consists of individuals who remove any exotic vegetation that is spotted and identified by the line of sweepers. Hacking teams are mainly concerned with the removal of invasive and aggressive exotic species. Aggressive and transformer exotic species have certain competitive abilities, e.g. the production of allelo-pathogens to inhibit the establishment of natural vegetation. The aggressive exotics occurring on the Conservation Unit cannot be eradicated through natural successional processes. These species should not however be confused with the indigenous pioneer and weedy species.

A list of exotic vegetation encountered during the study period is given in Table 5. For each species the scientific name and potential means of elimination are provided. The removal of exotic vegetation can also be assisted through the management of natural succession. This principle applies mainly to the weedy pioneers of old fields. Pioneer exotic and other weedy species tend to establish themselves in areas where severe disturbances of the upper soil layers have occurred. Part of the successful removal of these weedy and pioneer exotics species includes the prevention of any further excessive top soil disturbances.

The mechanical removal of *Jacaranda mimosifolia* and *Melia azedarach* trees, and the two cactus species, *Cereus peruvianus* and *Opuntia ficus-indica*, involves initial clearing of the individual plants, their removal and the destruction of the plant material through burning and burying. The latter two species are renowned for their ability to re-establish vegetatively through pieces of broken plant material that fall on the ground during the elimination process or when transporting the material to be burned or buried. Essential to the initial success of removing exotic vegetation are the annual follow up operations utilising the same sweeping techniques as proposed for the removal of human structures. This is done due to the propagation abilities of the exotic plants from outside the Conservation Unit. It must be emphasised that these sweeping actions for the removal of exotic vegetation only solve the problem temporarily, and that more permanent solutions must deal with the cause of the exotic vegetation problem. This also applies to the education of staff members with regards to preventing the distribution of any unnatural elements both within and outside the Conservation Unit, as well as establishing ornamental garden plants with aggressive and invasive characteristics.

Management level 2

The current design of management units are a direct result of the historical agricultural practices to which the area now defined as the Conservation Unit has been exposed. The imposed agricultural disturbances include the clearing of aboveground vegetation, the deep ploughing of certain blocks of land, the addition of minerals and nutrients, the establishment of monoculture of crop-producing species, and the annual mowing of grass to suppress the establishment of woody species. Portions of the property were exposed to grazing by cattle and sheep. Fire was excluded from the area for some 30 years. The management actions proposed for management level 2 fulfill the requirements as set by Objectives 1, 2 & 3.

Management units 1 & 2 of the *Acacia tortillis - Acacia nilotica* thorny woodland veld types are situated on soils with a relatively high clay content and have experienced little agriculturally induced disturbances. Management unit 1 was, however, ploughed on a single occasion in 1973

Table 5. Species name, common name, invasive characteristic and management strategy for exotic vegetation on the Conservation Unit, Cinergy Game Farm, Northern Province.

Species name	Common name	Invasive characteristic	Management strategy
Argemone mexicana	Yellow-flowered Mexican poppy	Pioneer weed	Natural succession
Argemone subfusiformis	White - flowered Mexican poppy	Pioneer weed	Natural succession
Waltheria indica		Perennial weed	Natural succession
Cereus peruvianus	Queen of the night	Aggressive invasive	Mechanical removal
Opuntia ficus-indica	Prickley pear	Aggressive invasive	Mechanical removal
Datura ferox	Large thorn-apple	Pioneer weed	Natural succession
Datura stramonium	Common thorn-apple	Pioneer weed	Natural succession
Xanthium spinosum	Spiny cocklebur	Pioneer weed	Natural succession
Xanthium strumarium	Cocklebur	Pioneer weed	Natural succession
Zinnia peruviana	Redstar Zinnia	Pioneer weed	Natural succession
Bidens bipinnata	Spanish-blackjack	Pioneer weed	Natural succession
Schkuhria pinnata	Dwarf marigold	Pioneer weed	Natural succession
Tagetes minuta	Tall Khaki Weed	Pioneer weed	Natural succession
Jacaranda mimosifolia	Jacaranda	Aggressive invasive	Mechanical removal
Melia azedarach	Syringa	Aggressive invasive	Mechanical removal

and the tree layer now consists mainly of *Acacia nilotica* and *Acacia tortillis* of similar dimensions and presumably of similar age. Tree density is high, probably as a consequence of this management unit not having been exposed to fire and grazing regimes, which would have reduced the establishment of *Acacia* species. The high *Acacia* density is apparently inhibiting the development of the grass and herb layers in this unit, probably as a consequence of competition for resources such as water and nutrients (Stuart-Hill, Tainton & Barnard 1987). The removal of randomly selected trees and shrubs of any size should create opportunity for productive grass species, such as *Panicum coloratum* and *Eragrostis heteromera*, along with other herbaceous plants to recolonise the area. Removal should continue until the figure for density of woody elements varies between 1000-1200 per hectare (Professor George Bredenkamp[1], pers. comm.). Management unit 2 has not been exposed to agricultural activities other than grazing by domesticated animals. No further human induced disturbance is recommended. Natural disturbances regimes discussed at the next level, i.e. fire and herbivory, will be used for management unit 2.

The *Sporobolus africanum* - *Acacia karroo* thornveld plant community includes management units 16, 17 and 19. Management unit 16 was exposed to a single ploughing event 30 years ago. The tree layer is dominated by various *Acacia* species, most of which are within the same height class and thus presumably of similar age. The randomly selected removal of individuals of any size should continue until the woody elements reaches a density of 1000-1200 individuals per hectare (Professor George Bredenkamp, pers. comm.). This will facilitate the colonisation of shrubs, grasses and other herbaceous elements typical of the microphyllous thorn savanna such as *Panicum coloratum*, *Eragrostis heteromera* and *Eragrostis lehmanianna*. Management unit 17 had all trees and shrubs removed around 30 years ago and was ploughed annually for 25 years. This area has been exposed to the mowing of grasses to inhibit shrub and tree establishment, thus enhancing productivity for grazing animals. As a consequence, the grass layer appears well established with woody elements such as *Acacia nilotica*, *A. tortillis* and *A. karroo* having started to colonise the area. Here cattle foraging, controlled through electrical fences, can be used to intensify grazing so as to ensure the reduction of pioneer and unpalatable grass species such as

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Sporobolus africanus, *Aristida canescens*, *Melenis repens* and *Heteropogon contortus*. Management unit 19 was cleared of all woody elements some 30 years ago but has since become reestablished. The only form of disturbance since then has been grazing by cattle and sheep. No further forms of human induced disturbances are recommended for management unit 19. Natural disturbance regimes discussed at the next levels will be applied to the management of management unit 19.

The *Tagetes minuta* - *Cynodon dactylon* old fields are the most recently ploughed fields within the Conservation Unit, and consist of management units 3, 7, 9 and 18. The vegetation on these managements units are between 1-3 years old. These areas are dominated by various pioneer exotics and indigenous plant species. Initiating the successional processes within these management units consists mainly of slashing / mowing these areas to promote the colonization of pioneer annual grass species typical of the region. Subsequent mowing of the grass layer at different heights, within various seasons and at varying frequencies will promote the establishment of pioneer perennial grass species. Once woody elements start colonizing, mowing could be replaced with manipulated natural disturbance regimes.

The *Eragrostis pallens* - *Burkea africana* vegetation type consists of five plant communities. The management actions designed for the various management units within the different plant community variations do not necessarily comply with the plant community variation in which these management units were placed. The management actions are based on whether the tree and shrub layer are present or not.

Management units 6, 8, 21 and 22 of the *Eragrostis pallens* - *Combretum zeyheri* variation, management unit 15 of the *Eragrostis pallens* - *Ochna pulchra* variation and management unit 11 of the *Digitaria brazzae* - *Terminalia sericea* variation are placed together for management purposes. These management units, except for management unit 11, were fenced off and, with the exception of management unit 15, were exposed to cattle and sheep grazing for over 30 years. These areas shows signs of bush encroachment, that is an increase in number of woody individuals per species. The grass layer and other herbaceous elements have been out competed by the woody elements.

Management unit 15 have been excluded from any grazing pressure due to the presence of *Dichapetalum cymosum*. *Ochna pulcra* and *Strychnos pungens* have formed dense stands within management unit 15. All individuals smaller than a certain size are currently being removed. However, no follow up poisoning of the stumps is currently being undertaken. Coppicing of new shoots from the stumps, as well as from the roots of mature individual trees will follow after the first rainfall season. The coppicing of these woody elements could again out compete the grass species.

Management unit 11 was cleared of natural vegetation on a single occasion some 30 years ago. Since then the area has been exposed to cattle and sheep grazing. Natural disturbance regimes, discussed at the next two management levels, through fire and herbivory, will be the preferred management strategies for management unit 11.

The suggested disturbance action for management units 6, 8, 15, 21 and 22 consist of opening up the tree layer for the establishment of grasses. The edges of management units 6, 8 and 15 should be opened up, so as to break the dense established woody layer. All the managements units (6, 8, 25, 21 and 22) should be exposed to random clearing of the woody elements until between 1900 and 2200 individuals per hectare are achieved (Professor George Bredenkamp, pers. comm.). This involves random selection and removal of individual trees and shrubs of any species and of any size and height class (except for the mature and old growth trees), and the smaller individuals of the same species surrounding it and removing them.

Management unit 10 of the *Digitaria brazzae - Terminalia sericea* vegetation type, management unit 12 of *Aristida stipitata - Aristida canescens* short grassland vegetation type and management units 4, 5, 13, 14 and 23 of *Cynodon dactylon - Hyperthelia dissolata* mixed grassland vegetation types were all exposed to a single clearing, ploughing and then subsequent mowing of the grass layer to suppress the establishment of trees and shrubs. The grass layer has therefore been well established for a number of years and has only been exposed to one form of mechanical disturbance on an annual basis. Assisting the establishment of woody elements is a priority within these management units. This can be achieved by randomly selecting enclosed areas for intensive grazing by cattle over very short periods of time. The areas exposed to this form of grazing must be of various sizes and exposed at different times of the year. Further assistance in the development of the plant community will be achieved through manipulating the natural disturbance regimes discussed at the next two management levels.

Management level 3

Actions for management level 3 are directed towards herbivory. Herbivory for any conservation areas is mainly determined by suitable habitat for game species in conjunction with the predetermined stocking rates and the biology of the game species in relation to their habitat requirements, population dynamics and social structures. Management approaches are in accordance with Objectives 1, 2 & 3.

In this study veld condition is used as a surrogate for habitat suitability. The current veld condition of the Conservation Unit is dictated by the recent termination of agricultural practices and the above average rainfall during the summer of 1999. The *Tagetes minuta - Cynodon dactylon* old fields dominate large parts of the clay soils area. Management unit 19 cannot support any grazers since there is very little grass present. The remainder of the management units are dominated by pioneer weedy species and have very little grass cover, consisting mainly of *Cynodon dactylon*. The veld condition of the *Tagetes minuta - Cynodon dactylon* old fields should improve with an increase in structure and function with increased successional development. However, selective grazing should be minimized within these areas. Unselective bulk grazing by mega-herbivores such as African buffalo, Burchell's zebra and white rhinoceros is preferable. These animals can tolerate pioneer annual and perennial species and create possibilities for the colonisation of other more palatable perennial grasses.

The veld condition is currently being determined through calculating the composition of grass species, classified into Decreasers, Increasers 1a and 1b, and Increasers 2 and 3, depending on their palatability, taste and nutritional value. Bare ground and the occurrence of small shrubs and other herbaceous elements also counts against the veld condition of a specific area. These measurements and criteria are based on the acceptability of these food sources to domesticated animals. Determining the veld condition for ecosystem management should rather investigate the function and structure of the ecosystem, relate the findings to heterogeneity of habitat, and then determine the potential stocking rate for the Conservation Unit.

Suitable habitat for the *Eragrostis pallens - Burkea africana* vegetation type varies considerably. Some areas shows very limited suitability, due to dense levels of bush encroachment in the *Eragrostis pallens - Ochna pulchra* dense woodland with very little grass. Other areas represent more suitable habitat within the *Cynodon dactylon - Hyperthelia dissolata* mixed grassland, and the *Aristida stipitata - Aristida canescens* short grassland. These vegetation variations are dominated by unpalatable grass species such as *Hyperthelia dissolata*, *Aristida stipitata*, *Aristida canescens*, mixed with more palatable species such as *Diheteropogon contortus* and *Digitaria brazzae*. Good veld management of the management units within the *Eragrostis pallens* - *Burkea africana* vegetation type will lead to the establishment of an open tree savanna, with palatable grasses dominating the shady areas underneath the trees and shrubs (e.g. *Panicum* sp.) and various grasses, either palatable or unpalatable, between the woody elements.

Annual precipitation figures are essential in determining veld condition and the stocking rates for the Conservation Unit. Rainfall figures from the Nylsvley Nature Reserve, measured from July to June, for the 1996-97, 1997-98 and 1998-99 are 668 mm, 496 mm and 565 mm respectively. Rainfall for 1998-1999 was below the average rainfall of 629 ± 118 mm per annum. The average amount of rain over the last two rainfall years is 530 mm, accumulating to only 1060 mm over the two years. Determining the economic carrying capacity was therefore based on conservative estimates. The current stocking rate, excluding browsers, is 125 % of the present economic carrying capacity. The total grazing capacity under average rainfall conditions for the Conservation Unit is 13.8 ha / LSU. The economic carrying capacity for the Unit based on the total grazing capacity converts to a total of 49 LSU game, with average rainfall. The present buffalo population (n=23) uses 47,3 % of the total LSU for the Unit. The white rhinoceros (n=6) uses 30,1 % and Burchell's zebra (n=8) 8,9 % of the total LSU. This represents 86,3 % of the total LSU game presently on the Unit being accounted for by unselective bulk grazers.

Selective grazers such as the red hartebeest, and the intermediate feeders such as the impala, eland and warthog, contribute a total of 32 % of the present stocking rate. The estimated figures for impala and warthog are, however, biassed as these animals continuously move between the Unit and neighbouring properties (personal observations). The current status of the bulk grazers, the selective grazers and intermediate feeders within the Unit, their sex ratio's and their social structure are given in Table 6.

Habitat requirements (see Skinner & Smithers 1990) for these animals are achieved within the Conservation Unit. Buffalo require a plentiful supply of grass, shade and surface water. Burchell's zebra require mainly open area woodland and grassland. The white rhinoceros has more specific habitat requirements ranging from areas with short grass, stands of medium *Panicum* sp., shallow waterholes for wallowing and adequate bush cover. Red hartebeest requires open woodland and grassland, whereas the impala depends on ecotones and surface water. Eland can occur in various types of woodland. Warthog depend on open ground, grassland, and open areas surrounding shallow waterholes for wallowing. The different habitat requirements of these herbivores appears to be met within the Conservation Unit. Successional development of the various management units will increase the potential numbers of individuals that can be supported by the Conservation Unit. Essential to the maintenance of genetic and reproductive fitness of the small number of individuals of each species is the rotation of breeding individuals. Continual removal of pre-selected males and females, and the timely introduction of new breeding individuals should ensure the prevention of inbreeding.

Management level 4

Management level 4 divides the Conservation Unit into vegetation areas based on sandy soils and vegetation areas dominated by soils with higher clay content. Vegetation in these areas responds differently to fire. Management actions prescribing to fire management are in accordance with Objectives 1, 2 & 3.

The two major approaches to fire management include control over unwanted fires, and the simulation of natural fires. Irrespective of the source of the fire, the preparation and control methods are similar. The first step in controlling unscheduled fires is the preparation of the Conservation Unit with fire fighting equipment and trained manpower, and having vehicles, water carts, water hoses, spades and flame burners all in good working condition. Secondly, a good communication system with the neighbouring landowners is also essential. Thirdly, fire breaks should be maintained along the boundaries of the Conservation Unit. This should be done before implementing any burn. Several techniques for creating a sufficient fire break have been proposed for farm management. However, most of these techniques involve the removal of above ground vegetation and topsoil through grading, which is against the conservation ethic underlying this management plan. The suggested technique makes use of the security road running next to the perimeter fence. Mowing the grass layer along the security road and, where possible, on the outside of the fence, should ensure a wide enough fire break from which a back burn (against the wind direction) can be initiated. Annual mowing of the fire break strip during the dry season will prevent the accumulation of fuel (dry plant material) to support unwanted runaway fires. A fire break should also be established, using the same techniques, around the manager's house and the boma.

Simulating natural fires within the confines of the Conservation Unit is a difficult procedure. Historically the frequency and intensity of natural fires must have been affected by the accumulation of dead plant material on the sandy relative to the clay soils area. Periods of high rainfall will also experience faster accumulation of burnable material. The intensity, frequency and spatial extent of fires are dependant on a combination of variables. These include the frequency and seasonality of ignition sources, the moisture content of the fuel, rate of fuel accumulation, structural and chemical characteristics of the fuel, the mosaic nature of the area and finally the local weather conditions at the time of the fire (Sousa 1984).

The characteristics of the fire will vary according to the reasons for having to use a fire on the Conservation Unit. Burning may be used to remove excessive lignified material, to stimulate the growth of moribund grass tufts, to control parasites, to suppress the development of small woody elements, or to manage bush density along with bush clearing activities. Different types of fire are needed to achieve these different goals.

To remove excessive lignified material, stimulate moribund grass tufts and control parasites, a downwind surface wind should be utilised. Low intensity conditions can be achieved through burning under cooler climatic conditions (ambient temperature < 20°C, relative humidity > 50 % at moist soil conditions and low wind speed) with wind direction the same as the direction of the fire. These conditions can be achieved by burning between 06h30 to 08h30 in the mornings, four days or more after the first ≈15 mm of rain.

Implementing burning to suppress the development of small woody elements needs backwind ground fire of high intensity. This can be achieved by burning under warmer conditions (ambient temperature > 20°C, relative humidity < 50 %, with moist soil conditions and at low wind speed) with a wind blowing in the opposite direction of the fire. Burning should be done between 10h00 to 13h00, again around four days after the first ≈15 mm of rain.

Managing bush encroachment with fire, along with bush clearing activities, requires a downwind crown and high intensity surface fire. This can be achieved under warmer climatic conditions (ambient temperature > 20°C, relative humidity of < 50%, with dry soil conditions) at higher wind speed range blowing in the same direction as the fire. Burning should be done before the first spring rains at the end of the dry season. Any area under consideration for burning should have at least 2000 kg grass per hectare (Prof. George Bredenkamp, pers. com.).

It is important to note the remaining unburned area should be big enough to sustain food

Table 6. Recommended sex ratios and the social structure for the large mammals (Skinner & Smithers 1990) on the Conservation Unit, Cinergy Game Farm, Northern Province .

Species	Male/ Female	Social structure	
Buffalo	(1/4)	Gregarious	1 Dominant Male: Females & Sub Adults: Bachelors
Burchell's zebra	(1/5)	Families	1 Dominant Male: Females & Calves: Bachelors
White rhinoceros	(1/3)	Families	1 Territorial Male : Females & Sub Adults
Red hartebeest	(4/6)	Families	1 Territorial Male : Females & Sub Adults: Bachelors
Impala	(9/36)	Gregarious	1 Dominant Male : Females & Sub Adults: Bachelors
Eland	(1/7)	Gregarious	1 Dominant Males : Females & Sub Adults: Bachelors
Warthog	(4/7)	Families	1 Dominant Male : Females & Sub Adults: Bachelors

resources for the animals after the burn. The burned area should, however, also be large enough to accommodate animal numbers as soon as the new growth resprouts. The response to fire as an agent of disturbance is different for the vegetation on sandy soils than the vegetation on clay soils. Clay soils, with higher levels of nutrients and minerals, respond more quickly and productively than sandy soils. Care should therefore be taken when exposing the vegetation on clay soils to fire. On clay soils minimum inter-burn frequency should be no less than every six years and only during times with above average rainfall. The vegetation on sandy soils can be exposed to fire every 3-5 years.

Several recent studies have suggested a new approach in fire strategies for protected and other natural areas (Brockett, Biggs & Van Wilgen; in press; Mentis & Bailey 1990). These studies indicate the value of adapting a patch-mosaic burning system to promote the establishment of habitat heterogeneity, by using random point ignitions under variable conditions (intensities, frequencies, seasons, etc.). However, these burning strategies are only recommended for areas larger than 20 000 hectares. The small area of the Conservation Unit does not lend itself to a mosaic burning program. At this scale the block burning system is suitable. In this system the different managements units within the different soil groups can be exposed to different and variable fires, promoting the establishment of heterogeneity. Monitoring done by expert ecologists, on the vegetation, successional pathways and community development should indicate if the response of the ecosystem to fire has the desirable effect.

Management level 5

Management level 5 considers the Conservation Unit a singular entity. Management actions at this level fulfil the requirements set out in Objectives 3, 4 & 5. Management decisions on the positioning of artificial waterholes, roads and fences, the removal of selected large game species above certain threshold levels, and leisure activities for the owner and his family will be discussed in this section. The provision of artificial waterholes within any conservation area remains a contentious issue. Three basic questions need to be addressed with the planning of artificial waterholes (Owen-Smith 1996). These are firstly the reasons for establishing artificial waterholes; secondly the spacing between artificial waterholes and thirdly where within the conservation areas artificial waterholes should be situated. The Conservation Unit of the Cinergy farm does not have natural perennial surface water available for game. At least four small depressions within the clay rich soils act as temporal vleis within management unit 2. These temporary natural waterholes are filled during the wet season, and dry up during the dry season. This annual cycle between the wet and dry seasons and the corresponding filling and drying up of waterholes, corresponds well with other protected areas (Walker, Emslie, Owen-Smith & Scholes 1987, Owen-Smith 1996). Artificial waterholes have been established on the Conservation Unit. This, and the small size of the Unit, has several management implications. These include the positioning, spacing, and fluctuation of the water levels within waterholes.

The Conservation Unit has six artificial waterholes, four of which can be filled through mechanical pumping. The other two depend on water runoff during the rainy season. All the artificial waterholes are situated within the *Acacia tortillis - Acacia nilotica* thorny woodland, the *Sporobolus africanum - Acacia karoo* thornveld and the *Tagetes minuta - Cynodon dactylon* old fields. These are all vegetation types with clay rich soils, which improves on their water holding capacity. The positioning of all waterholes on clay rich soils raises certain ecological concerns. Water dependant herbivores will be attracted throughout the year to the various waterholes if they remain filled during the dry season. This could result in both high feeding pressure on the vegetation around these waterholes, and severe trampling of the topsoil. Frequent and intense disturbance throughout the year will impede on the establishment of ecosystem processes including succession, sustainability of resources and the reestablishment of biodiversity.

Several ecological guidelines have been made regarding the spacing of artificial waterholes within different savanna types (Owen-Smith 1996). These guidelines, however, apply to larger protected areas. The Conservation Unit is too small to allow sufficient spacing between the various waterholes. By following the principle of rotating and fluctuating the water levels of the artificial waterholes, the manager of the Conservation Unit can simulate the spacing of artificial waterholes as applied to larger protected areas. This simulation of the spacing of artificial waterholes should alleviate the disturbance pressure on the vegetation and topsoil surrounding these waterholes. The recovery period for the vegetation should also fluctuate to ensure the establishment of a heterogenous patchiness within the Unit. The decision on how to control the water levels of the various artificial waterholes should be based on information obtained while monitoring veld condition of the areas in which the artificial water holes are situated.

The present road system on the Conservation Unit was designed to assist previous owners in the management of agricultural practices. These roads usually followed camp fence lines as well as both the centre-pivot and rectangular shaped boundaries of the cultivated fields (Figure 6). This resulted in too many small roads and other short cuts within the present Conservation Unit with no particular function, and major roads running in straight lines. On conservation areas roads should provide access to peripheral fence lines, to artificial water points or bomas (if applicable), sites of interest and routes to staff and guest housing. The third function of roads, more specifically the game viewing roads, should be for the personal benefit of the landowner. Game viewing roads should be optimised so as to access as much of the Conservation Unit as possible.

The proposed new road system will access all the vegetation types and areas of interest not covered by the present road system (Figure 7). Certain sections of the new road, as well as parts of the present road system, run through the *Acacia tortillis - Acacia nilotica* thorny woodland, the *Sporobolus africanum - Acacia karoo* thornveld and the *Tagetes minuta - Cynodon dactylon* old fields, all of which are situated on clay soils. These sections of the road should be closed during times of high rainfall until the topsoil has dried out sufficiently. Failure to do so may lead to the churning of the topsoil as well as excessive disturbance to the vegetation. The roads running within the deep sandy soil areas should still be accessible for vehicles but should be monitored for any excessive disturbance.

The following techniques are proposed for closing the current roads and for establishment of a new road system. The roads to be closed on the sandy soils should be blocked off at either end. Almost all the roads running through the deep sand, and the fences along which they run, have large amounts of sand heaped up next to the road. The closed off sections of these roads should be refilled with this sand. This should be done using manpower and not mechanically with heavy grading machines. The filled sections can then be sparsely covered with the branches that were removed during the clearing of the bush encroached areas.

The closure of road sections running through the clay soils should be treated differently. The clay content of the soils causes the upper layer to compact when a large amount of pressure is applied. The closed sections of these roads should be ripped to a depth of 30 cm in each vehicle track. This must be conducted mechanically towards the end of dry season when the soil has dried out. This procedure will break the compacted upper layer of the soil on the vehicle tracks and assist in the re-establishment of vegetation. The closed sections can also be packed with branches obtained during the clearing of the bush encroached areas. This will protect young seedlings that might establish themselves along the abandoned vehicle tracks. The design, planning and implementation of the new road system must be conducted so as to cause the least amount of disturbance to the soil, vegetation and animals on the Conservation Unit. No mechanical clearing of any vegetation and / or removal of topsoil must occur for establishment of the new road system.

The proposed new road should be clearly marked to limit confusion, resulting in vehicles driving outside the predetermined areas. The new road system, as shown in Figure 7, is a recommended plan. As far as possible should the new roads as suggested for the Conservation Unit, only consists of two-wheel tracks. These two-wheel tracks should preferably run through the centre and not between the management units, or vegetation ecotones.

The maintenance of sections of the present road system, along with the proposed new road system should be of high priority. Under no circumstances should mechanical maintenance such as the grading of the top soil layer, be applied. The smoothing of roads due to excessive use must be done manually, for example returning the sand that has been displaced to the side of the road with spades, followed by a smoothing action by pulling a lightweight object (e.g. set of tyres tied together with a solid weight on top) with a vehicle over the roads to be maintained. These actions ensure that sand particles fill the holes that have formed in the roads without having to grade these roads. This would result in the removal and displacement of the topsoil. Closing the roads running through the clay soil areas during periods of high rainfall is essential to successful maintenance of all the roads within the conservation areas.

Breeding of selected game species within the Conservation Unit fulfils the requirements set out in Objective 3 & 4. The management of selected large game species like white rhinoceros, Cape buffalo, eland and red hartebeest within the confines of the Conservation Unit will be determined by two factors other than economic and financial considerations, and other related market demands that determine the management actions to be taken for the game breeding enterprise. They include, determining the annual stocking rates for the Conservation Unit and, the selection process for removing individuals from the population as determined by the species population dynamics.

The stocking rates for the Conservation Unit should be determined annually by an individual with ecological training, based on the various veld condition measures and climatic variables. These should then be related to information obtained through annual censusses. This will assist with the decisions to be taken on the species, number of individuals and the age / sex

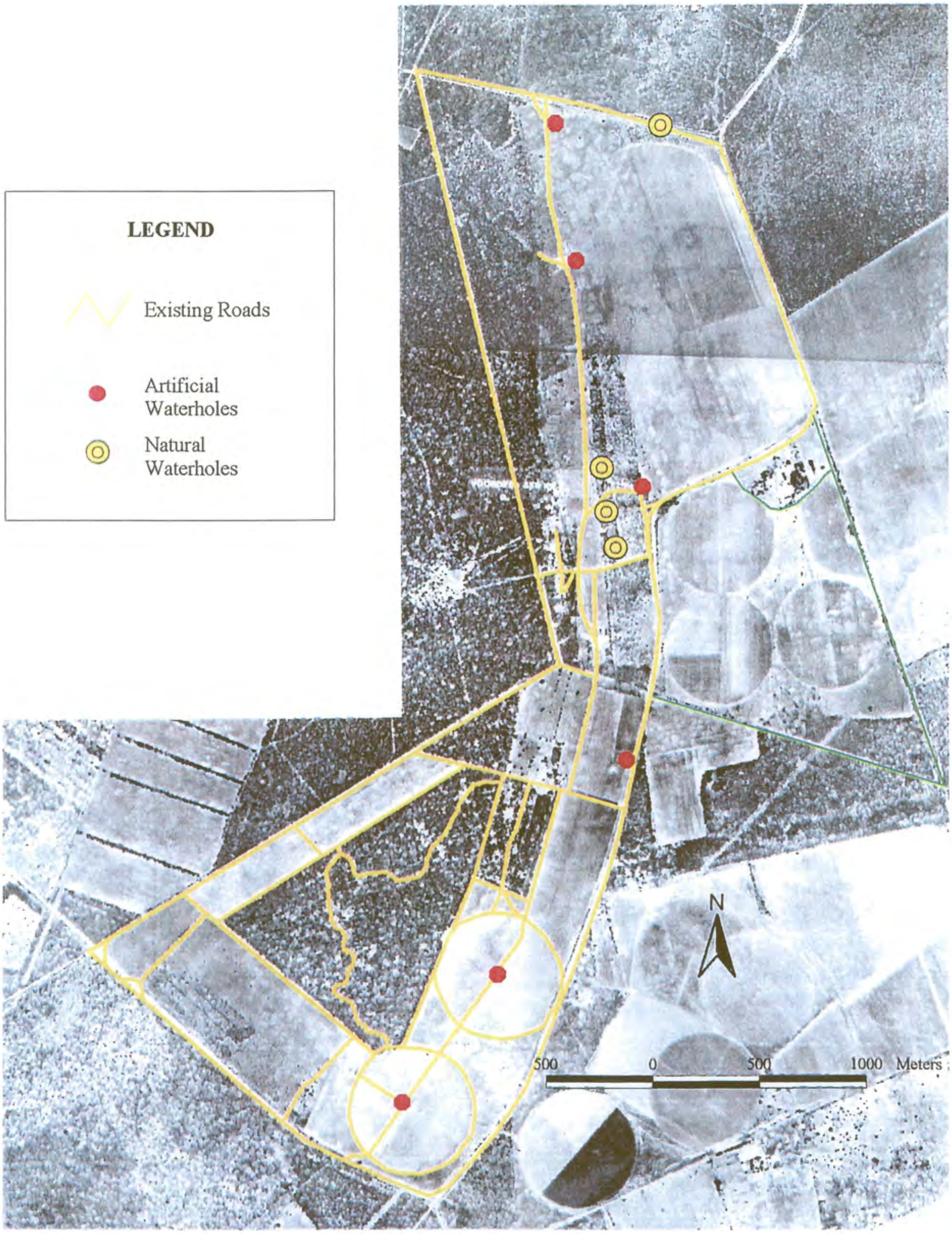

Figure 6: The Existing Road Network and Positions of Artificial and Natural Waterholes on the Conservation Unit, Cinergy Game Farm, Northern Province.

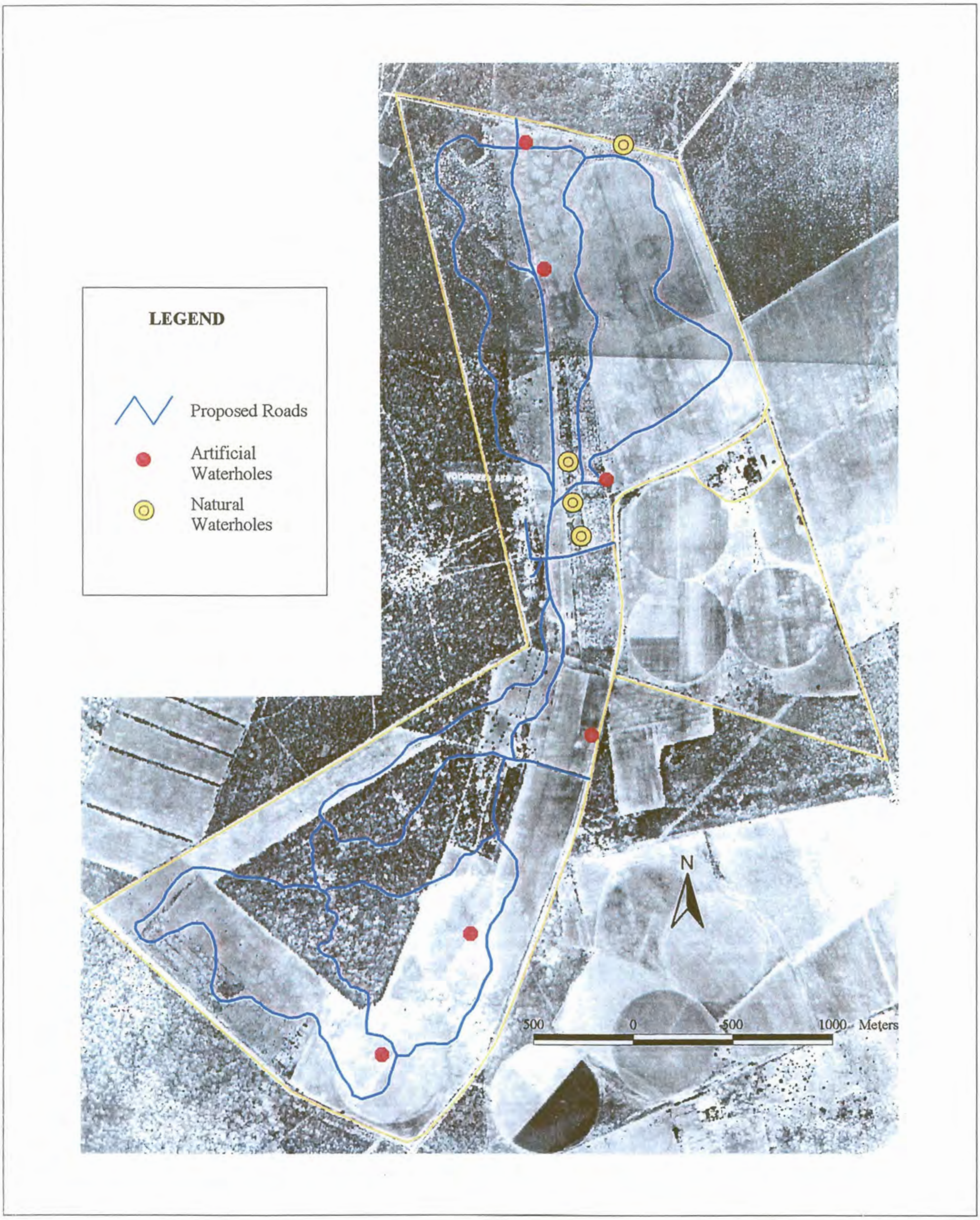

Figure 7: The Proposed Road Network and positions of Artificial and Natural Waterholes on the Conservation Unit, Cinergy Game Farm, Northern Province.

ratio of individuals that should be removed. Ecological opinion with a theoretical background, genetic considerations, the population biology and social structure of the selected species all needs to be considered when adding or removing wildlife from the Conservation Unit.

Leisure activities for the owner and his family on the Conservation Unit are in accordance with Objectives 3 & 5. Emphasis should be placed on non-intrusive eco-tourism activities which include hiking, horse riding, wildlife photography and game viewing. The establishment of hiking- and / or horse riding trails within the Conservation Unit should be done in accordance with the standards set out for the management of the road system on the Conservation Unit. Game viewing hides can be build at the water holes. The positioning of these hides should be of such a nature that they will not intrude on game visiting the water holes. At the same time the maximum benefit should be obtained by photographers and game viewers. Leisure activities must always be conducted so as to never harass or intimidate the wildlife. This should ensure that animals become habituated to vehicles and horses, rather than becoming habituated to humans. Enforcing these issues within the Conservation Unit will increase the safety of humans and wildlife alike.

Management level 6

Management level 6 includes the Conservation Unit of the Cinergy Game Farm with its surrounding areas. Management actions suggested at level 6 of the hierarchal management framework fulfil the requirements set out in Objectives 1 & 3. Issues regarding management decisions and tactics include the control of exotic animals and plants entering the Conservation Unit and the facilitation for dispersal of selected indigenous species. These issues are closely related, since the first deals with preventing individuals from entering the Conservation Unit and the second promotes the movement of individuals between the Conservation Unit and its neighbours.

The initial removal of exotic vegetation from the Conservation Unit has been discussed at management level 1 of the hierarchal management framework. It is, however, only treating the effect and not the cause of the exotic vegetation problem. The cause lies partly with neighbouring areas outside the Conservation Unit serving as source pools. A concerted effort should be undertaken to involve and assist neighbouring properties, so as to remove and eradicate invasive exotic plants. The continuos inspection of the Conservation Unit, in order to detect the establishment of such exotic plants is essential if further infestations are to be avoided.

Anti-poaching patrols should have the capacity to control all exotic elements coming into the Conservation Unit. This should be done in accordance with National and Provincial legislation. Good neighbour relations are an essential component to the successful execution of management actions at this level of the hierarchal management plan. Promoting the control of unwanted animals to neighbouring landowners will assist in the conservation efforts to protect wildlife within the Conservation Unit.

Several species occurring on the Conservation Unit (eg. porcupine, aardvark, black-backed jackal and warthog) may have territories or home ranges that extend beyond the Conservation Unit. Ideally individuals should be able to disperse freely so as to improve population viability. However, this ideal can not be achieved under game ranching conditions typical of the study area, especially when considering the economic realities of game ranching. The 10 feet high game fence surrounding the Conservation Unit may prevent certain small and medium size animals (eg. porcupine, aardvark, black-backed jackal and warthog) from dispersing. Establishing opportunities for these animals to move freely between the Conservation Unit and its neighbours, without imposing a security risk, is indeed a challenge to any conservation management team. The establishment of a conservancy amongst landowners should be one of the ultimate goals in alleviating species specific range sizes and the population dynamics problem. Increasing the spatial scale will also increase the viability of an ecological entity. A temporary solution includes inserting funnels large enough to accommodate medium size animals, allowing them to move between the Conservation Unit and it's neighbouring properties. This does however increase the probability of exotic animals entering the Conservation Unit. Neighbouring landowners must therefore be in agreement with the management of the Conservation Unit when finding solutions to eradicate exotic elements such as feral dogs and cats and allow for free movement of indigenous game.

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APPENDIX 1

Preliminary Conservation Management Plan for the Proposed Cinergy Conservation Unit[2]

Objectives

- To contribute to the conservation ethic by consolidating land previously exposed to land use practises such as game farming, cattle ranging and other agricultural activities into a singular conservation unit with characteristics typical of an indigenous, self-sustaining natural system.
- To restore the consolidated unit to a singular ecosystem where natural and indigenous processes with faunal and floral elements typical of an natural ecosystem prior to disturbances evoked through agriculture, dominate.
- To develop a conservation ethic amongst all stakeholders so as to enhance and maintain biological diversity[3] through a pro-active conservation management operation.
- To develop a self-sustaining game breeding enterprise which will supply for some of the needs of other animal breeders and conservationists.
- To enact and maintain some self-sustaining, non-invasive leisure activities to the benefit of the owners and their families without interfering with the maintenance of ecological processes that will restore and maintain ecosystem viability, resilience, resistance and variability.

The Conservation Management Paradigm

The consolidation of land privately owned and managed by several landowners into a single unit set aside for some land use activities other than crop production and intensive cattle ranging, provides an opportunity to develop a unit that will fulfill the conservation[4] ethic without

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[2] Following earlier discussions with Dave Alexander this unit may include sections of the present Cinergy Farm and Mosdene west of the Boekenhout road and with the inclusion of another adjoining property may extend over an area of 6 000 ha.

[3] Biological diversity refers to the diversity of species, variability within species, and the diversity of ecological processes which ensures ecosystem resistance and resilience

[4]Conservation here reflects on all actions taken to ensure the maintenance of biological diversity for future generations. These actions may include restoration of land, species populations and community

distracting from popular environmentally orientated commercial activities such as animal breeding. Considering the objectives listed above, management plans which will meet with the needs of the owners need to be develop. Conceptually such a management plan needs to comprise the following;-

- An operational framework for setting and evaluating attainable and acceptable goals.
- A predictive modelling framework through which the outcomes of the operational framework can be predicted.
- A response framework through which response of the system to the operational framework can be monitored and be responded too.

Each of these frameworks may consist of several processes, the details of which should be developed and agreed upon by all parties involved. The processes in turn comprise a number actions which usually are taken care of through day to day operational activities. Day to day operational activities need to be continually evaluated without deviated from the management plan. However, the management plan in itself be upgraded or altered with the consent of all parties involved.

Modern day conservation and the goal(s) of conservation management practised by private landowners have shifted from game farming and the management of species for their intrinsic values to managing them for their roles in ecosystem function. Emphasis is no longer placed on conserving "states" but rather on maintaining and enhancing processes delivering states. This shift or change most probably arose from the realisation that cost effective conservation management relies on the manager activating and maintaining natural processes rather than continually modifying them. Conservation management based on the activation and maintenance of natural processes also have the benefit of enhancing resistance and resilience of the system. Conceivably such management needs to be based on accepting and reinstating natural regimes of local change resulting from local or regional disturbances.

Natural systems are predisposed to such natural regimes of disturbances, while disturbances brought about by man more often than not are of scales and intensities beyond the

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structure and function, sustainable development and sustainable use.

resilience of these systems.

Conservation management aiming at the maintenance of natural processes depends on the application of a suite of ecological principles ranging from spatial and temporal dynamics to metapopulation theory. These principles are well beyond agriculturally[5] based game farming exercises and accordingly rather demanding on the manager. However, several benefits are to be accrued from management directed at correcting rather than modifying natural systems, the most important thereof being the development and maintenance of resilience, resistance to stochastic disruptions through enhanced spatial and temporal variability.

The amalgamation of land in view of establishing a conservation unit provide opportunities to restore such land to a predetermined state through the activation and manipulation of natural processes. However, such restoration[6] requires the setting of clear objectives and goals and a plan through wich these objectives and goals can be achieved. A plan directed at achieving conservation related objectives and goals requires a knowledge base of the system to be conserved and of the ecological principles to be applied to achieve the conservation objectives and goals. The setting of a management plan allows one to delineate activities but may be continually changed to achieve the objectives and goals of the conservation action.

Cinergy and other properties in a Conservation Management Setting

Existing development on the farm Cinergy, its location, area, and the ideals expressed during extended discussions gave rise to the objectives listed above. The land use options embodied in the objectives resulted in the portion of the farm west of the provincial road being developed into a conservation unit.

The amalgamation of adjacent properties with the exiting Cinergy Conservation Unit (CCU) will preferentially be based on extending the objectives, and where applicable management and action plans of the former, to include the Total Conservation Unit (TCU). The objectives of the TCU will thus be directed at restoring and maintaining biological diversity within the limits imposed by space, time and financial resources, with emphasis on the Unit being managed as a

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[5] Agricultural based activities centres on the promotion of productivity, usually at the cost of diversity and accordingly system resilience and resistance.

[6] Restoration refer to actions taken to recover the compositional, structural and functional properties of an indigenous, self-sustaining natural system. It usually involves the activation of natural processes by aiding local colonisation and extinction.

singular entity, taking cognisance of the different stages of successional development that exists on the different properties at he time of amalgamation. Accordingly conservation management will involve the following:-

- The consolidation of relevant properties into a singular fenced in unit with indigenous animals on all the properties freely intermingling.
- The enclosing of all dwellings used for housing so as to minimize negative man-animal interactions.
- The establishment and maintenance of an effective anti-poaching campaign.
- The establishment and maintenance of an effective fire control operation.
- The establishment and maintenance of an effective programme to control invasive exotic plants.
- The evaluation of field conditions and potential ecological carrying capacity of the TCU.
- The establishment, maintenance and management of viable wildlife populations to enhance field recovery and to maintain it at acceptable transitional stages and states.
- The establishment of a field management programme through the restoration of ecological processes, including acceptable disturbance regimes resulting from selective grazing, controlled bush clearing, controlled fire and selective maintenance of water holes.
- The maintenance of a road network that will have minimal impact on ecological processes affected by spatial variables, thereby minimizing edge effects.
- The development of a programme that will enhance the conservation ethic through participation in selected and controlled educational and recreational activities.

Rudi van Aarde
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18 May 1999

APPENDIX 2

Braun-Blanquet table for the vegetation type classification for the Conservation Unit, Cinergy Game Farm, Northern Province.

Species	Relevè number																						
	1	2	6	8	21	22	11	20	12	4	5	13	14	23	10	15	16	17	19	3	7	9	18
Acacia nilotica	a	a	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Acacia tortillis	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	a	.	.	.	.	.	.
Acacia gerrardii	+	a	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Aristida bipartita	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Aloe transvaalensis	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Euclea undulata	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Rhus leptodictya	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ziziphus mucronata	+	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.
Brachylaena neriifolia	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Brachiaria nigropedata	3	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Dich cine s. afri var.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Aloe greatheadii	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Blepharis species	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Grewia occidentalis	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Pentarrhinum insipidum	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Senecio barbertonicus	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Vernon poskea s. botsw	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Phyllanthus species	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Tapinanthus species	+	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Becium obovatum	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.
Sporobolus ioclados	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Eragrostis curvula	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Tragus berteronianus	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Boscia foetida	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Commelina africana	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cordia monoica	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Kalanchoe rotundifolia	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Viscum rotundifolium	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ximenia americana	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Blepharis integrifolia	.	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.
Hibiscus pusillus	.	+	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	.	.	.
Combretum zeyheri	.	.	a	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Triraphis andropogonoides	.	.	+	a	b	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Grewia flavescens	.	.	+	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ehretia rigida	.	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.
Ochna pulchra	.	.	+	+	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Combretum molle	.	.	+	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Strychnos pungens	.	.	+	+	.	+	+	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.

Senecio species	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Euclea undulata	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.
Acacia mellifera	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Acacia caffra	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Vangueria infausta	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Dombeya rotundifolia	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Bauhin peters s. macra	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Dombeya rotundifolia	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Lannea discolor	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Maytenus heterophylla	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Pollichia campestris	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Justicia species	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Asparagus laricinus	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Eragrostis gummiflua	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Kalanchoe paniculata	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Olea europa s. africa	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Peltophorum africanum	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.
Bulbostylis hispidula	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.
Dichrostachys cinerea	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.
Strychnos cocculoides	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Solanum incanum	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Rhus pyroides	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cassine transvaalensis	.	+	+	+	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Carissa bispinosa	.	+	+	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Asparagus suaveolens	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.
Opuntia ficus-indica	.	+	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.
Perotis patens	.	.	.	.	.	.	1	+	.	a	b	1	.	a	.	+	.	.	.	.	.	.	.
Pogonarthria squarrosa	.	.	.	.	.	.	+	.	a	a	1	a	b	1	1	.	.	.	.	.	.	.	.
Andropogon chinensis	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Aristi canesc s. canes	.	.	.	.	.	.	1	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.
Cucumis zeyheri	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Diheteropogo amplecten	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Merremia tridentata	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Pygmaeothamnus zeyheri	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ipomoea species	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ochna pulchra	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Eragro lehman v. chaun	.	.	.	.	.	.	.	a	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Acacia mellifera	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Peltophorum africanum	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Spirostachys africana	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Aristi stipit s. graci	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Acrotome species	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Dich cine s. afri var.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Terminalia sericea	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Tephrosia lupinifolia	.	.	.	.	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.
Hyperthelia dissoluta	.	.	.	.	.	.	.	.	.	+	a	.	.	3	.	.	.	.	.	.	.	.	.

Waltheria indica	.	.	.	+	.	.	.	.	.	+	+	+	+	.	.	.	.	.	.	.	.	.	.
Dichrostachys cinerea	.	.	.	.	.	.	.	.	.	.	+	+	1	.	.	.	+	.	.	.	.	.	.
Indigofera daleoides	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.
Indigofera filipes	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Sclero birrea s. caffr	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Babiana hypogea	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Panicu colora v. color	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Ziziphus mucronata	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Aristi stipit s. stipi	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.
Aristida diffusa	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.
Ochna pulchra	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.
Strychnos pungens	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.
Fadogia homblei	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.
Acacia gerrardii	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.
Conyza albida	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.
Sclerocarya birrea	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.
Digitaria brazzae	.	.	b	.	.	3	3	3	.	a	.	+	.	.	.	.	.	.	.	.	.	.	.
Burkea africana	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.
Bidens bipinnata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.
Lopholaena coriifolia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.
Myrica species	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.
Nidore resedi s. resed	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.
Zinnia peruviana	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.
Cleome species	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.
Merremia species	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.
Ochna pulchra	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	b	.	.	.	.	.	.	.
Indigofera species	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	+	.	.
Maytenus senegalensis	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	+	.	.	.	.	.	.	.
Agathisanthemum bojeri	.	.	.	.	.	.	.	+	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.
Eragrostis pallens	.	.	.	3	4	4	b	.	.	b	.	3	.	b	1	4	.	.	.	.	.	.	.
Aristida stipitata	.	.	.	+	.	.	1	.	.	.	+	.	.	.	+	b	.	.	.	.	.	.	.
Securidaca longepedunc	.	.	.	+	+	+	.	.	.	.	+	.	.	+	+	.	.	.	.	.	.	.	.
Vernonia poskeana	.	.	.	.	.	.	.	.	+	+	+	.	+	.	+	.	.	.	.	.	.	+	.
Burkea africana	.	.	.	.	+	+	.	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.
Schkuhria pinnata	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	.	+	+	.	.	.
Acacia karroo	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	a	.	.	.	.
Acacia niloti s. kraus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	a	.	.	.	.
Sporobolus africanus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	1	.	.	.	.
Hirpicium species	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.
Brachiaria brizantha	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.
Gomphocarpus fruticosu	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.
Osteospermum montanum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.
Solanum panduriforme	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.
Citrullus species	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.
Acacia tortil s. heter	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.
Abutilon austro-afric	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.

Enneapogon scoparius	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.
Lippia javanica	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.
Achyranthes species	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.
Cucumis hirsutus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	.	.	.	.	.
Sida cordifolia	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.
Acacia nilotica	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	.	.	+	.	.	.	.	.
Acacia tortillis	.	.	.	.	.	.	.	+	.	.	+	.	.	.	.	.	.	+	.	.	.	.	.
Terminalia sericea	.	.	b	+	a	a	1	+	.	+	.	.	.	+	+	+	.	+	.	.	.	.	.
Aristida canescens	.	.	1	.	.	.	.	.	3	b	.	.	.	.	1	.	1	.	a	.	.	.	.
Eragrostis lehmanniana	.	.	a	+	1	.	.	.	1	1	a	a	b	1	a	.	+	1	+	.	.	.	.
Heteropogon contortus	b	.	.	.	1	.	1	.	.	.	.	.	.	.	.	.	.	+	3	.	.	.	.
Digitaria eriantha	b	.	.	b	.	.	.	.	.	.	b	1	.	1	3	.	.	+	.	.	.	.	.
Eragrostis heteromera	b	1	.	+	a	.	.	.	1	.	a	.	.	.	.	1	1	.	.	.	.	.	.
Aristida congesta	1	.	.	.	1	.	.	1	a	a	1	1	b	b	a	a	.	1	.	.	.	.	.
Eragrostis rigidior	1	.	1	+	.	.	.	.	.	.	.	1	1	.	.	.	.	a	.	.	.	.	.
Panicum coloratum	1	3	4	b	a	b	+	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.
Dichrostachys cinerea	.	+	+	+	+	.	+	+	.	.	.	.	.	+	.	.	.	.	+	.	.	.	.
Hibiscus trionum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	+	+
Panicum schinzii	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.
Digitaria argyrograpta	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	a	.	.
Chloris virgata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	a	.
Eleusine coracana	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Datura ferox	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	a
Datura stramonium	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	a
Xanthium spinosum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
Xanthium strumarium	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
Cucumis species	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Crotalaria species	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	.	.	+	+	.
Melinis repens	.	.	.	.	.	.	.	+	.	.	.	1	a	.	.	.	.	1	.	+	.	.	.
Tagetes species	.	.	.	.	.	.	+	.	.	.	.	.	+	.	.	.	.	.	+	a	b	+	1
Urochloa mosambicensis	.	1	.	.	.	.	.	a	.	.	1	.	b	.	.	.	3	3	b	.	.	.	+
Cynodon dactylon	b	.	.	.	.	.	b	3	3	b	3	3	b	a	3	.	4	3	3	4	5	.	12

APPENDIX 3

DETAILS REGARDING THE USE OF INFRARED TRIGGERED CAMERAS

An infrared triggered camera can be used in the study of animals within their natural habitat. Movements around their burrows, access points to waterholes, potential feeding sites and their utilization of active game trails can be surveyed using this equipment. Shy and nocturnal animals not frequently observed by researchers, can now be photographed, their movements monitored, individuals identified, social interactions observed and populations studies conducted. The following is a description of the successes and problems experienced through the study conducted in 1999 on the Conservation Unit of the Cinergy farm.

A TM 1500 TrailMaster (Goodson and Associates Inc., Lenexa, Kansas) was used to trigger a Yashica T5D 35mm camera with built-in flash (Kyocera Corporation, Tokyo, Japan). ISO 200 camera film (12 exposure colour print) was used. The TrailMaster 1500 consists of a transmitter and receiver. The transmitter and receiver were secured on movable tripods. The transmitter then, when aligned correctly to the receiver, transmitted an infra-red beam to the receiver. The infra-red beam between the transmitter and receiver must not experience any interference from leaves or twigs. The camera was positioned to focus on the area between the transmitter and receiver.

The transmitter was connected to a camera with a transmitter cable. The transmitter and receiver were positioned in such a manner to activate the camera automatically as soon as the infrared beam is broken by an animal. Care should be taken as to not have the transmitter cable in front of the lens of the camera. The cable should furthermore not interfere with either the access route of an animal, or trigger the infrared beam.

The active time period was set from 30 minutes before dusk until 30 minutes after dawn. The active time period should be decided according to the animal that one considers to be photographed. The delay setting (the time that the beam must be broken before the camera will be activated), the time laps (the time between two consecutive photographs taken) and the positioning of the transmitter and receiver were changed according to the species expected to be photographed. The delay time for larger animals was set at 1,5 seconds, and for smaller game down to 0,5 seconds. The time laps varied between 30 and 60 seconds to prevent all the photographs used on one individual. The Trailmaster 1500 recorded the time and date at every incidence when the infra-red beam was broken.

The camera recorded the date and time of exposure on the photographs. The camera film was replaced when necessary. After the equipment was setup and tested, the area was evacuated. Daily inspection of the equipment was done from a distance to avoid any unnecessary disturbance. Care should be taken to minimize human disturbance as much as possible around the camera setup and intended photographing area. Sufficient time should also be allocated after setting up the equipment to allow for the human scent and other disturbances to disappear.

Only a single camera setup was used during this study period. Although initial success was achieved, for instance at the first porcupine burrow, subsequent camera setups failed to deliver any photographs of animals. This problem could be alleviated with using more cameras and infrared beam setups in order to cover all the different entrances of the single burrow system. The failure to photograph any aardvark could be ascribed to the same problem. Access routes to waterholes via the game trails, also needs more than a single camera setup.

The quality of all the photographs were sufficient to identify all the animals to species level. Some difficulty were experienced in sexing individuals due to bad positioning of the animal or the camera not being directed perfectly in the line with the animal movements. Identifying individual markings of the individuals will ultimately depend on the quality of the photographs. Anticipating the correct animal for a specific study is essential for determining the delay setting, as well as the time laps settings of the transmitter and cameras. Smaller and faster moving animals will have shorter delay settings, as well as shorter time lap periods than the larger slower moving animals.

The time period of four days for the camera setup was to short. It is possible that the animals were not given adequate time to become habituated to the camera setup, and subsequently shied away from it. Longer exposure periods to the animals might improve results. It is also important to note that the stands used for the transmitter, receiver and camera could be used as rubbing posts for the white rhinoceros and scent marking spots for territorial animals. These actions can potentially ruin the operation. Care should therefore be taken when positioning the camera equipment, especially around waterholes and game trails.

APPENDIX 4

Mammal species recorded from April 1999 until September 1999 on the Conservation Unit, Cinergy Game Farm, Northern Province.

Family	Species	English name	Afrikaanse naam
SORICIDAE	*Crocidura sp.*	Shrew	Skeerbekmuis
SORICIDAE	*Elephantulus branchyrynchus*	Short-snouted elephant-shrew	Kortneus klaasneus
CERCOPITHECIDAE	*Cercopithecus aethiops*	Vervet monkey	Blouaap
LEPORIDAE	*Lepus saxatilis*	Scrub hare	Kolhaas
HYSTRICIDAE	*Hystrix africaeaustralis*	Cape porcupine	Kaapse ystervark
SCIURIDAE	*Paraxerus cepapi*	Tree squirrel	Boomeekhoring
PETETIDAE	*Pedetis capensis*	Springhare	Springhaas
MURIDAE	*Mastomys coucha*	Natal multimammate mouse	Natalse vaalveldmuis
	Tatera leucogaster	Bushveld gerbil	Bosveldse nagmuis
	Tatera brantsii	Highveld gerbil	Hoëveldse nagmuis
	Dendromus melanotis	Grey climbing mouse	Grysklimmuis
HYAENIDAE	*Hyaena brunnea*	Brown hyaena	Bruin Hyena
CANIDAE	*Canis mesomelas*	Black-backed jackal	Rooijakkals
MUSTELIDAE	*Mellivora capensis*	Honey badger	Ratel
VIVERRIDAE	*Galerella sanguinea*	Slender mongoose	Swartkwasmuishond
	Mungos mungo	Banded mongoose	Gebande muishond
RHINOCEROTIDAE	*Ceratotherium simum*	White rhinoceros	Witrenoster
EQUIDAE	*Equus burchelli*	Burchell's zebra	Bontsebra
SUIDAE	*Potamochoerus porcus*	Bushpig	Bosvark
	Potamochoerus aethiopicus	Warthog	Vlakvark
BOVIDAE	*Alcelaphus buselaphus*	Red hartebeest	Rooihartebees
	Silvicapra grimmia	Common duiker	Gewone duiker
	Raphicerus campestris	Steenbok	Steenbok
	Aepyceros melampus	Impala	Rooibok
	Syncerus caffer	African buffalo	Afrikaanse buffel
	Tragelaphus strepsiceros	Kudu	Koedoe
	Taurotragus oryx	Eland	Eland

Bird species recorded from April 1999 until September 1999 for the Conservation Unit, Cinergy Game Farm, Northern Province.

Family	Species	English name	Afrikaanse naam
Struthionidae	*Struthio camelus*	Ostrich	Volstruis
Ardeidae	*Ardea cinera*	Grey Heron	Bloureier
	Ardea melanocephala	Blacheaded Heron	Swartkopreier
	Bubulcus ibis	Cattle Egret	Veereier
Scopidae	*Scopus umbretta*	Hamerkop	Hamerkop
Plataleidae	*Bostrychia hagedash*	Hadeda Ibis	Hadeda
Anatidae	*Alopochen aegyptiacus*	Egyptian Goose	Kolgans
	Plectropterus gambensis	Spurwinged Goose	Wildemakou
Sagittaridae	*Sagittarius serpentarius*	Secretarybird	Sekretarisvoël
Accipitridae	*Elanus caeruleus*	Blackshouldered Kite	Blouvalk
	Circaetus cinereus	Brown Snake Eagle	Bruinslangarend
	Buteo rufofuscus	Jackal Buzzard	Rooiborsjakkelsvoël
Phasianidae	*Francolinus coqui*	Coqui Francolin	Swempie
	Francolinus sephaena	Crested Francolin	Bospatrys
	Francolinus swainsonii	Swainson's Francolin	Bosveldfisant
Numididae	*Numida meleagris*	Helmeted Guineafowl	Gewone Tarentaal
Turnicidae	*Turnix sylvatica*	Kurrichane Buttonquail	Bosveldkwarteltjie
Otididae	*Eupodotis ruficrista*	Redcrested Korhaan	Boskorhaan
Charadriidae	*Vanellus coronatus*	Crowned Plover	Kroonkiewiet
	Vanellus armatus	Blacksmith Plover	Bontkiewiet
Glareolidae	*Cursorius temminckii*	Temminck's Courser	Trekdrawwertjie
Pteroclidae	*Pterocles bicinctus*	Doublebanded Sandgrouse	Dubbelbandsandpatrys
Columbidae	*Streptopelia semitorquata*	Redeyed Dove	Grootringduif
	Streptopelia capicola	Cape Turle Dove	Gewone Tortelduif
	Streptopelia senegalensis	Laughing Dove	Rooiborsduifie
	Oena capensis	Namaqua Dove	Namakwaduifie
	Turtur chalcospilos	Emeraldspotted Dove	Groenvlekduifie
Musophagidae	*Corythaixoides concolor*	Grey Lourie	Kwêvoël

Cuculidae	*Cuculus solitarius*	Redchested Cuckoo	Piet-my-vrou
	Clamator jacobinus	Jacobin Cuckoo	Bontnuwejaarsvoël
	Centropus burchellii	Burchell's Coucal	Gewone Vleiloerie
Strigidae	*Otus leucotis*	Whitefaced Owl	Witwanguil
	Glaucidium perlatum	Pearlspotted Owl	Witkoluil
	Bubo africanus	Spotted Eagle Owl	Gevlekte Ooruil
Apodidae	*Apus affinis*	Little Swifts	Kleinwindswael
	Cypsiurus parvus	Pakm Swift	Palmwindswael
Coliidae	*Colius striatus*	Speckled Mousebirds	Gevlekte muisvoël
	Urocolius indicus	Redfaced Mousebird	Rooiwangmuisvoël
Alcedinidae	*Ceryle rudis*	Pied Kingfisher	Bontvisvanger
	Halcyon albiventris	Brownhooded Kingfisher	Bruinkopvisvanger
Coraciidae	*Coracias caudata*	Lilacbreasted Roller	Gewone Troupant
Upupidae	*Upupa africana*	African Hoopoe	Hoephoep
Phoeniculidae	*Phoeniculus purpureus*	Redbilled Woodhoopoe	Gewone Kakelaar
Bucerotidae	*Tockus nasutus*	Grey Hornbill	Grysneushoringvoël
	Tockus erythrorhynchus	Redbilled Hornbill	Rooibekneashoringvoël
	Tockus leucomelas	Yellowbilled Hornbill	Geelbekneushoringvoël
Lybiidae	*Lybius torquatus*	Blackcollared Barbet	Rooikophoutkapper
	Pogoniulus chrysoconus	Yellowfronted Tinker Barbet	Geelblestinker
	Trachyphonus vaillantii	Crested Barbet	Kuifkophoutkapper
Alaudidae	*Eremopterix leucotis*	Chestnutback Finchlark	Rooiruglewerik
Dicruridae	*Dicrurus adsimilis*	Forktailed Drongo	Mikstertbyevanger
Oriolidae	*Oriolus larvatus*	Blackheaded Oriole	Swartkopwielewaal
Paridae	*Parus niger*	Southern Black Tit	Gewone Swartmees
Timaliidae	*Turdoides jardineii*	Arrowmarked Babbler	Pylvlekkatlagter
Pycnonotidae	*Pycnonotus barbatus*	Blackeyed Bulbul	Swartoogtiptol
Turdidae	*Turdus libonyana*	Kurrichane Thrush	Rooibeklyster
	Turdus olivaceus	Olive Thrush	Olyflyster
	Turdus litsitsirupa	Groundscraper Thrush	Gevlekte Lyster
	Myrmecocichla formicifora	Anteating Chat	Swartpiek
	Erythropygia leucophrys	Whitebrowed Robin	Gestreepte Wipstert

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Sylviidae	*Parisoma subcaeruleum*	Titbabbler	Bosveldtjeriktik
	Sylvietta rufescens	Lonbilled Crombec	Bosveldstompstert
	Cisticola aridula	Desert Cisticola	Woestynklopkoppie
	Cisticola chiniana	Rattling Cisticola	Bosveldtinktinkie
	Cisticola fulvicapilla	Neddicky	Neddikkie
	Prinia subflava	Tawnyflanked Prinia	Bruinsylangstertjie
Muscicapidae	*Melaenornis pammelaina*	Black Flycatcher	Swartvlieëvanger
	Melaenornis mariquensis	Marico Flycatcher	Maricovlieëvanger
	Batis molitor	Chinspot Batis	Witliesbosbontrokkie
Motacillidae	*Anthus cinnamomeus*	Grassveld Pipit	Gewone Koester
	Anthus caffer	Bushveld Pipit	Bosveldkoester
	Lanius collaris	Fiscal Shrike	Fiskaallaksman
	Corvinella melanoleuca	Longtailed Shrike	Langstertlaksman
Malaconotidae	*Laniarus ferrugineus*	Southern Boubou	Suidelike Waterfiskaal
	Laniarus atrococcineus	Crimsonbreasted Shrike	Rooiborslaksman
	Tchagra senegala	Blackcrowned Tchagra	Swartkroontjagra
	Malaconotus blanchoti	Greyheaded Bush Shrike	Spookvoël
Prionopidae	*Prionops plumatus*	White Helmetshrike	Withelmlaksman
	Eurocephalus anguitimens	Whitecrowned Shrike	Kremetartlaksman
Sturnidae	*Lamprotornis australis*	Burchell's Starling	Grootglansspreeu
	Lamprotornis nitens	Glossy Starling	Kleinglansspreeu
Nectariniidae	*Nectarinia mariquensis*	Marico Sunbird	Maricosuikerbekkie
	Nectarinia talatala	Whitebellied Sunbird	Witpenssuikerbekkie
Zosteropidae	*Zosterops pallidus*	Cape White-eye	Kaapse Glasogie
Ploceidae	*Plocepasser mahali*	Whitebrowed Sparrowweaver	Koringvoël
	Sporopipes squamifrons	Scalyfeathered Finch	Baardmannetjie
	Quelea quelea	Redbilled Quelea	Rooibekkwelea
Estrildidae	*Pytilia melba*	Melba Finch	Gewone Melba
	Lagonosticta senegala	Redbilled Firefinch	Rooibekvuurvinkie
	Uraeginthus angolensis	Blue Waxbill	Gewone Blousysie
	Uraeginthus granatinus	Violeteared Waxbill	Koningblousysie
	Ortygospiza atricollis	Quail Finch	Gewone Kwartelvinkie

Fringillidae	*Serinus flaviventris*	Yellow Canary	Geelkanarie
	Emberiza tahapisi	Rock Bunting	Klipstreepkoppie

Plant species recorded from April 1999 until September 1999 for the Conservation Unit, Cinergy Game Farm, Northern Province.

Family	Species	English name	Afrikaanse naam
Cyperaceae	*Bulbostylis hispidula*		
Commelinaceae	*Commelina africana*	Yellow Commelina	Geeleendagsblom
Asphodelaceae	*Aloe greatheadii*	Grass Aloe	Grasaalwyn
	Aloe transvaalensis		
Asparagaceae	*Asparagus laricinus*	Cluster-leaved Asparagus	Bergkatbos
	Asparagus suaveolens	Bushveld Asparagus	Katdoring
Iridaceae	*Babiana hypogea*		
Myriaceae	*Myria sp.*		
Loranthaceae	*Tapinanthus rubromarginatus*	Red Mistletoe	Rooivoëlent
Visaceae	*Viscum rotundifolium*	Round-leaved Mistletoe	Voëlent
Olacaceae	*Ximenia americana*	Small Sourplum	Klein Suurpruim
Amaranthaceae	*Achyranthes sp.*		
Illecebraceae	*Pollichia campestris*	Waxberry	Teesuikerbossie
Papaveracea	*Argemone mexicana*	Yellow-flowered Mexican poppy	Geelblombloudissel
	Argemone subfusiformis	White-flowered Mexican poppy	Mexikaanse papawer
Capparaceae	*Cleome sp.*		
	Boscia foetida	Smelly Sheperd's tree	Stinkwitgat
Crassulaceae	*Kalanchoe paniculata*	Large Orange Kalanchoe	Hasie-oor
	Kalanchoe rotundifolia	Common Kalanchoe	Plakkie
Fabaceae	*Acacia caffra*	Common Hook-thorn	Gewone Haakdoring
	Acacia gerrardi	Red Thorn	Rooidoring
	Acacia karroo	Sweet Thorn	Soetdoring
	Acacia mellifera	Black Thorn	Swarthaak
	Acacia nilotica	Scented Thorn	Lekkerruikpeul
	Acacia tortillis	Umbrella Thorn	Haak-en-steek
	Dichrostachys cinerea	Sickle Bush	Sekelbos
	Burkea africana	Red Syringa	Rooisering
	Bauhinia pietersiana	White Bauhinia	Koffiebeesklou

	Peltophorum africanum	Weeping Wattle	Huilboom
	Crotolaria sp.		
	Indigofera daleoides		
	Indigofera filipes		
	Tephrosia lupinifolia		Vingerblaarertjie
	Arachis hypogea		
Meliaceae	*Melia azedarach*	Syringa	Maksering
Polygalaceae	*Securidaca longepedunculata*	Violet Tree	Krinkhout
Dichapetalaceae	*Dichapetalum cymosum*	Poison Leaf	Gifblaar
Euphorbiaceae	*Phyllantus sp.*		
	Spirostachys africana	Tamboti	Tambotie
Anacardiaceae	*Sclerocarya birrea*	Marula	Maroela
	Lannea discolor	Live-long	Dikbas
	Rhus leptodicta	Mountain Karee	Bergkaree
	Rhus pyroides	Common Taaibos	Gewone taaibos
Celastraceae	*Maytenus heterophylla*	Common Spike-thorn	Gewone pendoring
	Maytenus senegalensis	Confetti Tree	Bloupendoring
	Cassine transvaalensis	Transvaal Saffronwood	Transvaalsaffraan
Rhamnaceae	*Ziziphus mucronata*	Buffalo-thorn	Blinkblaar-wag-'n-bietjie
Tiliaceae	*Grewia flavescens*	Roughed-leaved Raisin	Skurweblaarrosyntjie
	Grewia occidentalis	Cross-berry	Kruisbessie
Malvaceae	*Abutilon austro-africanum*		
	Sida cordifolia	Flannelweed	Verdompsterk
	Gossypium herbaceum	Wild Cotton	Wildekatoen
	Hibiscus pusillus	Dwarf Hibiscus	
	Hibiscus trionum	Bladder Hibiscus	Terblansbossie
Sterculiaceae	*Dombeya rotundifolia*	Wild Pear	Drolpeer
	Waltheria indica		
Ochnaceae	*Ochna pulchra*	Peeling Plane	Lekkerbreek
Cactaceae	*Cereus peruvianus*	Queen of the night	Nagblom
	Opuntia ficus-indica	Prickly Pear	Turksvy
Combretaceae	*Combretum hereroense*	Russet Bushwillow	Kierieklapper

	Combretum molle	Velvet Bushwillow	Basterrooibos
	Combretum zeyheri	Large-fruited Bushwillow	Raasblaar
	Terminalia sericea	Silver Terminalia	Vaalboom
Ebenaceae	*Euclea undulata*	Common Guarri	Gewone ghwarrie
Oleaceae	*Olea europea*	Wild Olive	Swartolienhout
Loganiaceae	*Strychnos cocculoides*	Corky-bark Monkey Orange	Geelklapper
	Strychnos pungens	Spine-leaved Monkey Orange	Stekelblaarklapper
Apocynaceae	*Carissa bispinosa*	Num-num	Noemnoem
Asclepiadaceae	*Gomphocarpus fruticosus*		
	Pentarrhinum insipidum	African Heartvine	Donkieperske
Convolvulaceae	*Merremia tridentata*	Miniature Morning Glory	
	Ipomoea sp.		
Boraginaceae	*Cordia monoica*	Snot Berry	Snotbessie
	Ehretia rigida	Puzzle Bush	Deurmekaarbos
Vebenaceae	*Lippia javanica*		
Lamiaceae	*Acrotome sp.*		
	Becium obovatum	Cat's Whiskers	Katsnor
Solanaceae	*Solanum incanum*	Thorn Apple	Gifappel
	Solanum panduriforme	Bitter Apple	Bitterappel
	Datura ferox	Large Thorn-apple	Grootstinkblaar
	Datura stramonium	Common Thorn-apple	Olieboom
Bignoniaceae	*Jacaranda mimosifolia*	Jacaranda	Jakaranda
Acanthaceae	*Blepharis integrifolia*		Rankklits
	Justicia sp.		
Rubiaceae	*Agathisanthemum bojeri*		
	Vangueria infausta	Wild Medlar	Wildemispel
	Pygmaeothamnus zeyheri		
	Fadogia homblei		
Cucurbitaceae	*Citrullus sp.*		
	Citrullis rehmii		
	Cucumis hirsutus	Wild Cucumber	Suurkomkommertjie
	Cucumis zeyheri	Wild Cucumber	Wildekomkommertjie

Astaraceae	*Vernonia poskeana*		
	Nidorella resedifolia		
	Conyza albida		
	Brachylaena neriifolia		
	Xanthium spinosum	Spiny Cocklebur	Boetebossie
	Xanthium strumarium	Cocklebur	Kankerroos
	Zinnia peruviana	Redstar Zinnia	Wildejakobregop
	Bidens bipinnata	Spanish-Blackjack	Knapsekêrel
	Schkuhria pinnata	Dwarf marigold	Kleinkakiebos
	Tagetes minuta	Tall Khaki Weed	Kakiebos
	Lopholaena coriifolia		
	Senecio barbetonicus	Succulent Bush Senecio	
	Osteospermum montanum		
	Hirpicium sp.		
Poaceae	*Andropogon chinensis*	Hairy Blue grass	Harige-blou gras
	Hyperthelia dissolata	Yellow Thatching grass	Geeltamboekiegras
	Heteropogon contortus	Spear grass	Assegaaigras
	Diheteropogon amplectens	Broad-leaved Bluestem	Breëblaarblougras
	Digitaria argyrograpta	Silver Finger grass	Silvervingergras
	Digitaria brazzae	Brown Finger grass	Bruinvingergras
	Digitaria eriantha	Common Finger grass	Vingergras
	Brachiaria brizantha	Common Signal grass	Broodsinjaalgras
	Brachiaria nigropedata	Blackfooted grass	Swartvoetjiegras
	Urochloa mosambicensis	Bushveld Signal grass	Bosveldbeesgras
	Panicum coloratum	Small Buffalo grass	Witbuffelsgras
	Panicum schinzii	Sweet Buffalo grass	Soetbuffelsgras
	Melinis repens	Natal Red top	Natal-rooipluim
	Aristida bipartida	Rolling grass	Grootrolgras
	Aristida canescens	Pale Three-awn	Vaalsteekgras
	Aristida congesta	Spreading Three-awn	Katstertsteekgras
	Aristida diffusa	Iron grass	Ystergras
	Aristida stipitata	Long-awned grass	Langnaaldsteekgras

Tragus berteronianus	Carrot-seed grass	Gewone Wortelsaadgras
Perotis patens	Cat's Tail	Katstertgras
Sporobolus africanus	Ratstail Dropseed	Taaipol
Sporobolus ioclados	Pan Dropseed	Panfynsaadgras
Eragrostis curvula	Weeping Love grass	Oulandsgras
Eragrostis gummiflua	Gum grass	Gomgras
Eragrostis heteromera	Bronze Love grass	Rooikopergras
Eragrostis lehmaniana	Lehmann's Love grass	Knietjiesgras
Eragrostis pallens	Broom Love grass	Besemgras
Eragrostis rigidor	Broad Curly Leaf	Breëkrulblaar
Cynodon dactylon	Couch grass	Kweek
Chloris virgata	Feather-top Chloris	Witpluim-chloris
Eleusine coracana	Goose grass	Osgras
Pogonarthria squarrosa	Herringbone grass	Sekelgras
Triraphis andropogonoides	Broom Needle grass	Perdegras
Enneapogon scoparius	Bottlebrush grass	Kalkgras
Zea mays	Maise	Mielies
Triticum aefticum	Wheat	Koring