ENVIRONMENTAL MANAGEMENT PLAN FOR THE WATERLAKE FARM LIFESTILE ESTATE

Waterlake farm
LIFESTYLE ESTATE

WILD ROUTE ENVIRONMENTAL CONSULTANTS CC
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BY

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

Every fenced game ranch should have a plan to guide its management and to ensure the effective use of its limited natural resources. The aim of an ecological management plan for a game ranch is to give scientifically based advice regarding the management options and recommendations. This will allow a sustainable use of the ranch without deterioration of the environment. When working in an uncertain and ever-changing environment like nature, where decisions are usually made before scientific proof can be obtained, a flexible and adaptive approach to management is needed. Key aspects of game and their habitat should be monitored so that trends will be noted in time, and management adjustments can be made accordingly.

South Africa have very good and comprehensive environmental laws in place. No development can take place without complying to the relevant Environmental Impact Assessment (EIA) laws. Although most of the global environmental assessment practice appears to be directed at the scoping and assessment stages of the EIA process, the mitigation, monitoring and management component of EIAs receive less attention. Attention is now being focused on the need to demonstrate that impacts can be monitored and managed. The Environmental Management Plan (EMP) is recognised as the tool that can provide the assurance that the project proponent has made suitable provisions for mitigation. The EMP is the document that provides a description of the methods and procedures for mitigating and monitoring impacts. It also contains environmental objectives and targets which the project proponent or developer needs to achieve in order to reduce or eliminate negative impacts. In reality, the implementation of the EMP, however, usually becomes the responsibility of the Home Owners Association (HOA) after the development is completed.

The development and implementation of a successful EMP has benefits beyond merely meeting legal obligations. It contributes to environmental awareness of the workforce, can facilitate the prevention of environmental degradation, and minimise impacts when they are unavoidable. The EMP also facilitates progress towards environmental targets and provides a tool for continual improvement of a company's environmental performance. After the construction phase of any large residential development, it is crucial to set up an EMP for the management of the remaining green zones or landscaped areas. Not only will this ensure that the conservation targets set during the construction and development phases are met, but also that the estate is managed in an environmentally friendly and sustainable manner.

Aspects that need to be included in the EMP is firstly the mapping of all the natural areas of the estate. These areas need to be surveyed in order to establish a baseline veldcondition and species composition. All areas also need to be surveyed for the presence of alien and invasive species. Fixed monitoring points should be marked in order to do repeat surveys. The EMP should also include a fire plan, water management plan and waste management / recycling plan. Guidelines and rules need to be included for the management of all species of fauna and flora found on the estate. A basic Environmental Management and Monitoring Programme should include the following aspects:

Fire, water & recycling plan

- Delineation and description of the vegetation units
- Determining of veldcondition
- Mapping and listing of alien plants (and animals)
- Management guidelines for application of fire as well as firebreaks
- Water management guidelines
- Waste management guidelines
- Vegetation monitoring Plan
- Ecological management year program

GENERAL OVERVIEW

The Waterlake Farm Estate is situated in the east of Pretoria on the Provincial road K631 on the farm Boschop 369 JR. a Topocadastral map of the farm is shown in **Figure 1**. The entire estate is approximately 218 hectare in size. Several old lands are still found on the farm and stables with camps are still in use for horses. These areas, and the areas where residential homes will be build will be excluded from the habitat study and only the areas where animals can roam freely will be surveyed. The planned layout of the estate is given in **Figure 2**.

The entire border of the property is fenced with a 2.4-meter electric fence with solar back-up and is sufficient to keep game in (**Figure 3**). Sufficient water is also provided on the farm through several earth dams and a water storage tank on the ridge for residential use (**Figure 4**). A sewerage plant is also present where waste water treatment is being done.

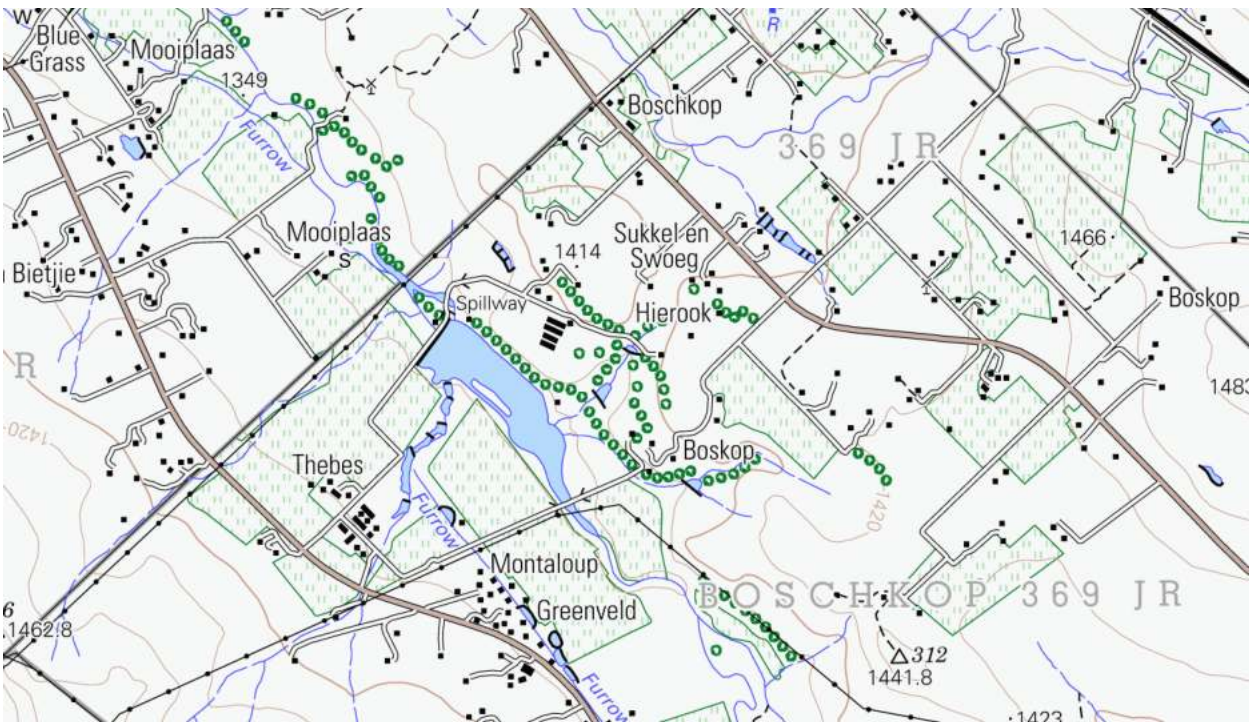

Figure 1: Topocadastral map of the Waterlake farm Estate

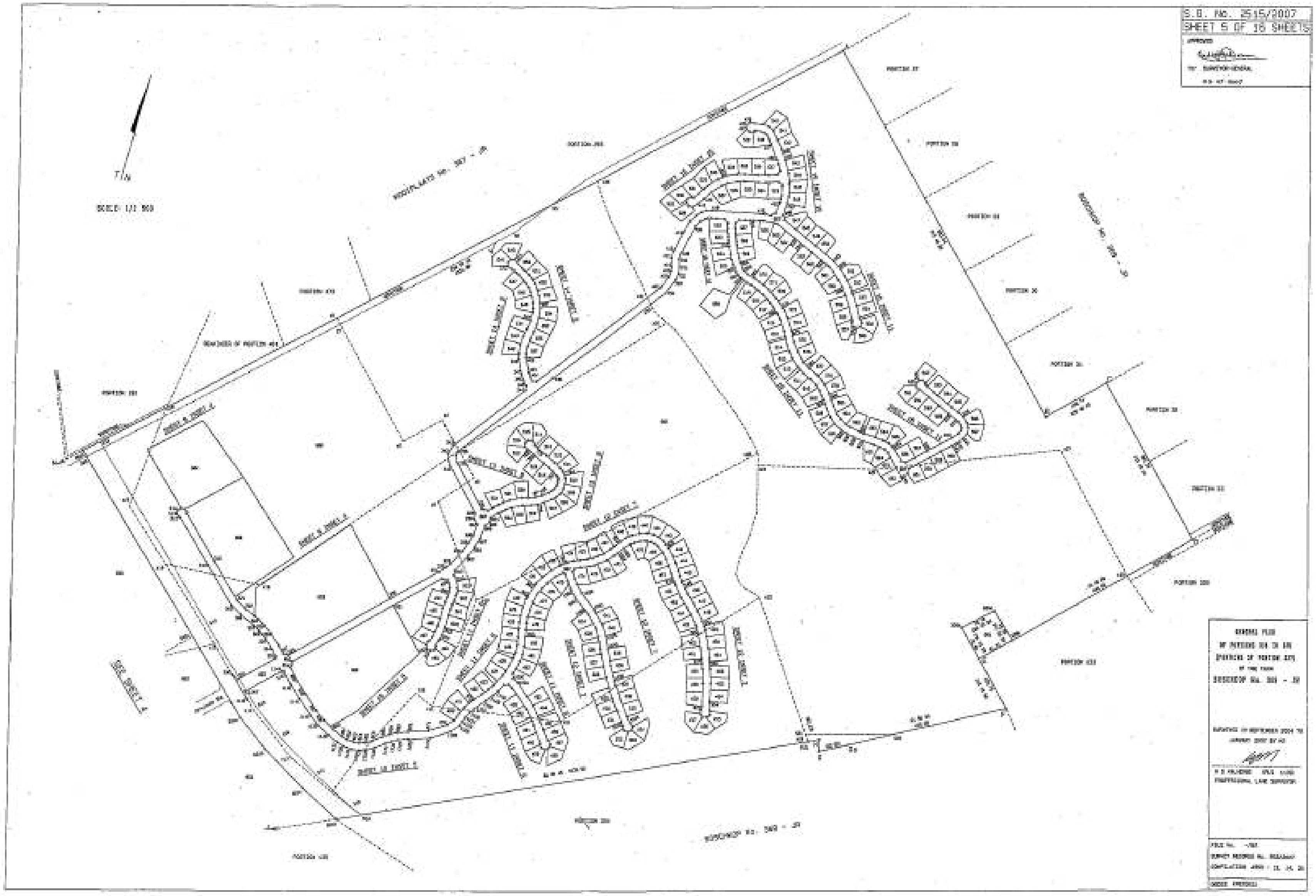

Figure 2: Layout of properties on the Waterlake farm Estate

Figure 3: The 2.4-meter game proof electric fence with solar back-up around the property

Figure 4: Samples of some of the many earth dams present on the farm

Physical geography, fauna and flora

The farm is located in the Savanna Biome. The Savanna Biome is the largest Biome in southern Africa, occupying 46% of its area, and over one-third of South Africa (Low & Rebelo 1998). Savanna is characterised by a grassy ground layer and a distinct upper layer of woody plants. Where the upper layer is near the ground the vegetation is sometimes referred to as Shrubveld, where it is dense, as Woodland, and the intermediate stages are locally known as Bushveld.

Within the Savanna Biome, altitudes range from sea level to 2000 meters above sea level, and rainfall are from 235 mm to 1000 mm per year. A major factor delimiting the biome is the lack of sufficient rainfall, which prevents the upper layer from dominating. Fires and grazing furthermore keeps the grass layer dominant and almost all species are adapted to survive fires, usually with less than 10% of plants killed by fire (Low & Rebelo 1998).

In general, the savanna regions of South Africa are the best game ranching area because of the large diversity of geology, soil, and vegetation types that can support a large diversity of grazers and browsers (Bothma 2002). In South Africa, the savanna vegetation type can be subdivided into four main types based on the floristic composition, namely:

- A fine-leaved or microphyllous type of savanna, which is dominated by *Acacia* species. It is found mostly on clayey soils, but also on the sands of the arid Kalahari region. These areas are generally known as sweetveld.
- A broad-leaved type of savanna, which is dominated by *Combretum* species and occurs mostly on sandy-loam soils of granitic origin. It is generally known as mixed or sourish-mixed bushveld.
- A mountain or sour bushveld type of savanna, which is dominated by broad-leaved species such as the wild seringa *Burkea Africana*, silver cluster-leaf *Terminalia sericea*, and Transvaal beech *Faurea saligna*.
- The mopane veld of Limpopo, which is dominated by the mopane *Colophospermum mopane*, the Lowveld cluster-leaf *Terminalia prunioides* and by species of the corkwood genus *Commiphora*.

According to Mucina & Rutherford (2006), the study area falls within the **Marikana Thornveld** (**SVcb 6**) (**Figure 5**). This vegetation type is found in the North-West and Gauteng Provinces and occurs on plains from the Rustenburg area in the west, through Marikana and Brits to the Pretoria area in the east. The vegetation is an open sweet thorn *Vachellia karroo* woodland, occurring in valleys and slightly undulating plains, and some lowland hills.

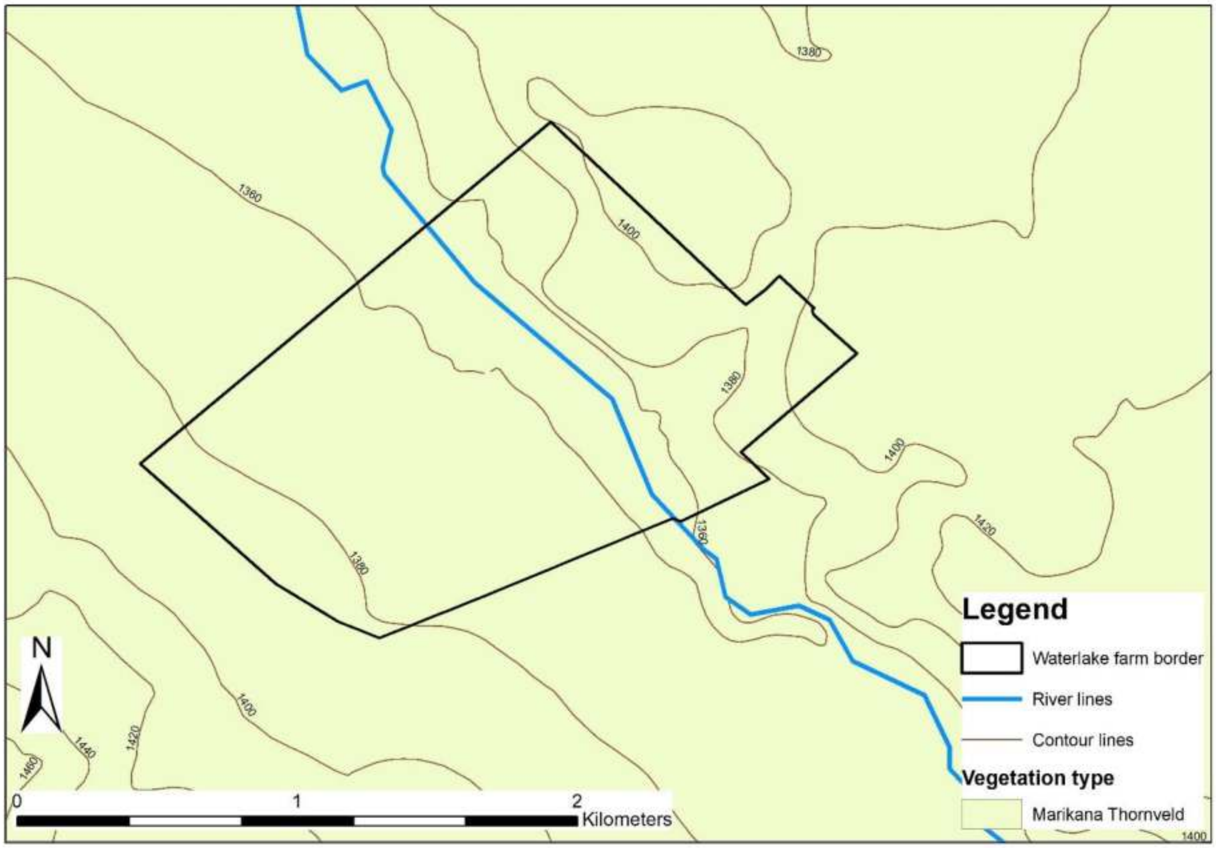

Figure 5: Vegetation types found on the farm

Shrubs are more dense along drainage lines, on termitaria and rocky outcrops or in other habitats protected from fire (Mucina & Rutherford 2006). In terms of geology, most of the area is underlain by the mafic intrusive rocks of the Rustenburg Layered Suite of the Bushveld Igneous Complex. To the south of the Pienaars River, Makolian dolorite is found, with Vaalian shale to the north (**Figure 6**). In terms of soils, this vegetation type mainly consists of vertic melanic clays with some dystrophic or mesotrophic plinthic catenas and some freely drained, deep soils. The entire farm is covered with red, yellow and greyish soils with a plinthic catena (**Figure 7**).

The climate consists of summer rainfall with very dry winters (Mucina & Rutherford 2006). The maximum annual precipitation (MAP) is between 600 mm and 700 mm. Frost is fairly frequent in winter and the mean monthly maximum and minimum temperatures as measured at the Pretoria University Experimental Farm in November and July is 32.8°C and -1.0°C (**Figure 8**). The mean annual rainfall for the Waterfall Farm Estate is 688 mm according to the weather bureau.

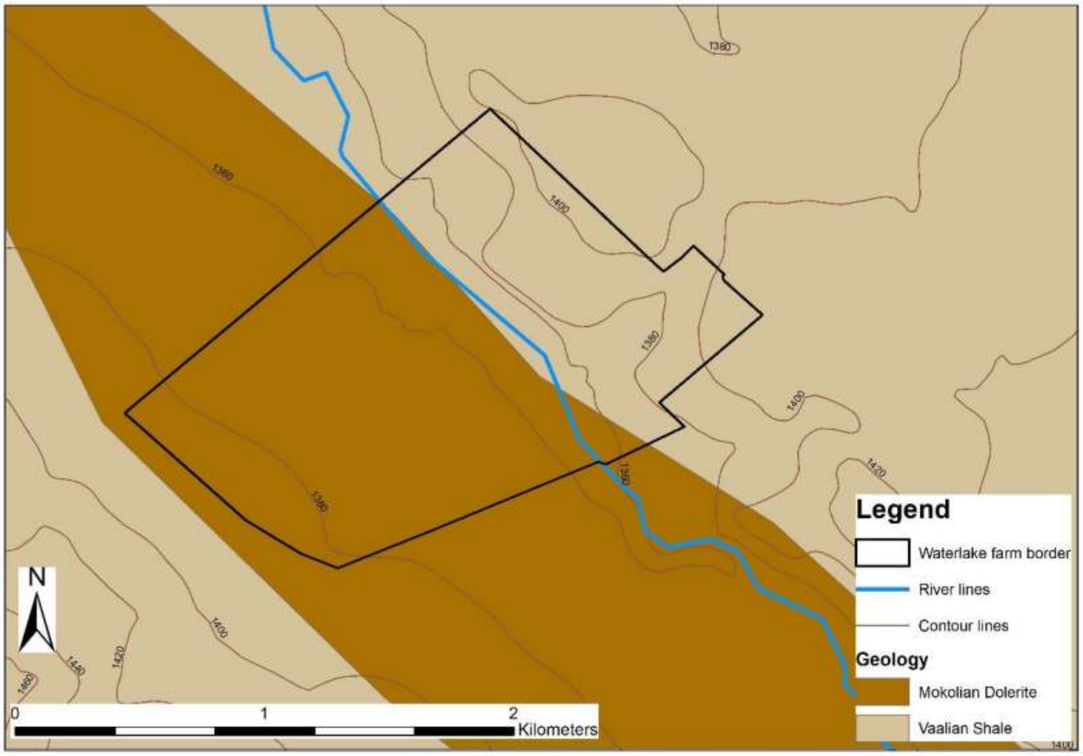

Figure 6: Geology found on the farm

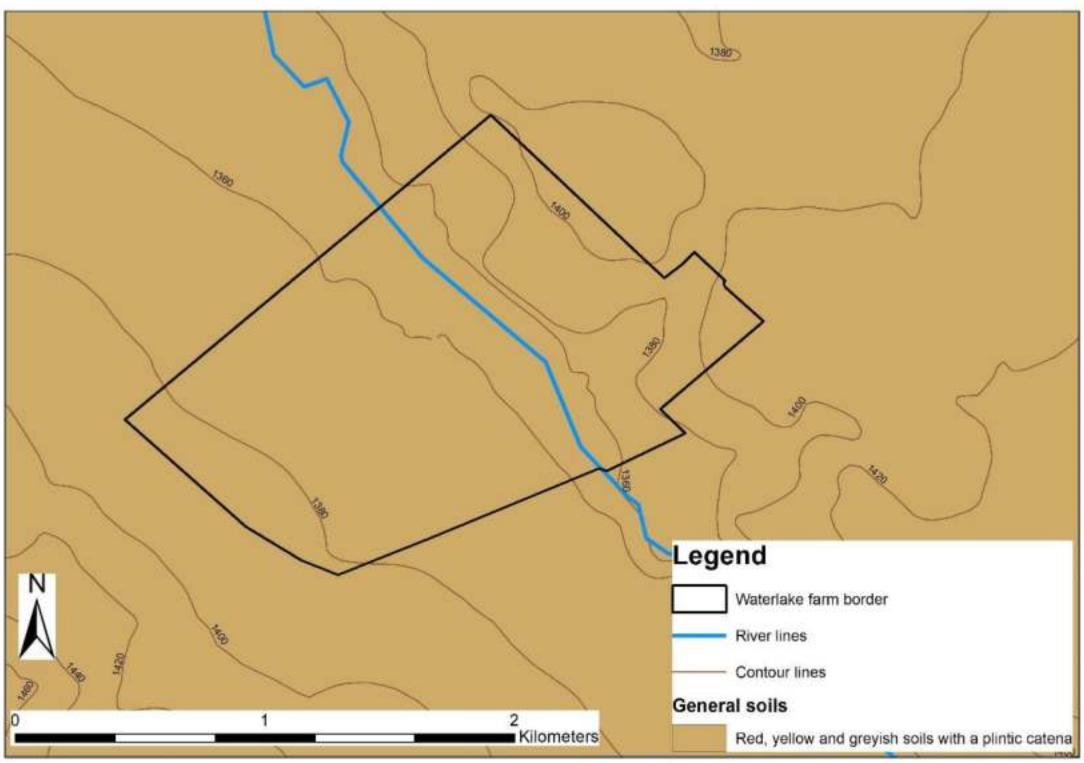

Figure 7: Soils found on the farm

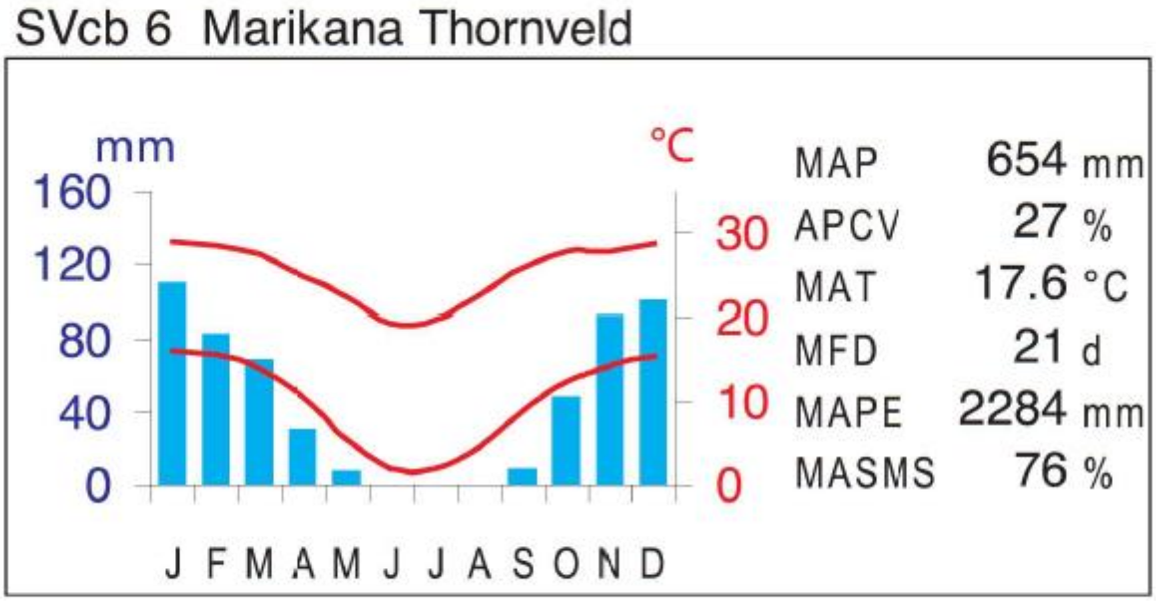

Figure 8: Graph showing the temperature and rainfall for the Marikana Thornveld

MATERIALS AND METHODS USED

Dividing the area into homogenous units

Any particular game ranch can be divided into a mosaic of different habitat types or homogenous units. Homogenous units are units with the same plant species composition and structure and thus the same palatability, production potential and grazing/browsing capacity. Each of these habitat types again differs in their ability to sustain animals. The different homogeneous units and their total area on the ranch form the basis for determining stocking rates. The type of animals and the numbers of each type should be chosen in such a manner to prevent having a detrimental effect on the vegetation or soil. For this purpose, sampling sites are placed randomly within the homogeneous units, and surveys are carried out to assess each habitat in terms of its potential to sustain animals. It is thus of great importance that the homogenous units are identified correctly.

An aerial photograph obtained from the Google Earth Internet site was used to divide the ranch into relatively homogenous units. The procedures of mapping out the vegetation communities by using various maps and aerial photographs are described in Bothma (2002). The first step is to become familiar with the total area of the ranch and its immediate surroundings. This was done by looking at the locality and physical geography, climate, geology and soil, vegetation, key environmental parameters, economic uses and conservation status as described in Low and Rebelo (1998) and Mucina and Rutherford (2006). After this, the aerial photograph was used to mark homogeneous units from an aerial view. The boundaries of the mapped units on the map were then subsequently verified in the veld, and changed, refined and adjusted where necessary. These final homogeneous units were then used for the completion of a map of the Study area. The total area of every individual homogeneous unit was then calculated, and is later used to estimate the grazing/browsing capacities and to evaluate the habitat for different types of game animals.

Veld condition and grazing capacity

The assessment of the veld condition is the first step towards the formulation of a veld management plan. Veld condition is regarded as the condition of the vegetation in terms of a functional characteristic like food production, resistance to soil erosion, physiognomical structure and the production of fuel for fire (Van Rooyen *et al.* 2002). For any ranch/reserve manager, it is crucial to know what the veld condition is in order to determine the grazing capacity and monitoring the effect of the animals on the vegetation. When determining the veld condition of every homogenous unit, the very first thing to do is to identify all plants present in the herbaceous layer and calculating their percentage composition. In the case of the herbaceous layer, the botanical composition of the grass sward is a good indicator of the inherent ability of the veld to produce forage for grazing ungulates (Trollope 1990).

Proportional grass species composition

The step-point method described by Mentis (1981) was used in order to determine the species composition and frequency of occurrence for the herbaceous layer in every homogenous unit. Measurement points were taken per homogenous unit as marked on the map. Surveys was conducted along a 100 m line transect.

Surveys were done with a range rod by recording the species closes to the point of the rod with every step. For each homogenous unit the cut-off distance for determining the nearest grass was taken as 30cm. Data was recorded on herbaceous survey sheets for further analyses.

Veld Condition score

To determine the veld condition of the area, the Ecological Index method (Vorster 1982; Danckwertz 1989) was used. Because the grazing value and ecological status of the different grass species differ from each other, the determination of veld condition rests on the plant species composition, especially of the grass species of a particular plant community. Different grass species react differently to grazing pressure, and are classified into different ecological status classes according to this. The current state of the veld can thus be evaluated on the presence or absence of these different types of grasses. By estimating the frequency of these grass species, the grazing capacity can be calculated. Grazing capacity depends on the veld condition and the rainfall of the particular habitat. Ecological status evaluation thus includes the classification of the grass species into groups on the basis of their reaction to grazing and fire. Van Oudtshoorn (1999) gives a subdivision of grasses into ecological status classes. His definitions are as follows and were used in this study:

Decreasers: Grasses that is abundant in good veld, but that decreases in number when the veld is overgrazed or under grazed. These grasses are palatable climax grasses such as *Themeda triandra* and *Digitaria eriantha.*

Increaser I: Grasses that is abundant in under-utilised veld. These grasses are usually unpalatable, robust climax species that grow without any defoliation, such as *Hyperthelia dissoluta* and *Trachypogon spicatus.*

Increaser 2: Grasses that is abundant in overgrazed veld. These grasses increase due to the disturbing effect of overgrazing and include mostly pioneer and subclimax species such as *Aristida adscensionis* and *Eragrostis rigidior.*

Increaser 3: Grasses that are commonly found in overgrazed veld. These are usually unpalatable, dense climax grasses such as *Elionurus muticus* and *Aristida junciformis.* These grasses are strong competitors and increase because the palatable grasses have become weakened through overgrazing. In addition, it is possible that they are stimulated by light grazing during overgrazing.

Invader: Invaders are plants that are not indigenous to an area.

To determine the veld condition, a grazing value is allocated to each of the ecological status classes, or in certain regions to individual species. The most commonly used values that was also used here, are:

Decreasers………… 10
Increasers I…………..7
Increasers 2……….... 4
Increasers 3……….... 1
Invaders…………….... 1

The sum of the percentage composition of each ecological status class multiplied with the weighted constant of each class represents an ecological index with a maximum value of 1000. An ecological index value of 0 – 399 broadly indicate poor veld, one of 400 – 600 indicates moderate veld, one of 601 – 800 indicates good veld and one of 801 – 1000 indicates very good veld.

Ecological Grazing Capacity

Although it is recognised that it is impossible to accurately determine the grazing capacity of an area, it would appear as though the combined veld condition and rainfall method of Danckwerts (1989), and the modified veld-condition-index method of Bothma *et al.* (2004) are suitable for determining a first approximation of grazing capacity.

The combined veld condition and rainfall method (Schmidt *et al.* 1995) was used to determine the grazing capacity. For this model the sample site veld condition score must be expressed as a percentage of a benchmark veld condition score. The highest veld condition score across all communities on a study site can be taken as the benchmark's veld condition score. In this study the percentage veld condition score was, however, obtained by expressing the ecological index value of each community as a percentage of 1000. This gives a percentage of the maximum ecological index value possible for every community. By substituting the mean veld condition score and annual rainfall into the model, short- and long-term grazing capacity estimates can be calculated. For the short term, the mean rainfall data from the previous two years must be used, and for the long term all available data. The equation used for this method is the following:

$$\mathbf{GC} = [-0.03 + 0.00289 \times (\mathbf{X1}) + [((\mathbf{X2}) - 419.7) \times 0.000633]]$$

where: **GC** = grazing capacity

X1 = percentage veld condition score

X2 = mean annual rainfall in millimetres per annum

The modified equation of Bothma *et al.* (2004) was used to determine the ecological grazing capacity of each homogenous unit. This equation incorporates range condition (veld condition score) the difference between the mean recent annual rainfall for the ranch measured over the past 2 years and the long-term mean rainfall of the South African savanna region, a topography index of habitat accessibility, the influence of fire on plant production, and the percentage grass cover. Grazing capacity is expressed in Grazer Units (GU`s). A Grazing Unit is the equivalent of a 180 kg animal that grazes exclusively. In South Africa, a blue wildebeest *Connochaetes taurinus* is commonly taken as 1 GU because it is an abundant, large herbivore with a mainly grazing diet.

The equation used to determine the grazing capacity is:

$$\mathbf{GU}/100\text{ ha} = 0.547 \times \{[\boldsymbol{c} + (\boldsymbol{r} - 419) \times 0.23] \times \boldsymbol{a} \times \boldsymbol{f} \times (\log_{10}\boldsymbol{g} - 1)^{0.4}\}$$

where

GU = grazer unit

c = the range condition index

r = the mean annual rainfall over the past 2 years at the ranch (mm)

419 = the mean long-term annual rainfall for the South African savannas (mm)

a = a topography index of accessibility – the degree of accessibility of the habitat to plains game on a scale of 0.1 – 1.0, with 1.0 = fully accessible

f = a fire factor on a scale of 0.8 – 1.0, with 0.8 = recent fire and 1.0 = no fire

g = the percentage grass cover

Ecological Browsing Capacity

The condition of the woody plants in a specific community is responsible for the browsing capacity of that community. The browsing capacity can be expressed as the number of animals of determined quality that can be supported by a habitat, with provision being made for specific, but not progressively increasing, impact on the natural resources (Van Rooyen *et al.* 2002). Browsing capacity is a function of many variables, including rainfall, management strategy and veld condition. It is also related to the browsable volume of trees and shrubs. For this reason, it is possible to estimate the browse capacity of an area by determining the browsable volume per hectare contributed by trees and shrubs. Browsing capacity is expressed in Browsing Units (BU`s).

RESULTS AND DISCUSSION

Dividing the area into homogenous units

The topography of the study area is generally flat to undulating with the flood plains of the Pienaars River running through the centre of the farm and a ridge with gradual slopes to the north. In general, the vegetation consists of old lands and open grassland, with some open and closed woodlands and thicket mostly along drainage lines and along the ridge. As a result, the study area was subjectively divided into four homogenous units (**Figure 9**). The homogenous units identified during this study is seen as sufficient for management purposes. A total of 12 survey sites were placed randomly on the farm during February 2023 in order to cover all the homogenous units (**Figure 10**). The results for the step-point surveys for each homogenous unit are given in **Table 1.** A summary of the results for every homogenous unit is presented in **Table 2**. The entire farm is approximately 218 hectares in size, but only the section available to free roaming animals (132 ha) were used for calculating stocking rates.

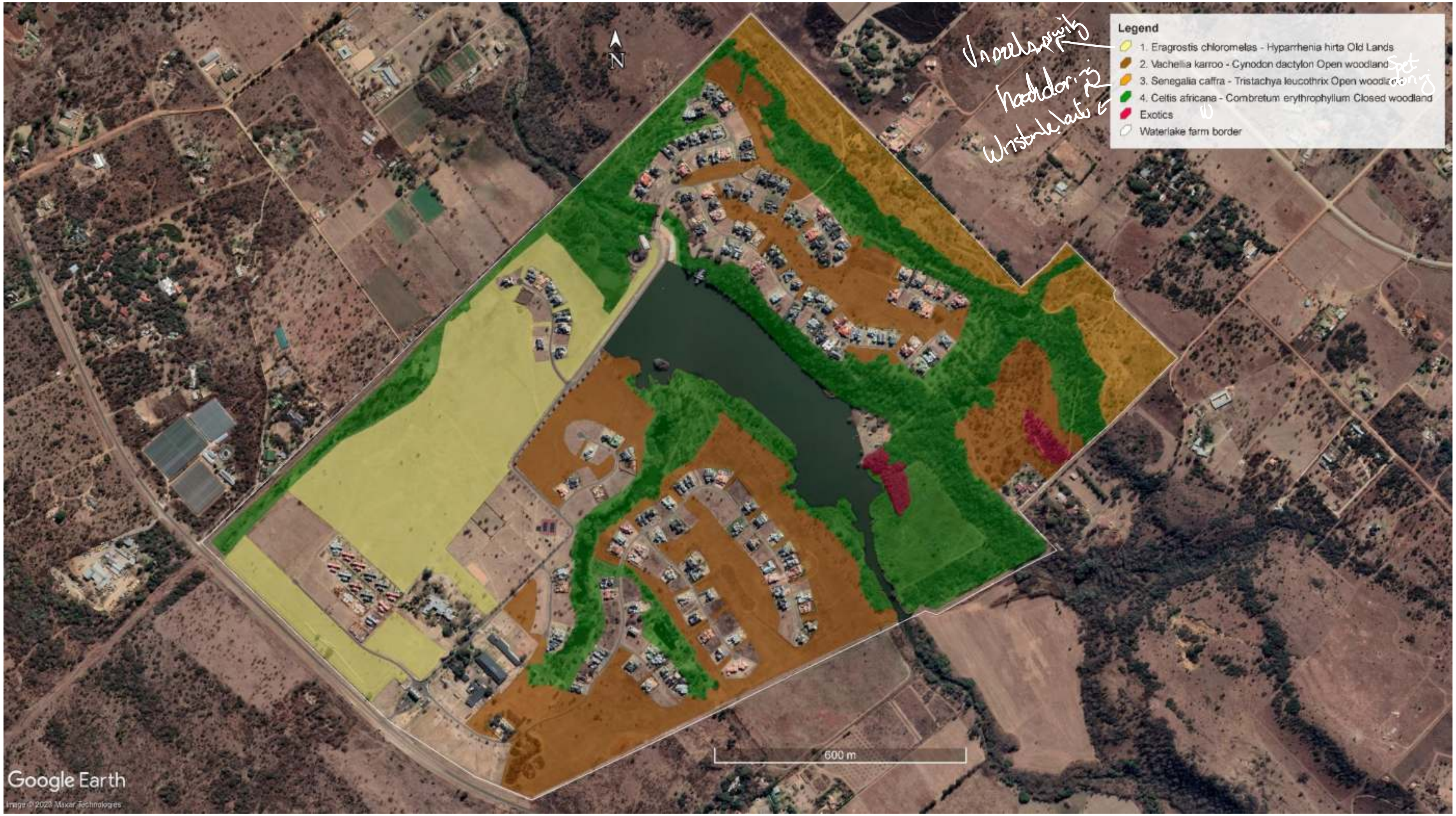

Figure 9: Location of the different homogenous units identified on the farm

Figure 10: Location of the different survey sites on the farm

Table 1: Results of step-point surveys for each homogenous unit

Ecological categories	Homogenous unit			
	1	2	3	4
Decreasers	10	9	20	14
Increasers I	10	7	52	3
Increasers II	79	80	28	1
Increasers III	1	0	0	0
Invader/alien	0	1	0	12
Veld condition score	488	460	666	180
Percentage VCS	49	46	67	18

Evaluation scale			
Very poor	0	-	200
Poor	201	-	400
Moderate	401	-	600
Good	601	-	800
Very good	801	-	1000

Table 2: Summary of the results in each homogenous unit on the farm

Characteristics of homogenous units	*Eragrostis chloromelas - Hyparrhenia hirta* Old lands	*Vachellia karroo - Cynodon dactylon* Open woodland	*Senegalia caffra - Tristachya leucothrix* Open woodland	*Celtis africana - Combretum erythrophyllum* Closed woodland	Entire ranch
Size (ha)	31	33	13	55	132
Tree density (trees/ha)	0	550	150	1163	
Tree cover (%)	0	30	9	68	
Shrub density (shrubs/ha)	0	200	425	488	
Shrub cover (%)	0	3	8	5	
Actual browse (kg/ha)	0	168	54	152	
Ecological browsing capacity:					
Browser unit / 100 hectare	0	11	4	10	
Browser unit / hectare	0.00	0.11	0.04	0.10	
hectare / Browser unit	0	9	28	10	
Total Browser units	**0**	**4**	**0**	**5**	**10**
Ecological status class (%)					
Decreasers	10	9	20	14	
Increaser 1	10	7	52	3	
Increaser 2	79	80	28	1	
Increaser 3	1	0	0	0	
Invader/exotic	0	1	0	12	
Range condition score	488	460	666	180	
Range condition index (%)	49	46	67	18	
Grass cover (%)	80	65	50	2	
Mean rainfall (mm/year)	688	688	688	688	
Topography index of accessibility	1	1	1	0.8	
Fire factor	1	1	1	1	
Ecological grazing capacity:					
Large animal units / hectare	0.28	0.27	0.33	0.19	
hectare / Large animal unit	4	4	3	5	
Grazer unit / 100 hectare	58	54	61	0	
Grazer unit / hectare	0.58	0.54	0.61	0.00	
hectare / Grazer unit	2	2	2	0	
Total Grazer units	**18**	**18**	**8**	**0**	**44**

Homogenous unit 1: *Eragrostis chloromelas - Hyparrhenia hirta* Old lands

	
Dominant grasses	**Dominant trees**
Eragrostis chloromelas (62%)	*Vachellia karroo*
Hyparrhenia hirta (10%)	
Digitaria eriantha (9%)	

This homogenous unit covers only approximately 31 hectares, representing 14% of the study area. It is found on the flat plains from the entrance gate in the southwestern side of the farm, running all the way to the large dam and Pienaars River. Very little woody vegetation is found in this habitat with the odd *Vachellia karroo*. The grass cover is fairly good with *Eragrostis chloromelas* (Narrow Curly leaf) (62%) dominant, followed by *Hypharrhenia hirta* (Common thatching grass) (10%) and *Digitaria eriantha* (Common finger grass) (9%). A summary of the characteristics of this homogenous unit is given in **Table 2**.

This habitat is virtually tree free with some scattered sweet thorn trees *Vachellia karroo* the only woody species found. The grass on the old lands is still being cut and bailed every year so there is no time for any woody species to establish and/or survive. No browser units (BU) can thus be stocked in this habitat. Should we bale or not?

Overgrazed

The range condition index value for this homogenous unit was calculated as 488 and the range condition score as 49% (**Table 2**). The veld in this community can thus be described as being in a moderate condition. Increaser 2 grass species (79%) dominate this community, followed by Decreaser species (10%) and Increaser 1 species (10%). The dominance of the increaser 2 species indicates that overgrazing is taking place in this homogenous unit, although the cutting and bailing of the grass will also contribute to this dominance. The average grazing capacity was calculated as 58 Grazer Units (GU) per 100 hectares or 0.58 Grazer Units per hectare. Two hectares of this habitat is thus needed to sustain 1 GU, and the stocking density for grazers in this habitat is 18 Grazer Units.

Homogenous unit 2: *Vachellia karroo - Cynodon dactylon* Open woodland

Dominant grasses	Dominant trees
Cynodon dactylon (27%)	*Vachellia karroo*
Eragrostis chloromelas (19%)	*Searsia pyroides*
Sorghum versicolor (8%)	

This homogenous unit covers only approximately 33 hectares, representing 15% of the study area. It is found on the flat plains between the houses as well as on the lower slopes of the ridge running along the northern section of the farm. The grass cover is fairly good, with *Cynodon dactylon* (Couch grass) (27%) dominant, followed by *Eragrostis chloromelas* (Narrow Curly leaf) (19%) and *Sorghum versicolor* (Black-seed sorghum) (8%). A summary of the characteristics of this homogenous unit is given in **Table 2**.

Very little woody vegetation is found on the plains between the houses where old lands use to be in the past. On the slopes of the ridge, however, where it is also a bit rockier and more protected, more woody species can be found. The average tree density in this homogenous unit is approximately 550 trees/ha, and the shrub density (< 3m) approximately 200 shrubs/ha. The available browse up to 5 meters was calculated as 168 kilograms per hectare, with only 19% (31 kg/ha) available below 2 meters, and 7% (12 kg/ha) below 1.5 meters. The average browsing capacity up to 5 meters was calculated as 0.11 browser units (BU) per hectare, or 9 hectares per browsing unit. The stocking density for browsers in this habitat is thus 4 browser units.

The range condition index value for this homogenous unit was calculated as 460 and the range condition score as 46% (**Table 2**). The veld in this community can thus be described as being in a moderate condition. Increaser 2 grass species (80%) dominate this community, followed by Decreaser species (9%) and Increaser 1 species (7%). The dominance of the increaser 2 species indicates that overgrazing is taking place in this homogenous unit. The average

Overgrazed?

grazing capacity was calculated as 54 Grazer Units (GU) per 100 hectares or 0.54 Grazer Units per hectare. Two hectares of this habitat is thus needed to sustain 1 GU, and the stocking density for grazers in this habitat is 18 Grazer Units.

Homogenous unit 3: *Senegalia caffra - Tristachya leucothrix* Open woodland

	
Dominant grasses	**Dominant trees**
Tristachya leucothrix (33%)	*Senegalia caffra*
Themeda triandra (13%)	*Searsia lancea*
Eragrostis chloromelas (9%)	*Diospyros lycioides*

This homogenous unit covers only approximately 13 hectares, representing 6% of the study area. It is found on top of the ridge in the northern side of the farm. The grass cover is fairly good with *Tristachya leucothrix* (Hairy trident) grass (33%) dominant, followed by *Themeda triandra* (red grass) (13%) and *Eragrostis chloromelas* (Narrow Curly leaf) (9%). A summary of the characteristics of this homogenous unit is given in **Table 2**.

The tree density in this homogenous unit is approximately 150 trees/ha, and the shrub density (< 3m) approximately 425 shrubs/ha. The available browse up to 5 meters was calculated as 54 kilograms per hectare, with only 50% (27 kg/ha) available below 2 meters, and 34% (18 kg/ha) below 1.5 meters. The average browsing capacity up to 5 meters was calculated as 0.04 browser units (BU) per hectare, or 28 hectares per browsing unit. This habitat is thus too small to sustain any browser units.

The range condition index value for this homogenous unit was calculated as 666 and the range condition score as 67% (**Table 2**). The veld in this community can thus be described as being in a good condition. Increaser 1 grass species (52%) dominate this community, followed by Increaser 2 species (28%) and Decreaser species (20%). The high percentage of Increaser 1 species is an indication that this community is underutilized. The average grazing capacity was calculated as 61 Grazer Units (GU) per 100 hectares or 0.61 Grazer Units per hectare.

Two hectares of this habitat is thus needed to sustain 1 GU, and the stocking density for grazers in this habitat is 8 Grazer Units.

Homogenous unit 4: *Celtis africana - Combretum erythrophyllum* Closed woodland

Dominant grasses	Dominant trees
*Paspalum dilatatum** (12%)	*Celtis africana*
Setaria sphacelata (8%)	*Combretum erythrophyllum*
Setaria lindenbergiana (4%)	*Searsia pyroides*

This homogenous unit covers approximately 55 hectares, representing 25% of the study area. It is found all along the drainage lines on the farm as well as along the ridge in the northern side of the farm. The grass cover is poor with the exotic *Paspalum dilatatum* (Dallis grass) (12%) dominant, followed by *Setaria sphacelata* (Common bristle grass) (8%) and *Setaria lindenbergiana* (Mountain bristle grass) (4%). A summary of the characteristics of this homogenous unit is given in **Table 2**.

The tree density in this homogenous unit is approximately 1163 trees/ha, and the shrub density (< 3m) approximately 488 shrubs/ha. The available browse up to 5 meters was calculated as 152 kilograms per hectare, with only 28% (42 kg/ha) available below 2 meters, and 14% (21 kg/ha) below 1.5 meters. The average browsing capacity up to 5 meters was calculated as 0.10 browser units (BU) per hectare, or 10 hectares per browsing unit. The stocking density for browsers in this habitat is thus 5 browser units.

The range condition index value for this homogenous unit was calculated as only 180 and the range condition score as 18% mainly because of the lack of grass (**Table 2**). The veld in this community can thus be described as being in a poor condition. Decreaser grass species (14%) dominate this community, followed by Increaser 1 species (3%) and Increaser 2 species (1%). With the low grass cover no Grazer Units (GU) can be supported in this habitat.

Determining stocking rates

Stocking rate is the area of land allocated to each specific animal unit (Tainton 1999). The number of animals by which a given ranch surface area is stocked, is generally accepted as one of the most important factors that affect animal production and the condition of the grazing. The optimal stocking rate of different game on a ranch depends on the available habitat, the quality of the habitat and the objectives for the game. The potential ecological carrying capacity on the ranch, number of game present, composition of the herds (both sex and age ratios), social systems, habitat selection, feeding and water requirements, selectivity towards different plant species and the management objectives are all important considerations when making recommendations on stocking rates (Van Rooyen 2002). Stocking rates must be aimed at ensuring maximum animal production without causing any deterioration of the veld. The stocking density is a management decision based on the objectives of the particular ranch, but should always be within the ecological capacity of the habitat to sustain grazing and browsing herbivores.

The ecological capacity of a ranch is a characteristic of the habitat, and primarily a function of the condition of the vegetation. The stocking density, however, is the owner's / manager's estimate of the land-to-animal relationship best suited to the objectives, and thus a production decision. For each type of animal there is a certain maximum sustainable stocking rate that may vary according to fluctuations in the environmental conditions (**Figure 11**). At low stocking rates, maximum production per animal unit is achieved but, after reaching the point where competition for resources starts, the production per animal will decrease to zero. For trophy hunting, for instance, the aim is to get maximum production per animal unit. For this purpose, the ranch should thus be stocked with species that are in high demand as trophies, and numbers of these species should be limited to the level where competition for resources between individuals are minimised. Sex ratios should also be maintained at parity to produce the maximum number of trophy-aged males. In the case of sport or venison hunting on the other hand, the aim is to harvest the maximum number of animals per year. The ideal species for this purpose is antelope with a high reproductive rate and good quality meat. Sex ratios should be maintained in favour of the females to ensure maximum production while guaranteeing reproductive success. For game viewing the aim would be to have a high stocking rate with a large variety of different species. When stocking a specific species, social structure is thus usually the limiting factor and not food availability. The optimal stocking rate ultimately depends on the objectives for the specific farm.

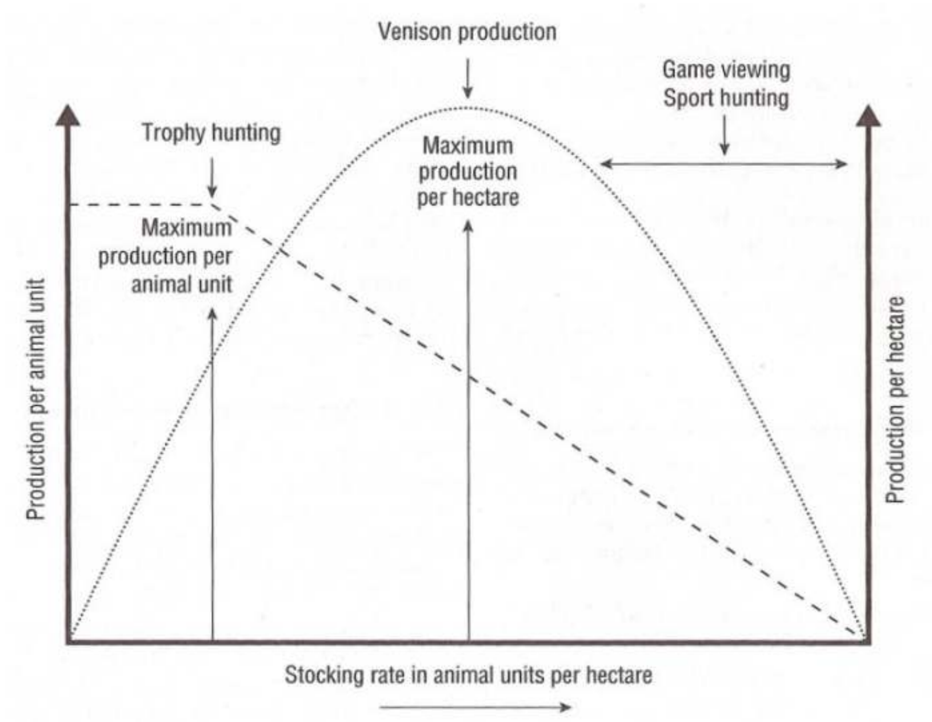

Figure 11: The effect of stocking rate on animal production performance

The current stocking density compared to the ecological capacity is given in **Table 3**. The farm is currently stocked at 139% of its ecological grazing capacity, and 391% of its ecological browsing capacity.

The maximum growth for any population will be achieved at a stocking density at half of the ecological capacity. At a density of more than half the ecological capacity, competition for resources and space will kick in and social structure becomes a more important factor in determining stocking density as the availability of food. The maximum stocking density for Waterlake Farm (according to social structure and available habitat) is given in **Table 4**.

Table 3: Current stocking density compared to calculated ecological capacity

Ecological Grazing Capacity (GU)	44	One graze animal unit equated to the energy requirements of a bluewildebeest of 180 kg
Ecological Browse Capacity (BU)	10	One browse animal unit equated to the energy requirements of a kudu of 140 kg

Type of animal	Number of animals	Minimum viable group size	Number of males per group	Number of females per group	Mean mass of animal in kg	% graze in diet	% browse in diet	% dicotyledon in diet	Graze-animal units per animal	Browse-animal units per animal	Equivalent graze-animal units per group	Equivalent browse-animal units per group	% of ecological graze capacity	% of ecological browse capacity
Low selectivity grazers														
Plain's zebra	6	(7) 7	1	5	300	90	0	10	1.32	0.18	7.92	1.06	18	11
Sub Total	**6**													
High selectivity grazers														
Blesbok	12	10	1	11	70	100	0	0	0.49	0.00	5.91	0.00	13	0
Reedbuck	7	4	2	5	60	90	8	2	0.39	0.05	2.76	0.37	6	4
Waterbuck	10	6	3	7	200	92	5	3	1.00	0.10	9.96	1.05	23	10
Sub Total	**29**													
Mixed feeders														
Bushpig	11	3	4	7	80	40	20	40	0.22	0.39	2.40	4.34	5	43
Common impala	52	24	7	46	55	50	50	0	0.21	0.25	10.69	12.90	24	129
Kudu	8	8	2	6	200	18	61	21	0.19	1.07	1.56	8.57	4	86
Nyala	18	3	6	12	70	47	53	0	0.23	0.32	4.17	5.67	9	57
Red hartebeest	6	10	1	5	120	75	20	5	0.55	0.22	3.32	1.34	8	13
Springbok	52	25	10	42	37	80	20	0	0.24	0.07	12.70	3.83	29	38
Sub Total	**147**													
TOTAL	**182**												**139**	**391**

Table 4: Maximum stocking density for Waterlake Farm (according to social structure and available habitat)

Type of animal	Mean mass in kg	LAU / animal	Animals / LAU	GU / animal (by weight)	Animals / GU	% grazing of diet	Graze animal unit equivalent per animal	BU / animal (by weight)	Animals / BU	% browsing of diet	Browse animal unit equivalent per animal	Maximum stocking (Social structure)	Maximum number for the farm	Recommended numbers for the farm
Blesbok	65	0.23	4.27	0.47	2.15	90	0.42	0.56	1.78	10	0.06	10/100ha	15	15
Burchell's zebra	260	0.66	1.51	1.32	0.76	93	1.23	1.59	0.63	7	0.11	4/100ha	6	6 7
Bushpig	55	0.21	4.84	0.41	2.43	80	0.33	0.50	2.02	20	0.10	16/100ha	20	10
Common impala	41	0.17	6.03	0.33	3.03	45	0.15	0.40	2.51	55	0.22	12/100ha	18	15 30
Greater kudu	140	0.42	2.40	0.83	1.21	15	0.12	1.00	1.00	85	0.85	4/100ha	4	4
Nyala	73	0.26	3.91	0.51	1.97	20	0.10	0.61	1.63	80	0.49	15/100ha	15	0 15
Red hartebeest	120	0.37	2.69	0.74	1.36	75	0.55	0.89	1.12	25	0.22	5/100ha	7	7 6
Reedbuck	55	0.21	4.84	0.41	2.43	95	0.39	0.50	2.02	5	0.02	1/5ha	6	6
Springbok	37	0.15	6.51	0.31	3.28	32	0.10	0.37	2.71	68	0.25	45/100ha	50	40 40
Steenbok	10	0.06	17.37	0.11	8.74	34	0.04	0.14	7.24	66	0.09	1/30ha	4	4
Waterbuck	205	0.55	1.80	1.10	0.91	84	0.93	1.33	0.75	16	0.21	5/100ha	7	6 6

GENERAL MANAGEMENT RECOMMENDATIONS

Every farm should be managed following sound veld management principles including fire management, alien plant eradication, erosion control, and rehabilitation of disturbed/degraded areas.

Fire management

Fire is regarded as a natural ecological factor in the grasslands and savannas of the world (Bothma & du Toit 2016). Fire caused by lightning is common in these areas. There are three types of fires namely, ground, surface and crown fires. The differentiation is based on the level where the vegetation burns:

- Ground fire – this fire burns beneath the surface of the soil in the thick layers of organic materials and plant debris.
- Surface fire – a fire that occurs in the herbaceous layer.
- Crown fire – a fire that includes all levels of vegetation strata, but mainly the leaf canopy of trees and shrubs.

Different vegetation reacts differently to fire and grazing. In veld management burning is mainly done for the following reasons:

- To remove old, unacceptable or dead plant material accumulated from previous seasons. This favours the growing of desired grass species and reduces undesired ones. If the old material is not removed it has a smothering effect on the desired grass species and the veld becomes deteriorated.
- To prevent or reduce bush encroachment by unacceptable woody or herbaceous invasive plants. Bush encroachment reduces the productivity of the grass layer, when it takes over.
- To create fire breaks in order to protect the grazing.
- Partial burns to stimulate rotational grazing.
- Controlling of parasites such as ticks.

Burning is unacceptable if it is to be used to stimulate new grass growth out of season. Fires should not take place in the summer, autumn, and winter (Bothma & du Toit 2016). Unless browsers are introduced after a burn, the use of a fire to prevent bush encroachment is very little effective. Trees and shrubs become reduced in height after the burn, but large trees are little effected. After a burn the leaves and young twig growth are made available to mixed feeders and browsers such as duiker and eland. The burning of veld tends to make the bushveld 'open' due to the burning of the lower branches and shrubs. This forced rotational grazing and browsing through burning ensures that preferential food types in the veld will not be eliminated, but rather promoted by a correctly implemented management plan, which includes a burning program.

According to the National Veld and Forest Fire Act (No. 101 of 1998), a duty is placed on owners of natural veld to prepare and maintain firebreaks on their side of the boundary. Owners of adjoining land and the Fire Protection Association for the area should be informed when burning is planned. Detailed requirements on fire protection associations, firebreaks, fire fighting etc. are described in the Act. Fire breaks should be prepared or maintained around the boundaries before the rainy season.

Veld burning should only be performed for the removal of old, unacceptable plant material. The time of burning should be decided on in such a way that the veld is able to reform a leaf cover as quickly as possible. If the veld is burned before the first spring rains, it remains bare and is thus more susceptible to soil erosion by water and wind. The recommendations for veld burning are therefore; not earlier than 6 weeks before the expected first spring rain and no later than 2 weeks after the first spring rain (Bothma 2002). If the veld has not been burnt before the first spring rains, due to signs of growth, it is done within 24 hours after the first spring rains of 15mm or more. Fires that are applied early in the summer, when the grass is growing actively, have a disastrous effect on the productivity, basal cover and species composition of the grassland. The damaging effect of the fire is determined by the physiological condition of the grass plants at the time of the burn rather than the burning season.

The development of a firebreak system is essential in all grassveld areas. The type of fire that is required to remove old, accumulated material is a less intense (cool) downwind fire (headfire). Although a headfire is apparently less intense at ground level than a backfire that burns against the wind, the temperature between 1 and 3 meters above ground level is higher in headfires than in backfires. The burning should be started along a firebreak as a short backfire. To secure safety a firebreak is burned. The fire is started on the upwind side, so that this headfire burns the greater proportion of the area.

Specifically for Water Lake Farm, it is recommended to maintain firebreaks around the perimeter of the property, and around all the buildings and private residences. This can be cut with brush cutters or slashed throughout the year, and burned during May before the fire season starts.

How wide must a firebreak be?

Do not understand Spring?

Erosion and roads

Soil erosion is a natural process that takes place extremely slowly. The dominant type of erosion over much of the land surface of South Africa is, however, not natural but man-made. The generally high rate of soil loss in South Africa can be ascribed to a number of factors, of which the following are probably the most important (Tainton 1999):

- An often-unsuitable terrain, with generally steep slopes
- Highly erodible and shallow soils
- Very high rainfall intensities over much of the summer rainfall regions
- A poor attitude to resource conservation
- The degradation of the plant cover and composition resulting from overgrazing and/or poor grazing practice
- Complex economic factors which arise from the constant struggle within the agricultural sector for the maintenance of lifestyles and living standards
- Unrealistically high land prices which encourage over-exploitation
- The use of land for purposes for which it is unsuited
- The uncontrolled use of fire in areas to which it is not suited
- Ineffective conservation legislation and/or its poor implementation
- Artificial support by the State of farmers who for one or other reason are unable to survive without such assistance, and in the process merely encouraging continued over-exploitation

The best method to control erosion is to take the utmost care to prevent it from developing in the first place. Although roads are a necessity, they are a disturbance to the natural environment and can turn into an eyesore when not planned and constructed correctly. Roads should therefore be positioned with care, with the effect and primary goal of each road being considered (Du Toit & Van Rooyen 2002).

The cause of almost all problems associated with roads is poor construction design, inappropriately routed roads, and/or insufficient attention to the drainage of run-off water (Coetzee 2005). Even the shallowest of wheel ruts can become a channel for water, and later turn into a small gully. This can eventually lead to an impassable road and a new erosion problem that requires attention. Problems with roads are particularly acute in landscapes with steep slopes and in areas that experience heavy downpours and flash flooding. Attention should be given to this problem while it is still manageable.

Roads have a twofold drainage problem; one occurs above ground level and the other below it. Surface drainage involves the channelling of all rainwater from the road surface and the surrounding areas. According to Du Toit & Van Rooyen (2002), surface water should be prevented from reaching the underground drainage system by the following means:

- The design of a convex road surface
- The placement of drainage canals parallel to the slope
- By allowing stormwater to pass underneath the road

Adapting the road design to the contours of the environment will allow for easier drainage. Underground drainage deals with water that filtered into the road foundation and the surrounding material, and is essential in the following areas (Du Toit & Van Rooyen 2002):

- Areas with a high-water table
- Seepage areas under the road foundation
- Active springs
- Surface water that enters the road foundation from a high median or from side channels through a porous road surface
- Areas with dolomite

The objective of road drainage is to deflect run-off water off the road surface and into the natural vegetation alongside the road (Coetzee 2005). This can be achieved by constructing drainage deflection humps across the road surface (**Figure 12**). The drainage hump slows the water flow, directs it off the road surface and concentrates it at a stable overflow site. The number of drainage humps will depend on the steepness of the slope, nature of the run-off, type of terrain, soil and vegetation cover through which the road passes as well as the number of natural drainages that cross the road. The hump must be constructed with a solid core of either stones or coarse gravel, covered with road surface material to form a gradual slope both sides. It should also extend well beyond the roadway on each side to prevent water from simply flowing around the hump and back into the road.

The key to successful cross-road drainage is effective construction and continual maintenance to clear any blockages of water flow and repair storm damage as soon as it occurs. The deflected water, especially on slopes, may eventually result in the formation of an erosion gully and it is critical that soil erosion is prevented at sites where the run-off water concentrates. **Figure 13** illustrates a method of drainage and slope protection.

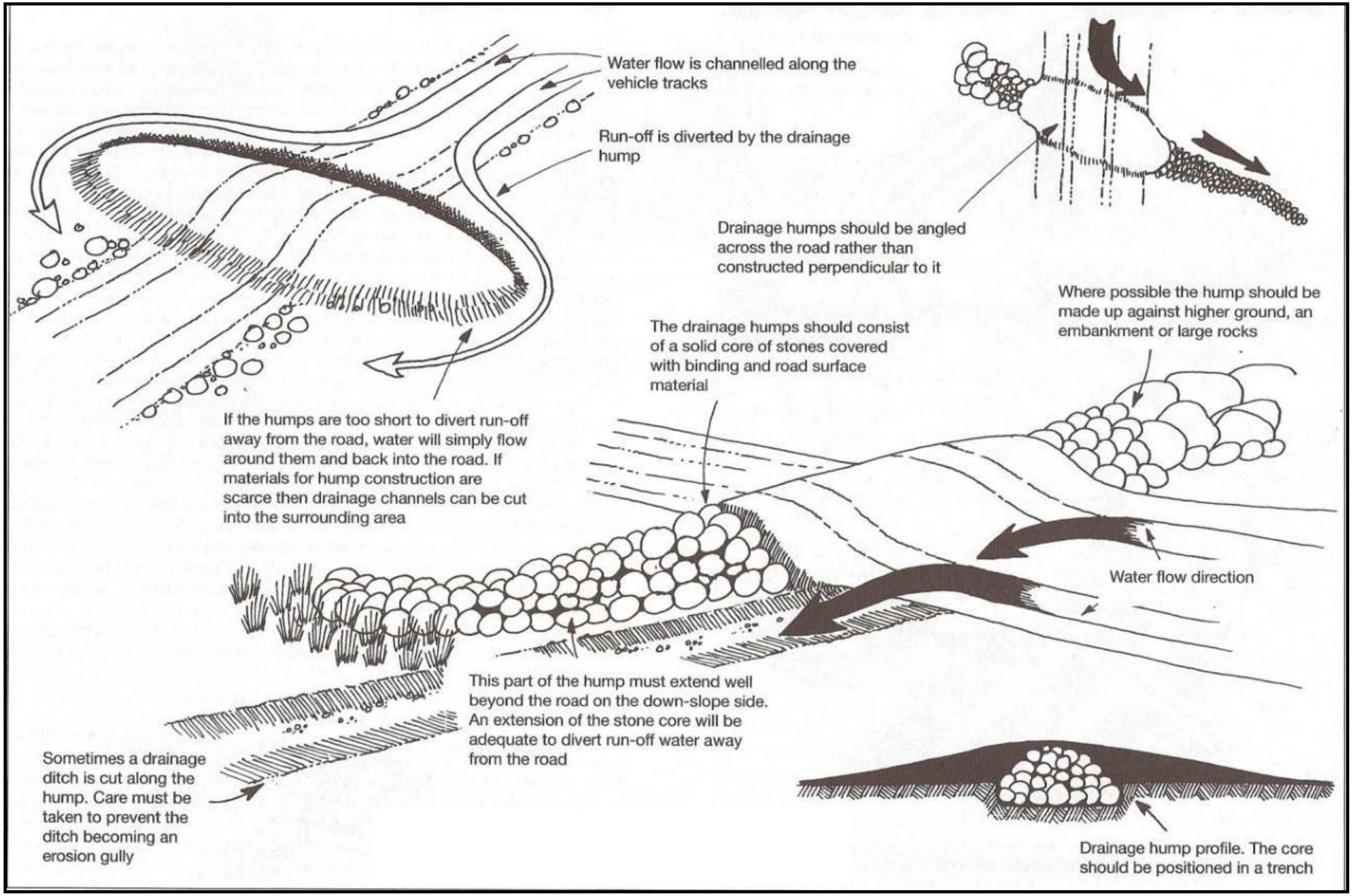

Figure 12: Road drainage humps (Source: Coetzee, 2005)

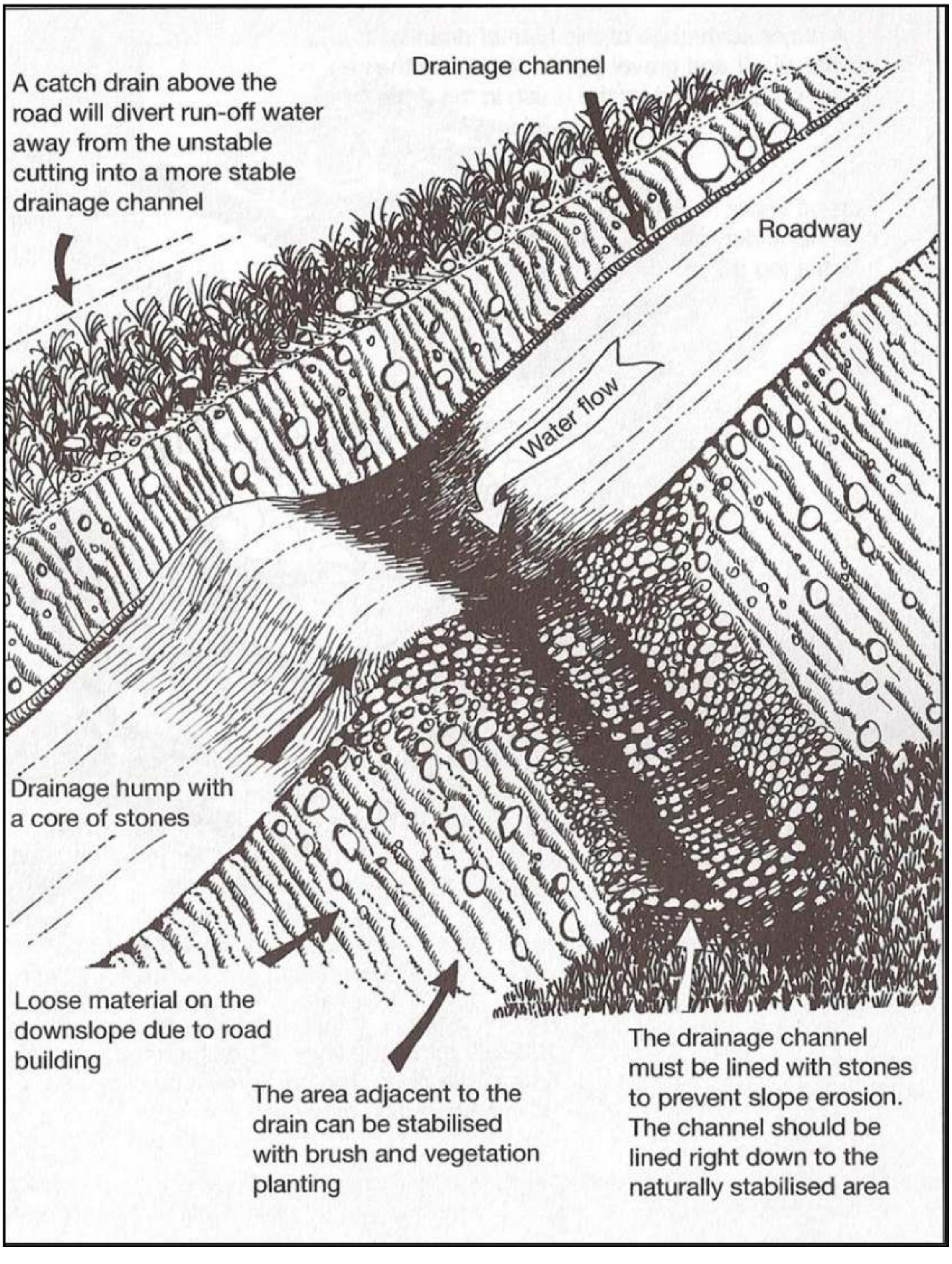

Figure 13: Drainage and slope protection (Source: Coetzee, 2005)

At small stream crossings, the construction of a low, concrete causeway or ford (**Figure 14**), or using pipes for under-road drainage (**Figure 15**) can be a permanent solution to the problem.

Should this option be considered, it is crucial that the structures are expertly constructed to ensure that they are able to resist the destructive force of storm-water and undercutting. According to Coetzee (2005) the following principles can help ensure the most sensitive routing, construction and use of roads in rangelands:

1. use the landscape as a guide to routing
2. avoid sensitive areas in the landscape
3. the means must be available for maintenance
4. aesthetics is important
5. off-road drainage is critical
6. build and maintain to the required standard
7. a code of road-use ethics must be adhered to by all road users

Water Lake Farm has a good road network giving access to all the private homes on the estate. There are, furthermore several gravel management roads giving access to al the green spaces present as well. Residents are not permitted to drive on these management roads with vehicles, but jogging and riding with bicycles are encouraged and part of the goals of the estate. Roads that are constructed poorly and/or against the contours, giving water a chance to collect and build up speed, will ultimately lead to erosion. This is equally true for vehicle roads and foot or bicycle paths. Proper design and maintenance are thus crucial. Some areas in the northern section of the estate were observed where erosion is currently taking place (**Figure 16**) and it is vital that maintenance is done there. Drainage humps will have to be constructed and runoff water must be slowed down.

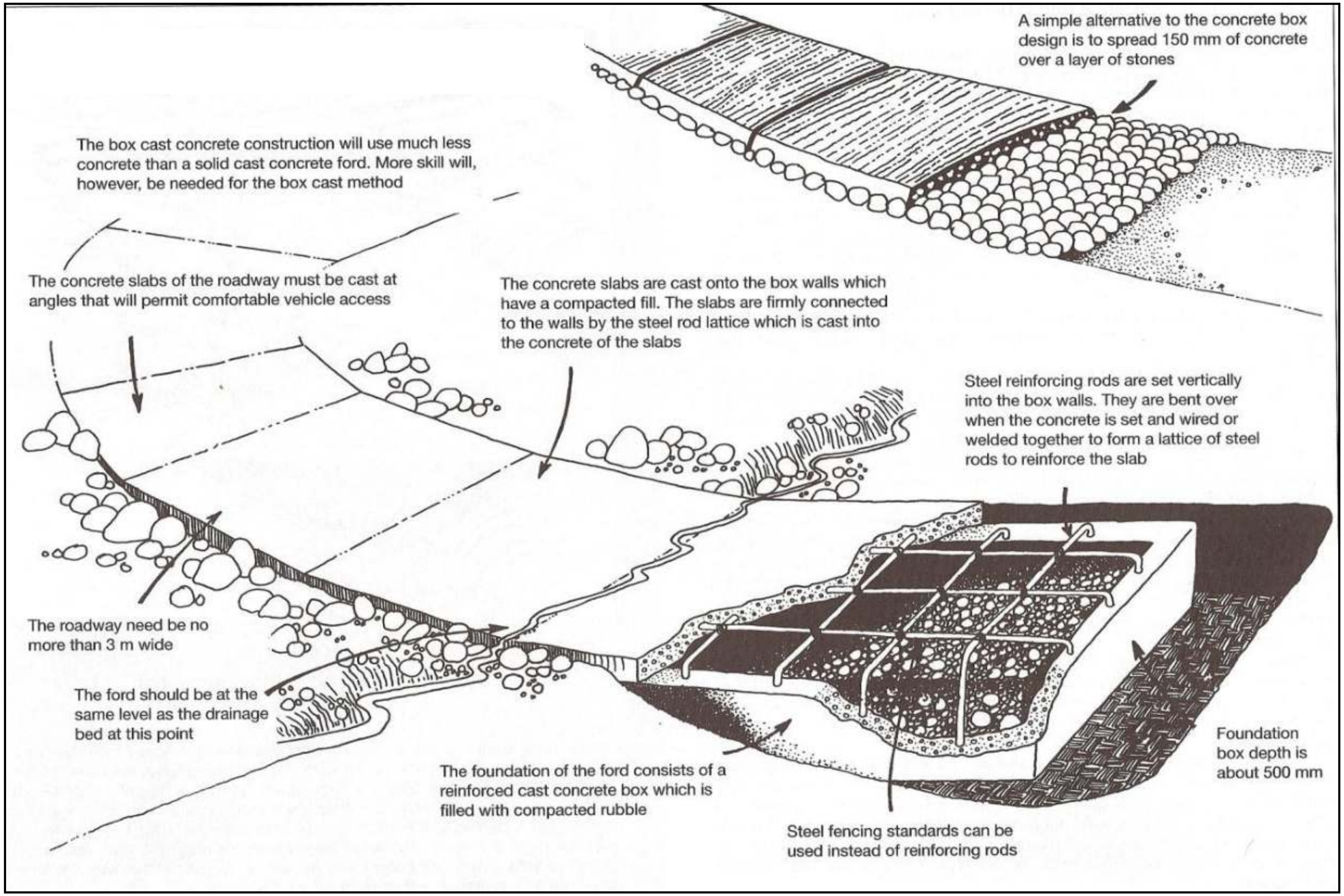

Figure 14: Concrete ford for drainage crossings (Source: Coetzee, 2005)

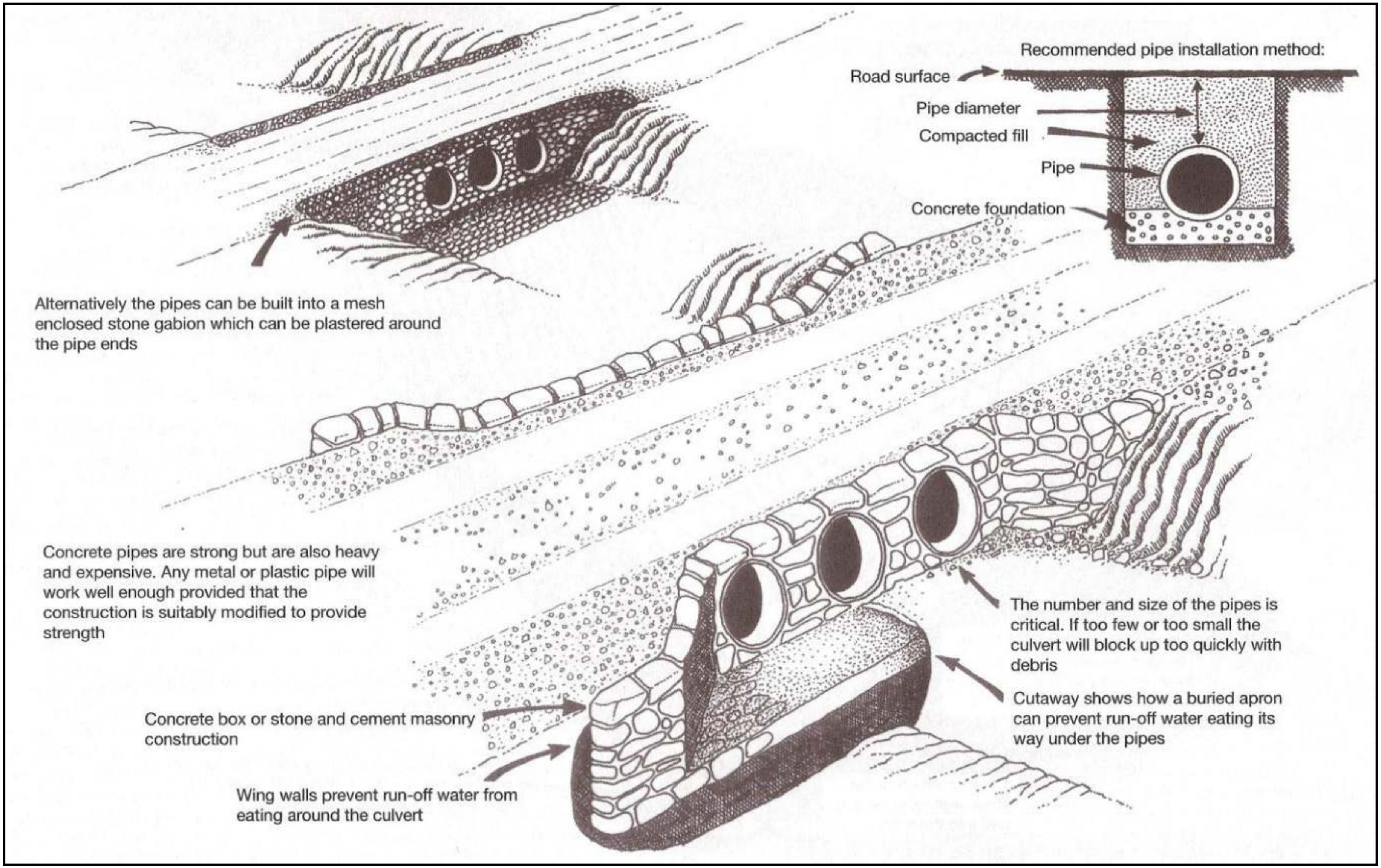

Figure 15: Using pipes for under-road drainage (Source: Coetzee, 2005)

Figure 16: Areas where erosion is taking place on the estate

Alien plant control

Requirements for landowners to take steps to control invasive alien plants on their properties are set out in the Conservation of Agricultural Resources Act (Act No. 43 of 1983) and the National Environmental Management Biodiversity Act (Act No. 10 of 2004). In terms of the Biodiversity Act, a person who is the owner of land on which a listed invasive species occurs must "take steps to control or eradicate the listed invasive species and to prevent it from spreading" (Section 73(2)(b)). Section 97 of the Biodiversity Act empowers the Minister to make regulations relating to the monitoring of compliance with and enforcement of norms and standards relating to the achievement of any objectives of the Act. In this regard, alien and invasive species are controlled by the National Environmental Management Biodiversity Act (NEMBA) (Act 10 of 2004) – Alien and Invasive Species (AIS) regulations, which were gazetted on 1 August 2014 and became law on 1 October 2014. Invasive species are divided into four categories:

Category 1a: Invasive species which must be combatted and eradicated. Any form of trade or planting is strictly prohibited.

Category 1b: Invasive species which must be controlled and wherever possible, removed and destroyed. Any form or trade or planting is strictly prohibited.

Category 2: Invasive species or species deemed to be potentially invasive, in which a permit is required to carry out a restricted activity. Category 2 species include commercially important species such as pine, wattle and gum trees.

Category 3: Invasive species which may remain in prescribed areas or provinces. Further planting, propagation or trade is, however, prohibited.

According to Dr Guy Preston, the impacts of invasive plants cannot be over-emphasised:

- They are the single biggest long-term threat to our water security. If our catchments are invaded by pines, wattles, hakea and other thirsty invasives, water security will collapse.
- South Africa is the third-most species-rich country in the world. Invasive species are the single biggest threat to our exceptional biological diversity.
- They exacerbate wild fires, many invasive species burning at ten-fold the intensity of the species that they displace.
- They exacerbate erosion, siltation of rivers and dams, sedimentation and poor water quality, mudslides and flooding.

There are several alien and invasive species that were identified on the farm during the surveys (**Table 5**). It is recommended to identify and mark the positions of all the exotic and invasive plants found on the farm, and to set up a control program for them.

The success of any clearing operation depends on the correct selection of the appropriate control methods. The chosen methods need to take into account the different growth forms, growth habit and reproduction of the specific species to be controlled. Other factors to consider include the size of the area to be cleared, the size of the plant and the environment in which it occurs. Small, low-density plants might easily be uprooted, whereas larger trees may need special equipment and/or the use of herbicides. When removing or limiting the spread of invasive plants, the control method needs to do the least amount of damage to the indigenous flora and fauna. The following three methods of control are commonly implemented.

Mechanical control. This uses physical force to either remove the plant or damage it to such an extent that it dies. Techniques include digging out, bark stripping, ring barking or the use of fire. This method can only be used on plants that do not coppice (plants that do not regrow when cut back) or root sucker (regrow from the root buds).

Chemical control. This is the use of herbicides to kill plants. Herbicides are divided into many groups based on what plants they kill, when they are applied, their movement in the plant and their behaviour in the soil. Herbicides are usually applied directly to the plant as a foliar application or to the stump immediately after the tree has been felled. There is no one herbicide that can be used in all scenarios.

Biological control. This form of control uses the plants' natural enemies to help control the invasion. This method seldom results in total control of a species, but limits and contains the spread. Examples of biological control agents include seed feeders, stem borers and gall formers. Clearing an area may hamper any existing biological control efforts.

Since one method of control is not always effective, it is common to apply integrated control. This involves combining the control methods, such as cutting down a tree (mechanical) followed by applying herbicide (chemical). Biological control can sometimes also be integrated successfully with other control methods, for example where seeds are destroyed by biological control agents and standing plants are controlled mechanically and chemically. Biological control can also weaken plants to the point where other methods become more efficient and cost-effective.

TABLE 5: Alien and invasive species identified during surveys

Category 1	Category 2	Category 3
Cirsium vulgare	*Sorghum halepense*	*Agave americana*
Datura ferox	*Pinus roxburghii*	*Grevillea robusta*
Solanum elaeagnifolium	*Populus x canescens*	*Morus alba*
Campuloclinium macrocephalum	*Acacia mearnsii*	*Tipuana tipu*
Verbena bonariensis		
Salvia tiliifolia		
Solanum pseudocapsicum		
Araujia sericifera		
Cuscuta campestris		
Cereus jamacaru		
Opuntia ficus-indica		
Gleditsia triacanthos		
Lantana camara		
Pyracantha angustifolia		
Eucalyptus spp		
Acacia podalyriifolia		
Ligustrum lucidum		
Solanum mauritianum		
Jacaranda mimosifolia		
Melia azedarach		
Gleditsia triacanthos		

- These are only species encountered during the surveys and not a complete list of aliens on the property

Animal Management

The reliable counting of wild animals on a game ranch is one of the cornerstones of effective wildlife management and it is recommended that a game census be undertaken at least every second year to determine game numbers, number of offspring and sex ratios. Counting of the animals is usually done in late summer and/or spring. Although different techniques exist to count game, it is important that the same technique is used on a particular ranch so that results can be compared from year to year. The cost of animal counts should, however, not be more than 1% of the total value of the animals. Important aspects regarding game in management include the following:

- Annual growth rate
- Age and sex composition
- Social organisation
- Behaviour of the population
- Population sizes

It is also important to record the annual mortality and/or animals taken off every year. The sex and approximate age of all carcasses found should be recorded as well as possible cause of death. Whenever animals are harvested, whether for trophy, venison or live sales, the species, age, sex, and body or carcass weight and trophy size where applicable should be recorded. A separate record sheet should be used for each species for every year, or from one count to the next. A blank recording sheet (**Figure 17**) and example of a completed sheet (**Figure 18**) is supplied (Zieger & Cauldwell 1998). Results from the current year's census are recorded first, including the structure of the population. Every consecutive observation during the year, which affects the total number of the particular species, is then recorded in terms of animal numbers and categories, including comments like trophy hunt (including trophy size and carcass weight), venison (including carcass weight), natural death or live sale. In this way information about the total number and population structure of every species will be available at any given time. By entering the minimum number of animals required in order to safeguard the population's viability, the annual harvesting quota can also be determined for every species (see **Figure 18**).

Species Account

Species: ___________

Period: ___________

Current population and harvesting quota

Date:	Total number	Adult males	Adult females	Subad. males	Subad. females	Juveniles
Count, start of this year	$= N_t$					$= B$
Minimum number						
Harvesting quota for coming season						

Actual harvest and natural deaths

Date	Comment	Number harvested	Found dead	Adult males	Adult females	Subad. males	Subad. females	Juveniles
Total		$= H$	$= D$					

Count, start of next year

Date	Total number	Adult males	Adult females	Subadult males	Subadult females	Juveniles
	$= N_{t+1}$					$= C$

Data required for parameter calculations:

Total count, start of this year	$= N_t$	
Total count, start next year	$= N_{t+1}$	
Juveniles, start of this year	$= B$	
Juveniles, start of next year	$= C$	
Total number harvested	$= H$	
Natural deaths	$= D$	
Unaccounted animals	$(N_t - N_{t+1} + C - H - D)$	$= E$

Population parameters:

Annual calving/lambing rate	$= (B \div N_t) \times 100$	%
Annual mortality rate	$= [(D + E) \div N_t] \times 100$	%
Annual growth rate	$= \{[(N_{t+1} + H) \div N_t] - 1\} \times 100$	%
Annual harvest rate	$= (H \div N_t) \times 100$	%

Figure 17: Species account recording sheet (Source: Zieger & Cauldwell, 1998)

Species Account

Species: ***Sable antelope***

Period: ***Dec 1995 – Dec 1996***

Current population and harvesting quota

Date: ***Dec 1995***	Total number	Adult males	Adult females	Subad. males	Subad. females	Juveniles
Count, start of this year	= N_t ***67***	***16***	***19***	***8***	***10***	= B ***14***
Minimum number	***54***	***10***	***16***	***7***	***7***	***14***
Harvesting quota for coming season	***13***	***6***	***3***	***1***	***3***	***0***

Actual harvest and natural deaths

Date	Comment	Number harvested	Found dead	Adult males	Adult females	Subad. males	Subad. females	Juveniles
20/2	***Carcass***		***1***			***1***		
3/3	***Carcass***		***1***				***1***	
1/7	***Trophy***	***1***		***1***		***(120 kg / 42 inch)***		
26/7	***Trophy***	***1***		***1***		***(132 kg / 44 inch)***		
29/7	***Trophy***	***1***		***1***		***(117 kg / 39 inch)***		
7/10	***Carcass***		***1***		***1***			
9/10	***Live sale***	***7***			***3***		***3***	***1***
Total		= H ***10***	= D ***3***					

Count, start of next year

Date	Total number	Adult males	Adult females	Subadult males	Subadult females	Juveniles
Dec 96	= N_{t+1} ***69***	***16***	***18***	***10***	***10***	= C ***15***

Data required for parameter calculations:

Total count, start of this year	= N_t	***67***
Total count, start next year	= N_{t+1}	***69***
Juveniles, start of this year	= B	***14***
Juveniles, start of next year	= C	***15***
Total number harvested	= H	***10***
Natural deaths	= D	***3***
Unaccounted animals	$(N_t - N_{t+1} + C - H - D)$	= E ***0***

Population parameters:

Annual calving/lambing rate	$= (B \div N_t) \times 100$	***20.9 %***
Annual mortality rate	$= [(D + E) \div N_t] \times 100$	***4.5 %***
Annual growth rate	$= \{[(N_{t+1} + H) \div N_t] - 1\} \times 100$	***17.9 %***
Annual harvest rate	$= (H \div N_t) \times 100$	***14.9 %***

Figure 18: Example of a completed species account record sheet (Source: Zieger & Cauldwell, 1998)

it is recommended to monitor tick loads on the animal species present on the farm. There are a number of apparatus in the market available for tick control on game, e.g. Tick-off, Duncan applicator and the Scorpion Dip Applicator and should be used to contribute to disease control of game species.

It is sometimes necessary to supply supplementary feeding such as lucern, antelope cubes, salt blocks and/or licks in the dry season. It is common for certain areas to have mineral deficiencies. These deficiencies affect animal productivity. Since animals are restricted in game reserves and ranches, it is necessary to provide supplements, because the animals cannot move freely in order to select the most nutritious food.

The nutritional value of grass species decreases as the grass matures, especially in autumn and winter. The digestibility also decreases with the maturation of the grass. Plant anatomy is the basic determinant of forage digestibility. Plant cell contents, being mainly carbohydrates and proteins, are almost completely digestible, but cell walls vary in digestibility according to their degree of reinforcement with lignin (Van Niekerk & Voigt 1999). As plants grow there is a greater need for fibrous tissues and therefore the main structural carbohydrates and lignin increase. Protein concentration decreases as the plant ages. Thus, digestibility decreases as plant increase in maturity. This tendency is more evident in sourveld regions. It is associated with deterioration in the condition of the animals. According to Bothma & du Toit (2016), the main objective of supplementary winter-feeding is to supplement deficiencies, as well as to stimulate the appetite of the grazing animal in order to better the utilisation of poorer grazing. Due to deficiencies in some of the macro-elements such as magnesium, sodium, phosphorus, calcium and sulphur, depressed growth or ill-health can occur in grazing animals. It is difficult to detect deficiencies in the trace elements because it only reduces the growth and fertility of the animal.

The protein concentration decreases as the plant ages. According to Niekerk & Voigt (1999), protein is probably the most common chemical component that limits animal performance. Generally, for ungulates on African veld, a minimum of five percent crude protein in natural pastures is required. Protein content varies among different forage species and generally declines with maturity. In general, the leaves of trees and shrubs seasonally provide a more constant and higher level of protein than the grasses. Considering that the leaves also contain tannins, alkaloids and other compounds that can interfere with digestibility, the proteins may be less available. The leaves of trees have less cellulose and hemicellulose than grasses. Due to seasonal loss and change of leaves, the chance that browsers could experience an energy shortage at certain times of the year is greater than for grazers. Thus, supplementation will usually be necessary during the autumn and winter months, when the protein levels are below the minimum requirements.

Protein supplements used in South Africa include peanut, fishmeal, whale meal, carcass meal, and blood meal. Corresponding with the dry season and forage quality, protein licks should be available four to eight months of the year.

Additional carbohydrates, required by animals for energy production, can be obtained from supplementary feeding. Mealie meal is the most important source of energy. As with protein supplements, energy licks should be available for four to eight months of the year.

As a supplement to natural grazing, appetite-stimulating licks with an ureum or protein base are preferred above supplementary energy-rich feeds as it increases the intake of dry material. The maximum ureum content of the licks must not exceed five percent (Bothma & du Toit 2016).

Practical recommendations

Salt forms a substantial component for all the supplementary licks. Not only does salt attract animals to the licks, but it also limits voluntary intake. Animals must be exposed to salt licks before adding another supplement. This ensures that they overcome salt hunger, thereby reducing the risk of animals abusing licks and having an over-dose.

It is important that lick containers be placed distributed in the veld so that the animals do not concentrate on certain places. In order to promote rotational grazing, licks should rather be placed in areas with unpalatable plants, than in overgrazed areas.

It is recommended that the licks should be placed on a cement base, so that it is not in contact with the soil. If the licks are placed directly on the soil leaching of the nutrients from the lick may occur. This can cause irreparable damage to the soils.

Types of supplementation

Mineral supplementation

The method of supplementation of a particular mineral depends to a large extent whether or not the mineral is stored in the body. Copper, cobalt, manganese, selenium and zinc are stored in a number of tissues and in the liver. Thus, supplementation with these minerals need only be at intervals. Molybdenum and iodine are not stored in the body so supplementation should be daily.

Salt licks are successful for mineral supplementation. The intake of minerals is regulated because animals apparently regulate their own intake of salt.

Phosphorus and calcium deficiencies are the most common in South Africa. Mineral supplements can be given in the form of a lick, consisting of the following:

- 45 kg dicalcium phosphate, 45 kg salt and 15 kg molasses, or
- Bonemeal, 30 kg salt and 15 kg molasses.

Due to the fact that mineral deficiencies are constant, it should not only be supplemented in winter. The soil type, rainfall and vegetation type of the area determines these deficiencies. The supplementation should be available throughout the year.

Protein supplementation

For levels below the minimum requirements of protein, supplementation will usually be necessary, particularly in autumn and winter months when the protein content of the veld and some summer grass pastures are inadequate. Physical limitations to the intake of the forage itself cannot be overcome by supplementation. Protein supplementation increases the rate of digestion, increases the rate of passage of digesta and may provide an additional source of amino acids at the tissues. Its net effect is one of increasing forage intake.

To improve the utilisation of low digestible crude foods, non-proteinaceous nitrogen (NPN) licks are also used. NPN sources are ureum and biuret. NPN licks provide the ureum that is broken down to provide materials for the rumen flora. When they die, they are broken down to provide a source of protein. NPN licks are cheaper than protein licks.

Ureum and biuret can be incorporated into mineral licks and lick blocks. Ureum poisoning can easily occur with an overdose. These licks usually contain dicalcium phosphate, a salt, making up 40 – 60 % of the mass. The salt can limit or encourage the ingestion of ureum. Ureum can be mixed with molasses syrup in order to reduce the chance of poisoning. Molasses and yellow mealie meal are added to make the lick palatable enough so that the minimum ureum is ingested.

Licks must not contain more than 5 % ureum for game. Thus, the salt concentration should be increased and the ureum concentration decreased when making the lick. When ureum is incorporated into a phosphate-salt lick, it is necessary to determine whether the animals are suffering from salt hunger and what percentage salt should be incorporated into the lick to limit intake. It is important that the animals must first be exposed to a phosphate-salt lick. This will ensure that they do not have salt hunger and hence the danger of ureum poisoning. The use of Biuret cancels the chance of poisoning, but it is, however, more expensive.

Rumevite licks, which consists of a mixture of mealie meal, dicalcium phosphate, ureum, dry molasses, salt and trace elements, provide preventative measures against ureum poisoning.

Similar lick blocks can be made, using the following percentages:

- dicalcium phosphate or bone meal 20
- mealie meal 10
- salt 40
- ureum 10
- molasses 15
- Lucern meal 5

Protein licks should be available for four to eight months of the year, corresponding with dry season and forage quality.

Energy-rich licks

Energy production by animals requires carbohydrates and additional carbohydrates can be obtained from supplementary feeding. Almost all grain and their by-products can be used as a basis for energy-rich licks. The most important source of energy is mealie meal, other sources are bran, oats, molasses and mealie germ meal. Voluntary increase in ingestion is increased with energy-rich licks, and is usually combined with protein licks. They should be available for four to eight months, depending on the forage quality.

The main objective of supplementary winter-feeding is thus to supplement deficiencies and to stimulate the appetite of the grazing animal so that poorer grazing is utilised more effectively. Appetite-stimulating licks with a urea or protein base are preferred above supplementary energy-rich feeds as a supplement to natural grazing. The amount of supplementation is dependent on the size of the animal and physiological condition. Only prescribed amounts of licks must be ingested. The local veterinary surgeon can be consulted as to what the local mineral deficiencies are in the area

Summer licks supply mainly phosphate, calcium and vitamin A and can contain trace elements such as copper, cobalt, iodine, manganese, zinc and magnesium. Winter licks contain energy, sometimes protein, urea, phosphate, calcium, sometimes trace elements and often vitamin A. Energy in the form of Kalori 3000 serves as a binding medium and improves the palatability of the lick.

The form and composition of licks varies between game types. In general licks are presented in the form of blocks, food pellets or energy food mixture in meal form. The best alternative though is to manage the veld well, so that no supplementary feeding is necessary. If supplementary feeding is required the following can be used in early winter and for the duration of winter:

- In Sourveld: 50% salt, 25% bonemeal or dicalcium phosphate, 20% K-3000 molasses and 5% urea.

Monitoring

A monitoring programme serves as an early warning system to detect changes or trends as a result of management actions, natural events or those areas where past mismanagement occurred with the goal to adapt management strategies where necessary. Aspects that need to be monitored are:

- climate (rainfall)
- veld condition in terms of plant species composition, species frequency, density and/or cover
- grass and browse biomass
- economic and ecological carrying capacity
- vegetation structure
- the effects of water provision
- the effects of bush encroachment and its control
- veld reclamation measures such as soil erosion control
- wildlife numbers, population growth, mortalities, wildlife distribution, herd composition, sex ratios and birth rates (breeding).

When management actions such as the release of megaherbivores are implemented on a game ranch, the possible changes caused by these actions should be monitored over time in order to facilitate and support decisions regarding the management of the ranch. Changes in the ecosystem may influence future management practices, and an adaptive management programme should therefore be followed.

Three important management programmes form the basis of adaptive management. This includes measuring vegetation change, animal performance and recording environmental conditions. It is necessary to measure the vegetation changes over time in order to obtain an indication of the success or otherwise the failures of the management programme. Vegetation monitoring is a logical outcome of the determination of veld condition. Vegetation surveys for monitoring changes in veld condition should be conducted at strategic places on the property. Care must also be taken when interpreting reasons for change, because the extent and nature of vegetation changes will depend on both management and on the environmental conditions which have been experienced. When monitoring vegetation, making use of the ecological status of the grass species can give an indication of the following:

- A change in species composition.
- Whether the ratio of plant species to each other has changed.
- Changes in ratios of Decreaser to Increaser grass species.

The adaptive management cycle is illustrated in **Figure 19**.

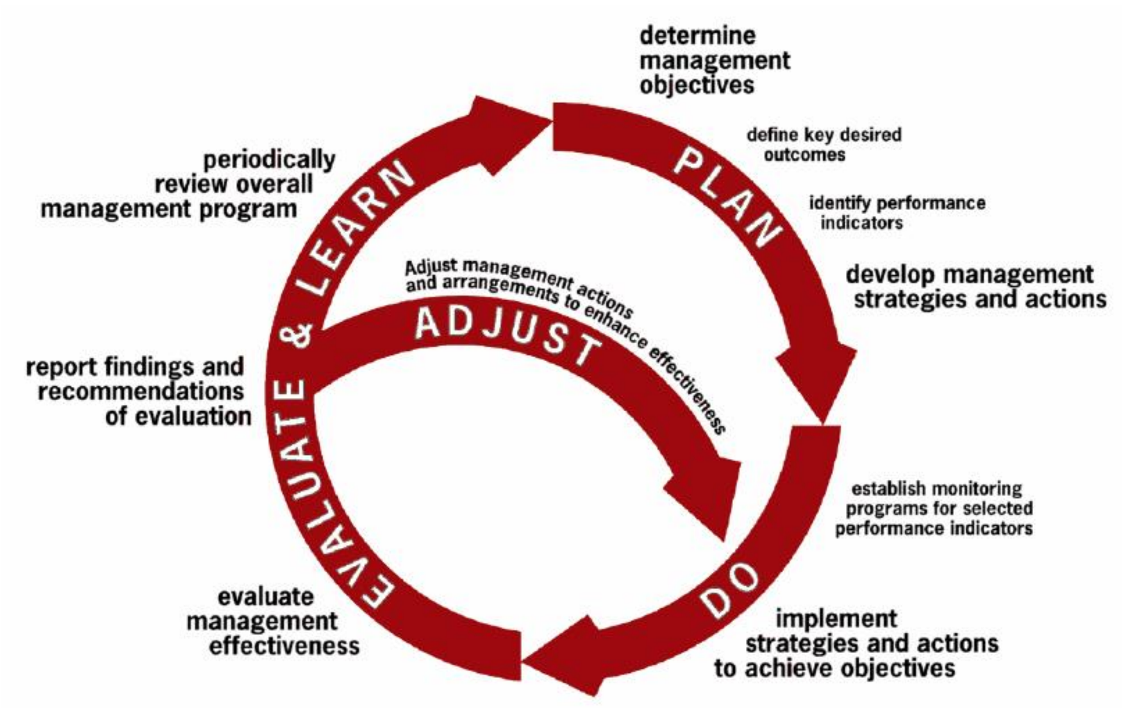

Figure 19: The Adaptive Management Cycle

In terms of the climate, it is important to measure the rainfall and temperature of the area. Long-term rainfall data should be obtained from the official weather station closest to the game ranch for comparative purposes and to determine long-term trends. The rainfall received on the ranch should also be monitored daily if possible. A reliable standard rain gauge can be used for this purpose. The minimum and maximum temperature should ideally also be measured daily at 8:00. This is usually done at a standard height of 1.2 meters above the ground, in a shaded and well-ventilated area (Bothma & Van Rooyen 2016).

Ecological monitoring of the habitat on a game ranch should aim at the purposeful and repeated examination of the state or condition of the habitat in relation to external stress (Van Rooyen 2002). This can be achieved by frequently testing the difference between baseline or initial surveys and follow-up surveys. It is necessary to measure the vegetation changes over time in order to obtain an indication of the success or otherwise the failures of the management programme being employed. In the past, ranchers relied on visual observations and their memory to monitor the changes in vegetation. Plant structure and species composition, however, constantly fluctuates from year to year and from season to season. Visual observations cannot distinguish between short term fluctuations and real changes in the vegetation. Fixed-points, or permanent reference sites, must be placed in each homogenous unit so that surveys can be conducted at these same points every year for monitoring purposes.

Monitoring points should be marked permanently with steel or wooden pegs planted or driven into the ground. To help locate the points, pegs can be painted yellow or white before installing them, and they should stand approximately 1 m above the ground in order to make them observable from a distance (Coetzee 2005). The permanent reference sites should be representative of the habitat type in which it is placed so that changes can be picked up and adjustments made accordingly. In order to compare the results of monitoring from year to year, it is furthermore essential to make use of the same scientifically acknowledged methods. This will ensure that real changes in the vegetation, as a result of the management system employed, are observed, and not changes due to climate.

A simple and inexpensive monitoring technique that should be implemented at every monitoring point is fixed-point photographic monitoring (Coetzee 2005). The use of this technique will result in a set of four photographs taken from a single point in each of the compass directions. Photographs are taken from a fixed point, at a fixed height, and in a fixed direction every time, making different sets of photographs comparable. Photographs will show changes in ground cover, vegetation density, plant canopy height, and even to some extend species composition. A field form (**Figure 20**) is then used to record information such as plant species composition, cover description and utilisation by animals, which is then filed together with the photographs for future reference.

PLOT NO:	DATE:	SURVEYOR:
GPS CO-ORDINATE:		
GRID REF NO:		

POINT DESCRIPTION: (How to find the plot marker)

HABITAT DESCRIPTION: (Use back of form, if necessary)

VEGETATION TYPE:

TREE & SHRUB SPECIES:

DWARF SCRUB SPECIES:

HERBACEOUS PLANT SPECIES:

COVER DESCRIPTION:

COVER TYPE	HEIGHT	% OF PLOT	DOMINANT SPECIES
CANOPY COVER			
GROUND COVER			

UTILISATION:

BROWSING INTENSITY:		PLANTS BROWSED	BROWSING HERBIVORES
HEAVY			
MODERATE			
LIGHT			

GRAZING INTENSITY:		PLANTS GRAZED	GRAZING HERBIVORES
HEAVY			
MODERATE			
LIGHT			

OTHER NOTES:

Figure 20: Fixed-point photograph record sheet (Source: Coetzee, 2005)

Summary of recommendations

For Waterlake Farm estate specifically, it is recommended to maintain firebreaks around the perimeter of the property, and around all the buildings and private residences. This can be cut with brush cutters or slashed throughout the year, and burned during May before the fire season starts.

It is important to maintain all roads and footpaths on the estate in order to prevent erosion. Drainage humps will have to be constructed and runoff water must be slowed down, especially where roads or paths are constructed on slopes. This is best done during the dry season from around April.

It is recommended to identify and mark the positions of all the exotic and invasive plants found on the farm, and to set up an appropriate control program for them. Integrated control should be applied where various suitable methods are used according to the specific species being controlled. Priority should be given to species and areas where the infestation is still low and the change of success thus higher. Follow up treatment is crucial for any control program and should be done every three months.

it is important to keep track of the numbers of game species present on the estate. Game numbers should be kept within the ecological capacity as calculated for the estate. Sex ratios of every species should also be kept correct in order to prevent fighting and to ensure maximum production. Excess animals should be removed on a yearly basis and it should be aimed to bring in new blood at least every two to three years in order to prevent inbreeding. For this purpose, male animals can be exchanged with other estates within Gauteng. Parasite loads should be monitored and if necessary controlled from January to April. Supplementary feeding will be required during the winter months when the nutritional value of the grasses decreases.

Fixed monitoring sites should be placed in all the habitats on the estate and at least fixed-point photographs taken annually. Ideally, vegetation surveys should be done at these sites annually or bi-annually and the results should be compared with previous years in order to pick up trends or changes as a result of management actions. An active adaptive management system should be followed where management strategies are adjusted where necessary as new information is obtained.

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Appendix 1: Results of the Step-point surveys for each survey site

	01	02	03	04	05	06	07	08	09	10	11	12
Aristida bipartita	5	3	5	17	4	0	0	5	0	0	0	0
Aristida congesta var. *barbicollis*	0	0	0	0	0	10	1	0	0	0	0	0
Aristida congesta var. *congesta*	0	0	0	0	2	0	0	0	0	0	0	0
Bewsia biflora	0	0	0	0	0	0	9	0	0	0	0	0
Bothriochloa insculpta	0	7	0	14	5	0	0	0	0	0	0	0
Brachiaria serrata	0	0	0	0	0	0	2	1	0	0	0	0
Cymbopogon caesius	0	0	0	0	14	0	0	8	0	0	0	0
Cynodon dactylon	2	8	0	18	46	18	3	3	0	0	0	0
Digitaria eriantha	0	8	19	4	5	1	1	1	0	2	0	0
Diheteropogon amplectens	0	0	0	0	0	0	0	2	0	0	0	0
Eragrostis chloromelas	70	70	45	4	14	40	17	0	0	3	0	1
Eragrostis gummiflua	0	0	0	0	0	5	0	0	0	0	0	0
Eragrostis nindensis	0	0	0	0	0	0	8	0	0	0	0	0
Heterpogon contortus	10	0	0	0	0	2	4	1	0	0	0	0
Hyparrhenia hirta	2	2	26	1	3	4	2	0	0	0	0	0
Hyparrhenia tamba	0	0	0	0	0	0	0	0	0	0	0	12
Melinis nerviglumis	0	0	0	0	0	0	0	4	0	0	0	0
Melinis repens	0	0	5	0	0	0	4	0	0	0	0	0
Panicum maximum	0	0	0	0	0	0	0	0	0	0	0	1
Panicum natalense	0	0	0	0	0	0	6	0	0	0	0	0
*Paspalum dilatatum**	0	0	0	0	0	0	0	0	0	0	0	47
Schizachyrium sanguineum	0	0	0	0	0	0	2	11	0	0	0	0
Setaria lindenbergiana	0	0	0	0	0	0	0	0	15	2	0	0
Setaria megaphylla	0	0	0	0	0	0	0	0	0	0	0	6
Setaria sphacelata var. *sphacelata*	1	0	0	3	0	0	0	0	0	0	0	31
*Sorghum halepense**	0	0	0	0	2	0	0	0	0	0	0	2
Sorghum versicolor	0	0	0	23	0	0	0	0	0	0	0	0
Sporobolus africanus	0	2	0	0	0	0	0	0	0	0	0	0
Sporobolus ioclados	0	0	0	2	1	0	0	0	0	0	0	0
Sporobolus pyramidalis	8	0	0	0	0	2	0	0	0	0	0	0
Themeda triandra	2	0	0	0	4	9	5	21	0	0	0	0
Trachypogon spicatus	0	0	0	0	0	0	3	0	0	0	0	0
Tristachya leucothrix	0	0	0	0	0	0	27	39	0	0	0	0
Urelytrum agropyroides	0	0	0	0	0	0	6	1	0	0	0	0
Urochloa mosambicensis	0	0	0	14	0	0	0	0	0	0	0	0