Use of grazing lawns by large herbivores

In the Compassberg Protected Environment, South Africa

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livinglands

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Abstract:

The Compassberg Protected Environment (CPE) in South-Africa suffers severely from erosion in the form of gullies.

Herbivory, bare soil, little water capture and lack of vegetation are the most important factors that contribute to erosion in the CPE. Grazing lawns are a vegetation type that is only found in South-East Africa. Grazing lawns can combat erosion more efficiently than any other vegetation type in South-Africa, and counters all factors that contribute to erosion in the CPE.

Living Lands is a non-governmental organisation (NGO) that cooperates with the private landowners of the CPE to combat erosion. The organisation and landowners want to reach a stadium where erosion is strongly reduced. This stadium can be achieved by creating grazing lawns around the gullies and by expanding the existing grazing lawns in size.

Recently, Living Lands did a lot of research into grazing lawn characteristics. However, several factors still need to be identified to develop an effective management strategy:

1. *The grazing pressure on each grazing lawn*. The grazing pressure directly determines the size and presence of a grazing lawn because grazing lawns consist of lawns grasses which out-compete bunch grasses under a high grazing pressure.
2. *The grazer species that use the grazing lawns.* Each species has a different feeding behaviour and consumes a different amount of grasses per day, so each species has a different influence on the presence of the grazing lawns.
3. *The effect of management treatments*. Each treatment has a different effect on the use of grazing lawn by large herbivores. It is important to know the effect of management treatments to develop a management strategy.

These factors led to the main research question: **What is the effect of large grazers, fertilising and mowing on the grazing lawns in "Diepkloof"?** Camera traps and dung counts were used to collect data on the effects of grazing, mowing and fertilising on grazing lawns.

1. It is concluded that the grazing pressure on the grazing lawns is relatively low (0.002 – 0.02 kg per day per m2) and should be increased to ensure the future presence of the grazing lawns. The main factor that influences the difference in grazing pressure between the grazing lawns is the size of the lawns. A secondary influence is a difference in the percentage of bunch grasses growing on each grazing lawn.
2. Black wildebeest, Blesbok, Cow and Springbok are classified as frequent users of the grazing lawns in “Diepkloof”. Grey rhebuck, Greater kudu, Klipspringer, Mountain reedbuck and Steenbok antelope are classified as rare users of the grazing lawns. The only species that have a significant influence on the grazing pressure and presence of the grazing lawns are Black wildebeests and Cows because they consume more kilogrammes of grasses than other species and appear in high densities.
3. The factor that leads to the highest increase in intensive use of the grazing lawns is no management, followed by fertilising with phosphor in combination with mowing once a year. However, most treatments involve mowing which increases the grazing pressure in a semi-natural way, so treatments that involve mowing may be more effective than the results show. More research needs to be done into the effect of management treatments.

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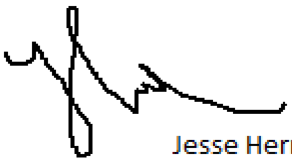

Jesse Hermens

List of acronyms:

Compassberg Protected Environment:	CPE
Correlation coefficient:	R2
Floor Area Ratio:	FAR
Grazing lawn area:	Agl
Grazing Pressure per Grazing lawn:	Pgl
Grazing Pressure per Species:	Psp
High Definition:	HD
Kilogrammes:	Kg
Non-governmental organisation:	NGO
Number of monitoring days:	D
Number per square metre:	N/m2
Probability-value:	P-value
Secure Digital-Card:	SD-Card
Square metre:	m2
Terra Mare Properties:	Pty
Total area of grazing lawns in m2:	A
Total frequency:	F
Universal Transverse Mercator	UTM
Van Hall-Larenstein University of Applied Sciences:	VHL

Glossary of terms:

Bunch grass:	Perennial grasses that grow in a cluster and are relatively intolerant against herbivory and drought. Bunch grasses contain fewer nutrients than lawn grasses and are less palatable for large grazers.
Camera trap:	Camera traps are devices used to monitor the presence and behaviour of wild animals. Camera traps collect data by photographing or filming individuals based on programmed settings.
Dung Count:	A dung count is a method of data collection based on counting and identifying dung pellets. The grazing population can be estimated by analysing the data collected with this method.
Dung Pellet:	Several dung droppings clumped together, produced during one defecation by one individual. Each dung dropping in a dung pellet has roughly the same shape and size.
Grazing lawn:	Areas in East Africa that consist of short nutrient-rich grasses. A grazing lawn consists of lawn grasses that are tolerant of drought and herbivory. Grazing lawns are created through intense grazing and are a natural tool against erosion.
Grazing lawn use:	The act of grazing and/or defecating on grazing lawns by large grazers. Grazers always make potential use of grazing lawns, because the camera traps and dung counts can only confirm the presence of individuals.
Grazing pressure:	The pressure exerted by large grazers on grazing lawns, given in consumed kilogrammes of grass per day per square metre. The grazing pressure is determined by the grazer species and the number of individuals using a grazing lawn and consumed kilogrammes.
Karoo vegetation:	A vegetation type that consists of deciduous plants, dwarf shrubs and grasses. A Karoo vegetation has a low density per square metre and contains a lot of bare soil.
Large grazers:	Herbivores that feed on plants and grasses with a minimal height of 30 centimetres. Species classified are classified as large grazer in this research vary from small antelopes to Black wildebeest.
Lawn grass:	Grasses that are more tolerant of herbivory and drought than other grasses. These grasses also contain more nutrients than most grasses.
Milton:	An area of several square metres where a grazing herd often defecates. These areas contain more bare soil and high densities of dung pellets.
Sighting:	An observation of an animal or herd during a certain time period. A sighting lasts from the moment when an individual is sighted on a grazing lawn till the moment it leaves the grazing lawn.

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1. Introduction:

1.1 Context and Project background:

Grazing lawns are areas in East-Africa that consist of short nutrient rich grasses (McNaughton, 1984). Large grazers create and maintain grazing lawns through intense grazing (McNaughton, 1984). Grazing pressure influences the vegetation composition, primary production of the area and the size of grazing lawns (McNaughton, 1984). Grazing lawns shrink in size when the grazing pressure is low and increase in size when the grazing pressure is high (Hempson et al., 2015). Grazing lawns are nutrient rich because grasses are kept short in a highly productive state (McNaughton, 1984).

Figure 1 shows a schematic image of a grazing lawn. Figure 2 shows one of the grazing lawns present in the project area, both figures are meant to give a better visualisation of the concept grazing lawns. Grazing lawns consist of lawn grasses and the surrounding areas consist of bunch grasses. (Hempson, et al., 2015; McNaughton, 1984; Novellie & Gaylard, 2013). Lawn grasses contain less stem and are richer in nitrogen and phosphor than bunch grasses (Prins, 2016), this is why large grazers find lawn grasses more palatable than bunch grasses (Prins, 2016). Lawn grasses thrive on grazing lawns because they are very tolerant of herbivory and drought (Veldhuis et al., 2014; Hempson et al., 2015). Grazing lawns are basically a natural nutrient pump because they continuously produce an increased amount of nutrients.

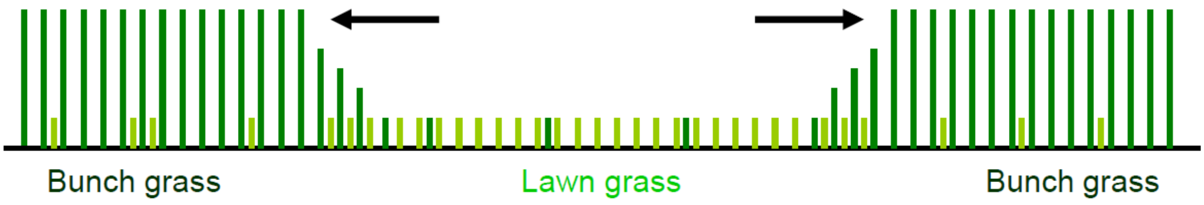

Figure 1: Schematic image of a grazing lawn and the difference between lawn grasses and bunch grasses (Prins, 2016).

Figure 2: Grazing lawn 2. in “Diepkloof”, presenting the visual difference between the a grazing lawn and the surrounding vegetation (Jesse Hermens).

Grazing lawns are important because they can combat erosion by providing soil cover and enhancing water capture (stewardship, 2013). Grazing lawns are more efficient in preventing erosion, than other vegetation types in East-Africa, because grazing lawns have a higher density of grasses per square metre (Reijers, 2015). Large grazers and other species are dependent on grazing lawns for their required food intake. Grazing lawns represent considerable economic, ecological and practical value.

This research is commissioned at the request of Living Lands, a non-governmental organisation (NGO) that focuses on nature and restoration of degraded landscapes. Living Lands manages "Diepkloof", an area of the Compassberg Protected Environment (CPE), South Africa. This area suffers from erosion and land degradation. The goal of Living Lands is to create a management strategy for grazing lawns in "Diepkloof" to protect the area against erosion.

Erosion and land degradation are a problem in South-Africa and have a negative influence on the development, economy and ecosystems (Le Roux, 2013). Living Lands wants to use this management strategy to combat erosion in other areas throughout South-Africa as well if the strategy is a success in the CPE.

1.2 Problem description:

The CPE suffers from land degradation, water- and wind erosion. Gullies are the main visible result of erosion in the area. Gullies are created by running water that erodes deeply into the soil, this results into small valleys (Ziebell, 1999). It is desired to achieve a stadium where erosion is strongly reduced and controlled within the CPE.

Herbivory, bare soil, little water capture and lack of vegetation are the underlying causes that contribute to erosion in the CPE. Grazing lawns contribute to erosion prevention by reducing the amount of bare soil, enhancing water capture and increasing the vegetation density.

Erosion can be strongly reduced by creating grazing lawns around gullies and increasing the size of the current lawns (Tucker, 2016). A high grazing pressure is needed to maintain newly created grazing lawns. A high grazing pressure can be achieved by attracting large grazers to the grazing lawns by fertilising with either nitrogen or phosphor.

However, the organisation is relatively new in the area and unfamiliar with the concept of grazing lawns. Information on the following three subjects is needed to be able to develop a management strategy:

- Vegetation characteristics
- Soil characteristics
- Grazing pressure
- Grazer species that use the grazing lawns
- Effect of management treatments

Last year, Living Lands executed two studies on grazing lawns in “Diepkloof”. One study was focused on identifying vegetation and soil characteristics of the grazing lawns by M.Reijers (2015). The objective of the second study was to determine the influence of several management treatments.

The effect of management treatments, grazing pressure on the grazing lawns and grazers that use the grazing lawns in “Diepkloof” are still unknown, but information about these subjects is necessary to develop a management strategy.

1.3 Objective and research questions:

The objective of this study is to identify these three unknown factors to protect the CPE against erosion. These factors are important for the development of a management strategy because of the following reasons:

- It is important to know the *grazing pressure on each grazing* lawn since grazing lawns are created through grazing: Lawn grasses can grow because they are more resistant to herbivory than bunch grasses. So grazing lawns exist only when the grazing pressure is high enough.
- It is important to know which *grazer species forage on the grazing lawns* in “Diepkloof” because each species consumes a different amount of kilogrammes (kg) per day. So each species exerts a different pressure on the grazing lawns, meaning that each species has a different influence on the presence of grazing lawns.
- *Management treatments* have a huge influence on the grazing pressure. The frequency and kind of management treatments determine whether a grazing lawn increases or decreases in size. The frequency and effect of management treatments also determine if new grazing lawns can be created.

This absence of knowledge has led to the main research question:

What is the effect of large grazers, fertilising and mowing on the grazing lawns in "Diepkloof"?

Three sub-questions are developed to answer the main research question. Each sub question is focused on one of the unknown factors.

- Q1. What is the grazing pressure on each grazing lawn in “Diepkloof”?
- Q2. Which large grazers make use of the grazing lawns in “Diepkloof”, and what is the grazing pressure that each species exerts?
- Q3. Which management treatments lead to more intensive use of the grazing lawns in “Diepkloof” by large grazers?

1.4 Thesis outline:

The objective of this research is to cover the knowledge gap, hindering Living Lands in the development of a management strategy for the grazing lawns in “Diepkloof”. The grazing pressure on the grazing lawns, grazer species that make use of the grazing lawns and the effect of management treatments on the grazing lawns are the factors that need to be identified.

The literature study in section 2 is meant to understand the concept grazing lawns, identify knowledge gaps and to select proper research methods to execute this research.

An area description and description of the grazer species present in the area are given in section 3. A site selection is made to ensure that accurate data is collected and that this research is feasible within the available time frame.

Camera traps and dung counts are the methods used to collected data and are described in section 4. The data analysis used to create the results is described in section 4 as well.

The results collected during the fieldwork are present in section 5. Each result focuses one of the sub-questions, enabling the development of a management strategy in the future.

Section 6 compares the collected results to other research and studies. Chapter 6 also discusses several factors that have an influence on the results.

The conclusion is given in section 7 and answers the main research question. This report helps Living Lands to develop a management strategy for the grazing lawns in “Diepkloof”.

Recommendations and suggestions for future research are given in section 8.

2. Literature review:

This review contributes to the following subjects: grazing lawn properties, grazing lawn management, camera traps and dung counts. The purpose of this study is to understand the concept of grazing lawns and to select proper methods to collect data.

The literature used in this review is about grazing lawns in Africa. Literature used in this review are retrieved from high-quality sites like Jstor (ITHAKA, 2000), research gate (researchgate.net, 2008) and Nature.com (Mc Millan Publishers). Keywords or search terms are: “Grazing lawn properties”, “Grazing lawn initiation”, “Grazing lawn management”, “Effects of grazing on grazing lawns”, “Grazing lawn usage”, “camera trap methods” & “dung counts”. Most of the used document are found by inserting these keywords into google scholar. The commissioning organisation provided several documents as well that are used in this literature review.

2.1 Grazing lawn properties:

Methods and examined properties:

Two methods are commonly used in research to identify the effect of rainfall and fire on grazing lawns characteristics such as vegetation and soil properties. Both methods are described below:

The first method consists of multiple plots placed on a grazing lawn. Half of these plots are fenced while the other half remains unfenced. This method enables us to observe the influence of grazers on vegetation and the changes in the vegetation. McNaughton (1984) and Novellie (2013) used this method to establish facts on water-soil-plant balances, effects of grazing on vegetation composition and the influences of rain and fire on the grazing lawns. The number of plots, total area and duration of the research varies between the studies.

The second method consists of only unfenced plots on both the grazing lawns and the surrounding vegetation. This method enables a comparison between grazing lawns characteristics and the characteristics of the surrounding vegetation. The effect of fire and rainfall can also be measured with this method. Plots are spread over a relatively large area. Spreading plots over a large area enhances the susceptibility to external influences. However, plots on a small area provide bias as well, because the plot characteristics may differ from the surrounding area. Studies that used this method differ in the number of plots, area size and duration of the research.

Several studies were conducted on specific grazing lawn characteristics and interactions.

> Archibald (2008) looked into the influence of fire. This study focuses on an area where fire occurs regularly (Archibald, 2008). Archibald only uses unfenced plots, varying in size.
>
> Kraaij”s (2009) study focuses on fire frequency and its influence on nutrient availability. His study uses spatial counts to determine the post-fire dispersal of a grazer population (Kraaij & Novellie, 2009).

The study of D.Stock and J.Bond (2009) examine if grazing lawns occur more frequent on specific soil types. The plots are placed on multiple soil types and are unfenced (D. Stock & J. Bond, 2009).

One study uses padlocks with various grass species (Prins, 2016). The research identified which grass types grazers prefer. The research determined that grazers prefer several kinds of lawn grasses above bunch grasses.

M.Reijers (2015) executed a research on grazing lawns in the CPE, to identify vegetation and soil characteristics. She divided the grazing lawns into four quadrants and took 12 random soil samples per quadrant.

Known facts:

The studies described above investigate grazing lawn properties, and determined the following facts:

Grazing lawns are created and maintained through intense grazing (McNaughton, 1984; Archibald, 2008; Teague et al., 2008; Novellie & Gaylard, 2013; Hempson et al., 2015; Reijers, 2015; Prins, 2016). Grazing lawns expand in size when all palatable grasses on a grazing lawn have been eaten (Archibald, 2008). A grazer randomly starts eating a new patch of grass (bunch grass), adjacent to the grazing lawn (Archibald, 2008). This new patch of grass is consumed to 2/3rd of its original height (Archibald, 2008), this process continues until a grazing lawn is large enough to support the needs of the grazing herd (Archibald, 2008). The bunch grasses are now subjected to herbivory and are slowly outcompeted and replaced by lawn grasses.

Intensive grazing leads to an increased forage quality because the grasses are kept in a nutrient rich state of growth (McNaughton, 1984; Reijers, 2015; Veldhuis et al., 2014). An increased forage quality means more nitrogen and phosphor per bite and better digestibility (McNaughton, 1984; Novellie & Gaylard, 2013; Veldhuis et al., 2014; McGranahan & Kirkman, 2003; Hempson et al., 2015; Reijers, 2015). Nitrogen, phosphor and sodium are the nutrients commonly found on grazing lawns. Nitrogen, phosphor and sodium are the nutrients that grazers require and are present in higher amounts on grazing lawns than on the surrounding vegetation (Veldhuis, 2014; Hempson et al., 2015; Prins, 2016).

Rainfall and its distribution have a big influence on the size of a grazing lawn (McNaughton, 1984; Archibald, 2008; Teague et al., 2008; McGranahan & Kirkman, 2003; Reijers, 2015; Prins, 2016). Rainfall allows a fast recovery and regrowth against intense grazing; this results in more available nutrients (McNaughton, 1984; Archibald, 2008). A dry period results in a slow regrowth, this means that there are less available nutrients. The required food intake of grazers can be fulfilled in a small area during a period of high precipitation (Archibald, 2008; Hempson et al., 2015). A much larger area is needed to fulfil the same the required food intake, during a season of drought.

Fire resets all grasses in an area to a short but nutrient rich state, this results in a post-fire dispersal (Archibald, 2008; Teague et al., 2008; McGranahan & Kirkman, 2003). All grasses provide the same amount of nutrients, this results in random grazing by large grazers (Kraaij & Novellie, 2009). New grazing lawns are created this way because grazers consume grasses on new locations.

The grass species that are most commonly found on grazing lawns are *Sporoblus*, *Eragrostis*, *Cynodon*, *Dactyloctenum*, *Digitatria longiflora*, *Sporobolus nitens* and *Urochloa* (McNaughton, 1984; Veldhuis, et al., 2014; Hempson et al., 2015). These species are all lawn grasses and are more tolerant of drought and herbivory than bunch grasses (McNaughton, 1984; Veldhuis, et al., 2014; Hempson et al., 2015). Lawn grasses are more resistant to grazing because they have horizontal stems or branched stolons with short internodes (Hempson et al., 2015; Prins, 2016). The canopy density is much higher on grazing lawns than the surrounding vegetation (McNaughton, 1984; Veldhuis et al., 2014). A high density makes grasses more attractive for grazers because this generates a greater food yield per bite (McGranahan & Kirkman, 2003; Hempson et al., 2015). Areas with a high density are also able to catch a lot of soil and absorb more water.

Novellie and Gaylard (2013) examined the long-term use of grazing lawns by cattle. Intensive use may lead to erosion and land degradation. However, the research shows that lawn grasses can resist high levels of herbivory. Novellie and Gaylard (2013) conclude in their research that grazing lawns can be used under any grazing pressure. Two reasons are identified that explain why lawn grasses are tolerant of herbivory:

- Herbivory removes old ineffective leaves and exposes new leave tissues to the sunlight (McNaughton, 1984); this explains why grazing lawns are not susceptible to overgrazing.
- Grazing lawns contain a high density of lawn grasses, which are a natural defence mechanism against herbivory (McNaughton, 1984); this is one of the reasons why grazing lawns are not sensitive to overuse.
- However, intensive use leads to trampling (Veldhuis et al., 2014; Hempson et al., 2015). Frequent trampling leads to a compaction of the soil, resulting in a change of hydrology (Veldhuis et al., 2014; Reijers, 2015).

Several studies point out that grazing lawns do not uniformly come into existence by grazing (D. Stock & J. Bond, 2009; Veldhuis et al., 2014). Several studies confirm that grazing changes the plant water balance (Veldhuis et al., 2014; Reijers, 2015). Hydrology is likely a factor of influence that contributes to the creation of grazing lawns (Veldhuis et al., 2014; Reijers, 2015). Grazing changes the water balance because more water is absorbed and evaporate on areas with short grasses. Changes in hydrology ultimately lead to grasses that are drought tolerant (Veldhuis et al., 2014; Hempson et al., 2015).

D.Stock & J.Bond (2009) state that soil characteristics play a role in the location of grazing lawns. However, they found no correlation between the soil characteristics and the presence of grazing lawns (D. Stock & J. Bond, 2009).

2.2 Grazing lawn management:

Methods and examined properties:

The most commonly used method to obtain information about the effect of management treatments on grazing lawns is designed by Prins (2016). This method is based on a multi-plots design (figure 3). Figure 3 shows the plots design used by Prins (2016), the plot consist of nine sub-plots. Several plots are established on a grazing lawn (Prins, 2016). The plots are 600 by 300 metres, and the sub-plots are 200 by 100 metres. Prins' (2016) study experiments with several management treatments to determine their influences on grazing lawns (Prins, 2016). These treatments recreate grazer influences by imitating grazing (mowing) and defecation (fertilising). Each sub-plots has its unique combination of mowing and fertilising.

Mowing is done 1 – 3 times a year, all the plots in a row are mown in the same frequency (figure 3). Row 1 is mown once a year, row 2 is mown twice a year, etc. Blue sub-plots in figure 3 are fertilised with nitrogen, red sub-plots are fertilised with phosphor and light blue sub-plots are not fertilised.

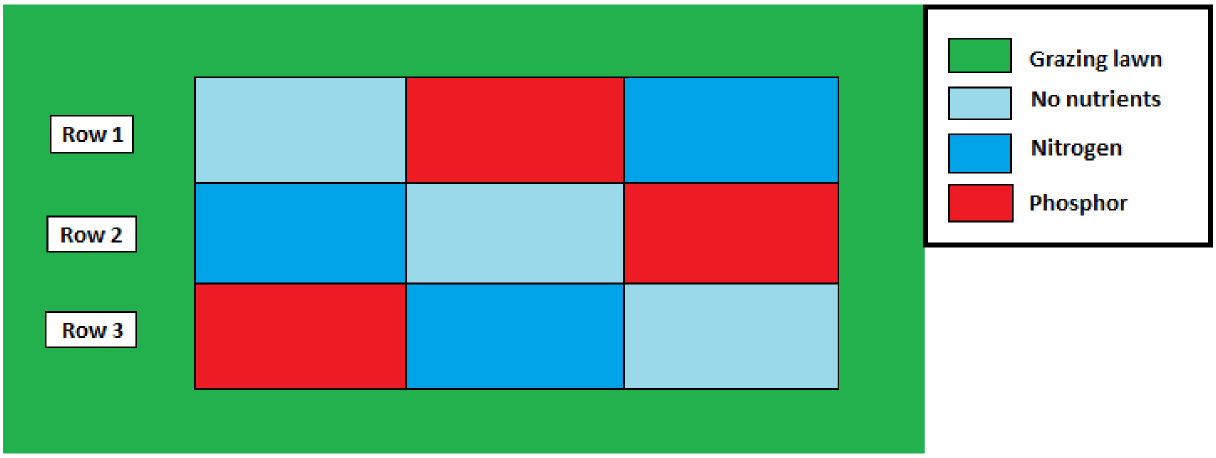

Figure 3: Plots design by Prins (2016) on the effects of management treatments on grazing lawns (Prins, 2016).

A similar design is used by Living Lands in "Diepkloof" (Tucker, 2016). Grazing lawns are divided into four quadrants, figure 10. Three of these quadrants are mown, and two of them are fertilised with either nitrogen or phosphor (Tucker, 2016).

As mentioned before in section 1.2, Living Lands performed a study on the effect of management treatments on grazing lawns. Living Lands executed four management treatments on the grazing lawns in "Diepkloof": mown once a year, fertilising with phosphor in combination with mowing once a year, fertilising with nitrogen in combination with mowing once a year; and no management. Each grazing lawn consists of four quadrants, table 1 shows which management activity was applied on each quadrant. The treatments were executed last year. However, the effect of these management treatments is still unknown because it takes time for the effects to be visible. The effects will be examined in this research, now that one year has passed.

Table 1: Executed management treatments on each quadrant, per grazing lawn in "Diepkloof".

Lawn	Quadrant:			
	1	2	3	4
1	No management	Mown and fertilised with phosphor	Mown	Mown and fertilised with nitrogen
2	Mown and fertilised with phosphor	No management	Mown and fertilised with nitrogen	Mown
4	No management	No management	No management	Mown

Known facts:

Grazing lawns can be established by mowing once a year (Hempson et al., 2015; Prins, 2016). An area needs to be at least 15 by 15 metres, to be converted into a grazing lawn (Prins, 2016). Smaller areas will contain a lot of unpalatable grasses (Prins, 2016). Grazing lawns can also be created in a semi-natural way by increasing the number of grazers (Prins, 2016).

Fire is a tool to create grazing lawns (Kraaij & Novellie, 2009; Prins, 2016). Season and frequency are the main parameters to consider when using fire as a management tool (Kraaij & Novellie, 2009; Prins, 2016). A low fire frequency and a high density of grazers lead to an expansion of grazing lawns (Kraaij & Novellie, 2009; Prins, 2016). It is recommended to use fire once every eight years (Kraaij & Novellie, 2009). Fire decreases the biomass and grass height; this results in an increased forage quality and post-fire dispersal. New grazing lawns attract more grazers; this results in an expansion of grazing lawns because of an increased grazing pressure (Hempson et al., 2015; Prins, 2016).

Grazing lawns can withstand use by cattle but seem vulnerable to goats and sheep (Hempson et al., 2015). It is recommended to have a buffer present that can be used when grazing lawns are not recovering due to minimal rainfall. A multiple species herd leads to the most effective use on grazing lawns (Teague et al., 2008; Adams, 2010).

Grazers are often shot to protect them from starvation or/and hunger (Archibald, 2008). Grazing lawns are created through intense grazing. Shooting individuals of a grazing population reduces the grazing pressure on the grazing lawn, this results in less nutrient rich grasses available (Archibald, 2008). Shooting animals has an indirect negative effect, this results in more hunger and starvation (Archibald, 2008).

2.3 Camera traps:

Camera traps made research into species presence and behaviour a lot easier (Ancrenaz & Andrew. J., 2012). Camera traps are a non-invasive tool that can be used continuously over a longer period in places that are difficult to access (Ancrenaz & J. Andrew, 2012; Cutler & Swan, 1999). Other advantages of camera traps are: camera traps last as long as their picture storage permits; work day and night; usable for spatial analysis; usable over a large area (Ancrenaz & J.Andrew, 2012). Camera traps also have several disadvantages such as: regular emptying; costs; difficulties to detect small animals; problems with battery duration (humidity); and a wrong set-up can result in little to almost no data collection (Ancrenaz & J.Andrew, 2012).

Several technical characteristics have an influence on pictures quality and site selection (Trolliet, 2014). The most important factors are trigger speed, the detection zone, recovery time, picture resolution, flash, active/passive and if the camera type is digital or film (Ancrenaz & J.Andrew, 2012; Trolliet, 2014; Meek & Guy, 2012; Rovero & Zimmermann, 2013).

Trigger speed is the time delay necessary for the camera to shoot once an animal has broken the infrared sensor (Trolliet, 2014; Meek & Guy, 2012; Rovero & Zimmermann, 2013). A slow trigger speed does not allow the photographing of fast moving individuals (Meek & Guy, 2012).

The detection zone is the zone covered by the camera's infrared beam. This function detects movement (Trolliet, 2014; Rovero & Zimmermann, 2013). The detection distance of a camera is important when focusing on animal species with a small body mass. Larger animals are easier to detect at further distances than smaller animals.

Cameras working on an infra-red laser are called "active camera traps" (Ancrenaz & J.Andrew, 2012; Rovero & Zimmermann, 2013). There are also passive camera traps based on body heat (Ancrenaz & J.Andrew, 2012).

Recovery time is the amount of time necessary for a camera to prepare the next shot after it was last triggered (Meek & Guy, 2012; Rovero & Zimmermann, 2013). The time can vary from 0.5 seconds to a full minute.

Picture resolution determines the number of megapixels in a picture (Rovero & Zimmermann, 2013). More megapixels per picture gives a sharper more detailed result, but also consumes more memory, this results in fewer photos.

There are two kinds of flashes: black and white. Black flashes present pictures in black and white, while a white flash presents pictures in colour (Ancrenaz & J.Andrew, 2012; Meek & Guy, 2012).

Camera traps should be placed on at the height of 30-40 centimetres to monitor small animals and higher for other species. Higher placed camera traps, will not provide specific data like sex (Ancrenaz & J.Andrew, 2012; Meek & Guy, 2012).

A camera should be positioned horizontally on a flat surface (Meek & Guy, 2012). A camera should be placed at a sharp angle when put on a hillside.

All hindering vegetation should be removed after placing the camera traps (Ancrenaz & J.Andrew, 2012; Meek & Guy, 2012).

Highly visited areas by people should be avoided because persons might trigger a trap and scare off animals (Ancrenaz & J.Andrew, 2012; Meek & Guy, 2012).

2.4 Dung count:

Dung counts are a method to estimate the population and distribution of animal species (The Deer Initiative, 2008). Dung counts can also estimate the grazing pressure exerted on a certain area (Best Practice Guidance). Dung counts are most efficient and accurate in enclosed areas because the movement of herds between areas could cause an inaccurate representation of the size of the population (The Deer Initiative, 2008). Dung counts can also be used as a tool to observe the impact of management treatments (The Deer Initiative, 2008).

Dung counts are usually done around an area that attracts many individuals, such as drink troughs or grazing lawns (Thrash et al., 1993). This method is relatively labour intensive and time-consuming (Boafo, et al., 2009).

The following information needs to be identified to execute an effective dung count:

- "What is the purpose of the collected data?"
- "What is the size of the survey area?"
- "Which animal species are present in the area?"

Data collection goes very slow if the persons conducting a dung count are not aware of the species living in the area. Being familiar with these species present in the area, and being able to distinguish their dung, allows fast data collection.

There are multiple sampling methods to execute a dung count these differ in plot size, plot shape and frequency. The following sampling methods are often used:

- Permanent sample plots: A relatively large area is examined with this method. Permanent sample plots are established varying between 10m2 and 50m2. All dung pellets are counted within a sample plot. Dung counts are repeated at a regular interval, depending on the grazing pressure.
- Floor Area Ratio (FAR) Method: This method counts the number of dung pellets, based on the fact that defecation rates are constant within a species (The Deer Initiative, 2008). The survey area is divided into different vegetation types based on age, vegetation and soil. Plots are randomly placed, whenever a dung pellet is sighted, the plot size should vary between the 50m2 – 200m2.
- 50 X 1M linear plot: Permanent sample plots are established in a line of 50 by 1 metre, the number of dung pellets is counted each week. Old dung should be removed from the plot after counting.

2.5 Knowledge gaps:

There are a few knowledge gaps on grazing lawn characteristics and the effects of grazing and plant-water-soil balances. The following factors are still unknown or not known in detail:

- Heterogeneous herds create niche options because species eat different parts of the grass. Each species eats grasses down to a different height (Adams, 2010). Ann Adams (2010) points out that species have a preferential feeding behaviour, this results in optimum utilisation of the nutrients available (Adams, 2010). Little information is available about the use of multi-species herds on grazing lawns.
- No clear information is available on the effects of soil temperature on grazing lawns, so this needs to be studied in more detail.
- Various studies mention that hydrology is a major factor in grazing lawn development. More research needs to be done to get a better indication of the exact role of hydrology in the creation of grazing lawns.
- Goats and sheep consume more kilogrammes of grasses than other grazers and eat grasses to their base (crown). Farmer/land owners do not want these species on their grazing lawns. Thus the exact effects of goats and sheep on grazing lawns is currently unknown.

Much data and information are available on grazing lawns in East-Africa, but not much is known on grazing lawns in South-Africa, especially in the CPE. Only one pilot study has been executed in the CPE on vegetation and soil characteristics because of this the following information is still unknown:

- Living Lands is familiar with the species that live in the CPE. However, the organisation does not know which species make use of grazing lawns in the CPE and in which numbers.
- The grazing pressure on the grazing lawn in “Diepkloof” are currently unknown.
- Fire has never been used as a management tool in “Diepkloof”, nor did any natural fires occur. The effects of fire and the possibility of fire as a management tool in “Diepkloof” are currently unknown.
- The CPE is located in a relatively high and mountainous area. The escarpment has an unknown influence on the grazing lawns in “Diepkloof”. The organisation believes that hydrology plays a prominent role in the creation and processes of the grazing lawns in “Diepkloof”, but they need to research this further.
- The grazing lawns in “Diepkloof” have not been managed before. The effects of management treatments on the grazing lawns in “Diepkloof” are unknown.

2.6 Literature conclusion:

This sub-section states useful facts to develop a management strategy. These facts focus on grazing lawn properties and grazing lawns management. This sub-section also defines the selected methods.

Grazing lawn properties

The following factors need to be considered when developing an effective management strategy:

- Creation and expansion of grazing lawns happen naturally by grazing, based on the grazing pressure.
- Intensive grazing results in an increased forage quality, because grasses are kept in a nutrient rich state (McNaughton, 1984; Reijers, 2015; Veldhuis et al., 2014).
- Rainfall affects the grazing lawn's size because this allows faster growth and recovery of the grasses.
- Lawn grasses are more resistant to herbivory because they have horizontal stems and branched stolons (McNaughton, 1984; Veldhuis et al., 2014).
- Grazing lawns have a higher density than the surrounding vegetation; this attracts more grazers because it generates a greater food yield per bite (McGranahan & Kirkman, 2003).
- Grazing lawns can withstand intense grazing because lawn grasses are a natural defence mechanism against herbivory.

Grazing lawn management

Two forms of management present could be implemented in "Diepkloof":

- Change the grazing pressure

The size of a grazing lawn can be increased or decreased by influencing the grazing pressure. The grazing pressure can be changed by (1) mowing a grazing lawn 1 – 3 times a year, or by (2) changing the herd composition.

(1)Natural grazing is mimicked by mowing several times a year but is faster and more intense. Mowing a grazing lawn several times a year results in an expansion of the grazing lawn because the grazing pressure is increased. It is recommended to mow along the sides of a grazing lawn and the surrounding vegetation to achieve success.

(2)The grazing pressure of a grazing lawn can be influenced by changing the herd composition. Some species like Cow and Black wildebeest consume more grass per day than Klipspringer or Springbok. Species also differ in grazing behaviour during the day. Changes in species composition can be made to ensure use throughout the day, or the increase the grazing pressure intensity.

Grazers are often shot during a period of hunger to decrease the grazing population. Then more food becomes available for the remaining population. However, a smaller population results in a lower grazing pressure causing to grazing lawns to decrease in size. Less food is available for the remaining population because of the smaller grazing lawns. Hunting should be avoided to prevent a decrease in forage quantity.

- Increasing nutrient availability

Increased nutrient availability attracts more individuals because this increases the food yield per bite. Grazing lawn characteristics change when more individuals use the lawns such as; vegetation, soil compaction, grass density, hydrology and available nutrients.

Nutrients can be increased by fertilising a grazing lawn with either nitrogen or phosphor. Nutrients can be distributed over a grazing lawn as salts, in a compact form. The nutrients are absorbed by the soil and are used by the vegetation as substances to grow. Fire can also be used to increase to nutrient availability.

Living Lands applied several management treatments last year. The effects of these treatments can be partially analysed within this research. The knowledge gap regarding effective management strategies is covered during this research.

Decision on methods used in this study:

Camera traps and dung counts are selected as methods to collect data during this research. These methods appear to be most effective regarding time, costs and inaccessibility of the area.

The used methods described in 2.1 and 2.2 are used to examine parts of a grazing lawn. The grazing lawns in "Diepkloof" are too small to establish multiple plots or execute management treatments on a big scale. The grazing lawns in "Diepkloof" should be examined entirely instead.

The CPE is hard to access, and it is only possible to stay in the area is for a couple of weeks. Researchers need a break of 2 – 3 weeks because of logistical reasons. The use of camera traps provides an advantage, under these circumstances because they provide data over a continuous period of time, without the researchers being present in the area. Camera traps do not disturb the wildlife, thus causing less bias.

The standardised method for camera traps and dung counts are adapted to the circumstances of "Diepkloof" and are described in detail in chapter 4.

3. Site description:

3.1 Research area:

General and History

This research is conducted in “Diepkloof”, an area south-west in the CPE, South-Africa (figure 4). The CPE is founded by several private land owners. Terra Mare Properties (Pty) is the legal owner of “Diepkloof” and is represented by its director Ton Poiesz (stewardship, 2013). The total area of “Diepkloof” is 4.289 hectares. The private landowners of the CPE established contact with Living Lands for collaboration to protect and preserve the area (stewardship, 2013).

Historically the CPE has been degraded due to overgrazing by livestock. The CPE is currently returning to its natural because the carrying capacity of the area is now high enough to support the grazing population. The grazing pressure declined in because the private land owners sold most of their cattle.

Figure 4: Location the CPE and “Diepkloof” within the CPE (stewardship, 2013) (google maps)

Area Description

The CPE lies in the mountainous escarpment of the Karoo, at an altitude of 2000 metres, above sea level. The CPE is characterised by the Compassberg, with a height of 2500 metres. The area suffers from erosion and gullies, disrupting the local ecosystem. Poorly developed soils, an arid climate, bare soil, and grazing contribute to the effects of erosion.

Hunting is allowed in “Diepkloof” because it is private land. Hunting is regulated and occurs regularly by the owners for recreational purposes. A small number of animals are shot throughout the year; this causes a minor influence on the grazing population.

Climate

The area has a typical southern hemisphere climate, consisting of a warm and a cold season. The temperature varies between the 9 and 29 degrees (figure 5). The average annual precipitation in the area is 624 millimetres (figure 5). Figure 5 shows the average rainfall and temperature for Nieu-Bethesda, a small village located next to the CPE.

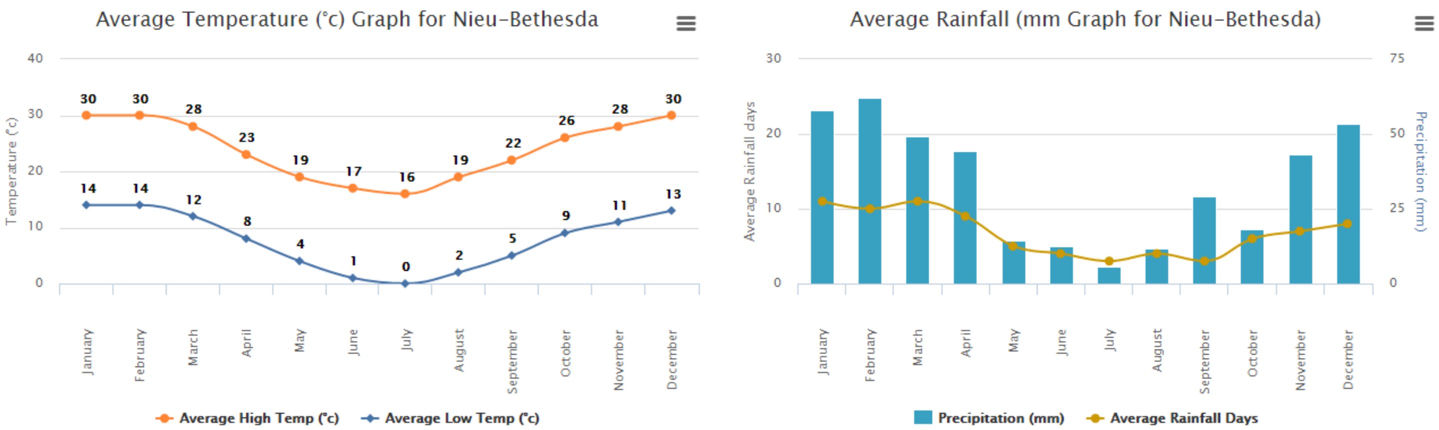

Figure 5: Average temperature for Nieu-Bethesda (left), average rainfall for Nieu-Bethesda (right) (World Weather online, 2000).

Vegetation

The CPE is characterised by a Karoo vegetation, existing of dwarf shrubs and grasses, figure 6 (S A National Biodiversity Institute, 2016). The plants in this vegetation type are deciduous and have a low density. A Karoo vegetation does not need much precipitation and can withstand extreme cold and heat (S A National Biodiversity Institute, 2016). A lot of bare soil is present in this vegetation type. A combination of bare soil, extreme weather and low vegetation leads to a high erosion hazard.

Figure 6: Example Karoo of a vegetation existing of shrubs and grasses,

3.2 Site selection:

There are five grazing lawns present in “Diepkloof”, see figure 7. The grazing lawns in “Diepkloof” are the natural result of grazing, defecation, and urination of grazers (stewardship, 2013). This enrichment has led to a change in the composition of grass species and primary production of the grazing lawns (stewardship, 2013).

Grazing lawns 1, 2 and 4 are selected for this research.

A large gully is present through grazing lawn 3 and was therefore not included in this research. The gully makes data collection difficult and could cause highly biased data.

Grazing lawn 5 is not examined because it is difficult to access.

The grazing lawns cover the following areas.

- Grazing lawn 1: 2637 m2.
- Grazing lawn 2: 774 m2.
- Grazing lawn 4: 1444 m2.

Total area grazing lawns: 4855 m2.

The size of the grazing lawns is determined by the use polygon shapefiles in ARCgis. The shapefiles are created by Living Lands with a GPS tracker.

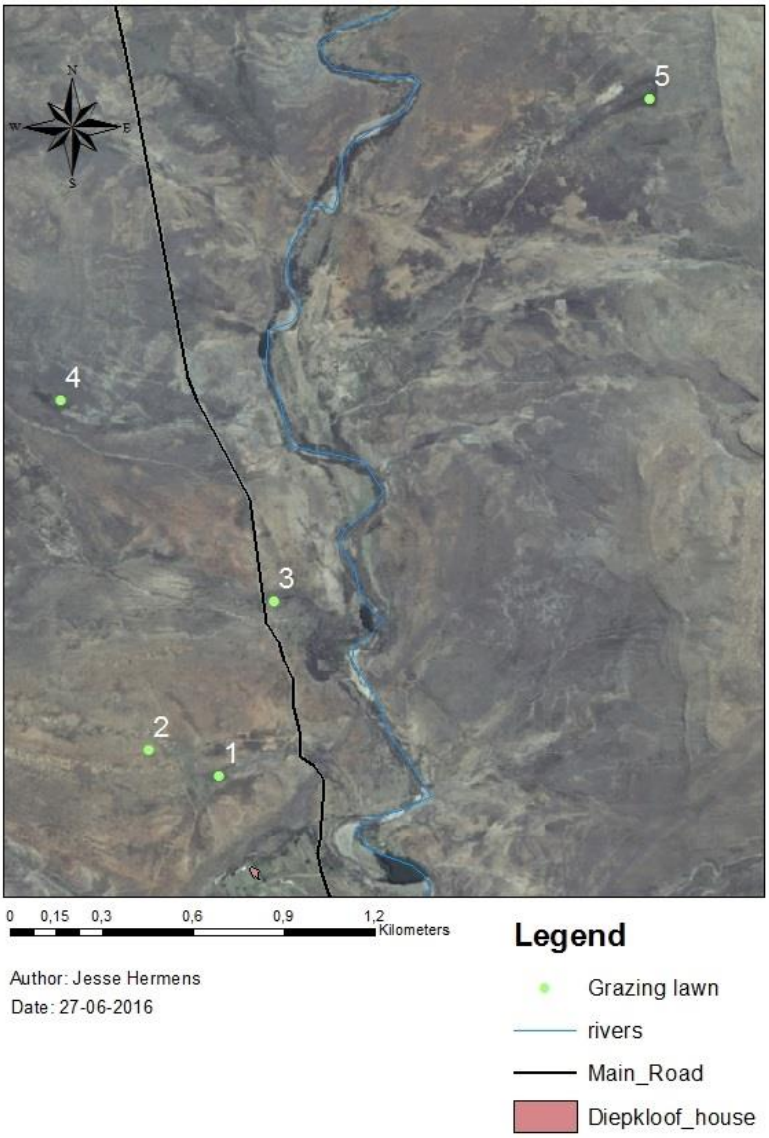

Figure 7: Locations of the grazing lawns in “Diepkloof” (Jesse Hermens).

3.3 Grazer species:

"Diepkloof has a healthy population of large herbivores, consisting of nine species (table 2). Cows are introduced in the area, all other species are native to "Diepkloof" (stewardship, 2013). This research focuses on these nine species because they are the only species that use the grazing lawns in "Diepkloof". These grazers consume grasses as part of their diet and nutrition (stewardship, 2013), this has led to the assumption that all of them use the grazing lawns in "Diepkloof".

Table 2: The ten large grazers of "Diepkloof". Main food: (Michigan, 2014)

Local Name	Latin Name	Main food	Intake Kg/day
Black wildebeest	*Connochaetes gnou*	Bushes & shrubs; leaves, wood, bark & flowers	3,5
Blesbok	*Damaliscus dorcas philipsii*	Grasses; Eragrostis, Themeda & Danthonia	1,7
Cattle (cow)	*Bos taurus*	Grasses	10
Greater Kudu	*Tragelaphus strepsiceros*	New grass, leaves, fruits, herbs, vines & flowers	3,5
Grey rhebuck	*Pelea capreolus*		-
Klipspringer	*Oreotragus oreotragus*	Leaves, fruits & flowers	-
Mountain reedbuck	*Redunca fulvorufula*	Primarily grasses &leaves	0,7
Springbok	*Antidorcas marsupialis*	Grass & leaves (seasonally)	1,1
Steenbok antelope	*Raphicerus campestris*	Grass, leaves, fruits, twigs and roots	6,2

The primary food that each species needs is given in kilogrammes per day in table 2 (Michigan, 2014). This data is collected on a similar vegetation type as grazing lawns, so the preferred food and required intake should be rather similar on the grazing lawns in "Diepkloof". No information on intake per day was found on Grey rhebuck and Klipspringer, indicated with (-) in table 2. However, Grey rhebuck and Klipspringer consume probably the same amount of grasses as a springbok (2kg).

4. Methods of data collection:

From the literature studied it becomes apparent that camera traps and dung counts are the most efficient methods to collect the required data.

Camera traps are devices to monitor the presence and behaviour of wild animals. Camera traps gather data by photographing or filming individuals based on programmed settings such as trigger speed (see section 2.3). Camera traps allow an efficient use of the small time frame and collect data 24 hours a day. Dung counts are a method of data collection based on identifying dung pellets. Grazer species leave dung behind on the grazing lawns after a visit. Therefore the presence of dung proves that certain individuals visited the grazing lawn. The size of a herd or the number of animals can be estimated based on the number of dung droppings. Details about the camera traps, dung counts and permanent sample plots are described in chapter 4.1 and 4.2.

4.1 Camera trap:

Three camera traps are placed in "Diepkloof". One camera trap is placed on each grazing lawn. The exact location of the camera traps is given in figures 8 and 9. The figures show the coordinates in 35 Universal Transverse Mercator (UTM). The camera detection zone is visualised in figures 8 and 9 and shows which areas of the grazing lawns are monitored. The camera traps were present in the field from 8th March until 19th April, a total of 42 days.

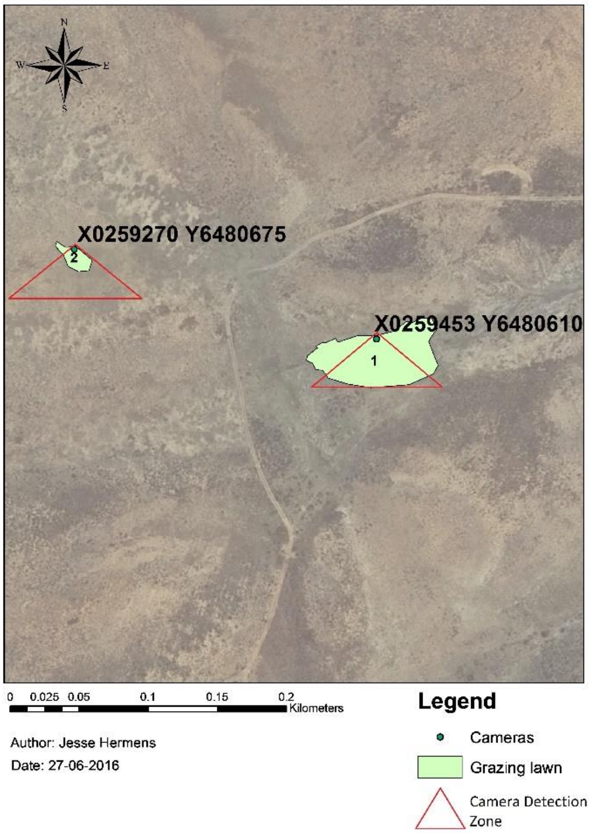

Figure 8: Location of camera traps on grazing lawn1 & 2 (Jesse Hermens)

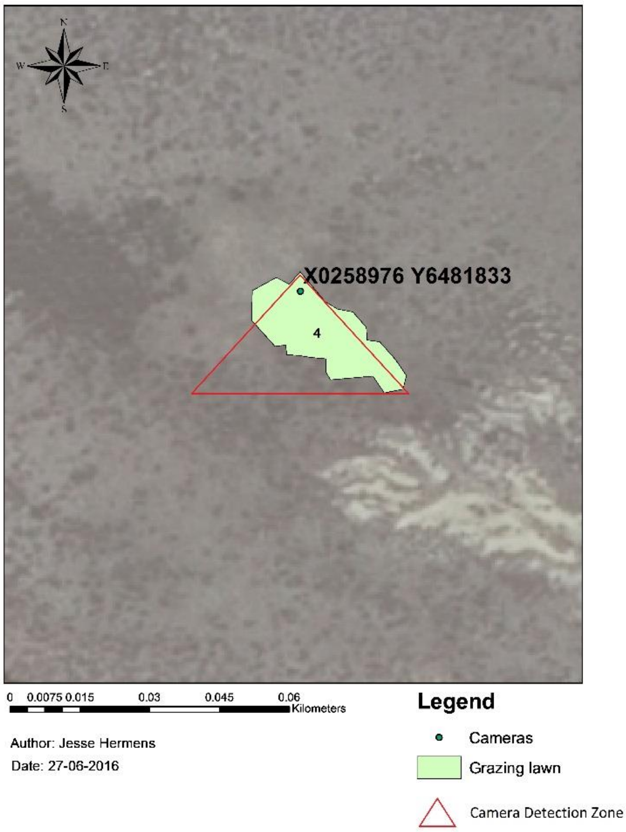

Figure 9: Location of camera trap on grazing lawn 4 (Jesse Hermens).

The type of camera traps used during the research is Bushnell Trophy CAM HD, model# 119736. The programmed settings are: Image size, 5 Mega Pixel; Capture number, 1; Interval, 1 minute; Field scan interval, 15 minutes. A picture is taken every minute if movement is detected. An additional picture is taken every 15 minutes, whether movement is detected or not.

The camera traps are placed in an iron case with a lock after programming the settings. An iron pole is placed on each grazing lawn and placed in the ground. The cameras are attached to the iron poles on a height of 1.20 metres. A lower placement of 30-40 centimetres from the ground is recommended by other studies and literature (Trolliet, 2014; Hughson, Darby, & Dungan, 2010). However, Living Lands recommends placing the cameras at the height of 1,20 metres to protect them from cattle. The cameras are placed with the lens facing south, to prevent reflection from sunlight in the camera lens.

Photos taken by the cameras are stored on a Secure Digital-Card (SD-Card) within the camera. Each week, data collection takes place by transferring photos from the SD-Card to a field laptop.

Appendix I contains sample pictures. The conditions in which pictures are taken vary each day and are for example influenced by weather conditions. Appendix I presents pictures during night, day, mist and rain. Weather conditions make it difficult to classify and recognise animals on the photographs, appendix I gives an impression of the difficulties that occurred.

Analysis of data obtained with camera traps

Data from the camera traps is stored in a database with Microsoft Excel. The camera trap database contains data on species, location (coordinates), date, duration of presence and the number of animals visible on the photographs. It is not possible to identify all individuals due to dark or vague pictures. These entries are marked as unknown in the database. The database contains 2416 entries.

Non-grazing species are occasionally recorded by the camera traps. Data on these individuals is stored in the database but is not used in the analysis or results. These species are: Black-backed *Jackal (Canis Mesomelas)*, Blue Crane *(Anthropoides paradiseus)*, Leopard tortoise *(Stigmochelys paradalis)*, Baboon *(Papio hamadryas)* and Pied crow *(Corvus albus)*.

Data is sorted per sighting in chronological order to calculate the frequency per grazer species. A sighting is the period of time when an individual or herd makes use of a grazing lawn. Multiple pictures are taken during one sighting. The total number of animals observed in one sighting is summed up and then divided by the number of photos, to calculate the average number of animals during one sighting. The averages of all sightings are summed up to show the total frequency (F) per species.

The following factors are used calculate the grazing pressure per species (Psp):

- Total frequency (F)
- Total area grazing lawns in m2 (A)
- Number of monitoring days (D)
- The required food intake per day in kilogrammes (Kg).

The following formula is used to calculated the grazing pressure per species; the outcome is in kilogrammes of consumed grasses per day per square metre: Psp = [F / A / D] * Kg. The total area of the grazing lawns in shown in section 3.2. The number of monitoring days is always 45. The required food intake is indicated for each species in table 2.

The grazing pressure for each grazing lawn (Pgl) is calculated by a formula, the outcome is in kilogrammes of consumed grasses per day per square metre. The following factors are used in the formula:

- Total frequency (F)
- Grazing lawn area (Agl)
- Number of monitoring days (D)

The formula to calculate the grazing pressure for each grazing lawn is: Pgl = F / glA / D. The area per grazing lawn is shown in chapter 3.2. The number of monitoring days in always 45.

An ANOVA (single factor) test is done over the camera trap data, to indicate whether or not the grazing herds significantly differ between the grazing lawns in "Diepkloof". The data was first filtered to only select species that often occur on the grazing because species with a low number of sightings could bias the ANOVA test. All species with more than 100 sighted individuals are classified as species that often occur, these species are Black wildebeest, Blesbok, Cow and Springbok. The three grazing lawns are monitored for 45 days, so the data set consists of three set of 45 entries.

4.2 Dung count:

Field staff involved in this research received a training in identifying dung droppings. The training was given by Colin Tucker, a staff member of Living Lands. The training took place before the first dung count, to ensure accurate data collection. The training focuses on the large grazers described in chapter 3.3.

Old dung that was still present on the grazing lawns was removed, this eliminates the chance of old dung being confused with fresh dung. Old dung was removed with spades and buckets and thrown far away from the grazing lawn.

Each grazing lawn is examined once a week. Examination of a grazing lawn takes up an entire workday, so it takes three days to examine all grazing lawns. This process is repeated each week. The following data is collected on each grazing lawn during a dung count: lawn number, date, recorder, waypoint and absence or presence of rainfall. The following data is recorded for each dung pellet: Species, freshness and photo identification number.

Rainfall changes the texture and structure of dung droppings, making it more difficult to identify dung droppings. A photo is taken whenever a dung dropping remains unidentified or when the recorder doubts about the dung's origin (species).

Each grazing lawn is divided into four quadrants, see figure 10. These quadrants follow the boundaries of the management treatments that were executed last year. A division in quadrants also allows a comparison between the dung frequency and the management treatments.

The grazing lawn and transition zone (figure 10) are examined by four persons during a dung count. A dung count is performed per quadrant, and every dung pellet within a quadrant is identified. Quadrants within a grazing lawn are always examined in the same sequence: Q1, Q2, Q3. Q4.Three persons walk next to each other in a straight line from north to south, leaving approximately one metre between each person. The dung's origin, intermediate frequency and freshness of all dung pellets on his or her line are identified. The person that identified the dung pellets shouts the information to the fourth person, which records the data on a field form, appendix II. The identifiers start a new line together when all dung on their line is identified.

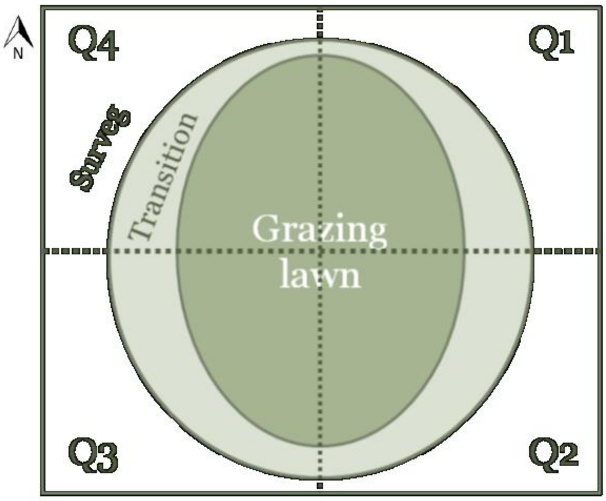

Figure 10: Schematic design of a grazing lawn divided into quadrants (Reijers, 2015)

The dung catalogue of Kevin Murray (2011) is used in the field to identify dung droppings. The catalogue is used together with knowledge received from the training.

The following abbreviations for grazer species are used in the field to enable fast and effective data collection during the dung counts.

Table 3: Abbreviation for grazer species during the dung counts

Grazer species	Latin name	Abbreviation
Black wildebeest	*Connochaetes gnou*	BWB
Blesbok	*Damaliscus dorcas philipsii*	BB
Cow	*Bos Tauros*	Cow
Greater kudu	*Tragelaphus strepsiceros*	Kudu
Grey rhebuck	*Pelea capreolus*	GR
Klipspringer	*Oreotragus oreotragus*	KS
Mountain reedbuck	*Redunca fulvorufula*	MR
Springbok	*Antidorcas marsupialis*	SP
Steenbok antelope	*Raphicerus campestris*	STB

Dung freshness is classified into three categories, for efficient notation; A, B & C. The freshness is not recorded after seven days, first because dung counts are performed each week and secondly dung is too old after seven days to determine freshness.

- A. Produced today
- B. Produced in the past 2-3
- C. Produced in the past 4-7 days

Analysis of the data obtained with dung counts:

Dung count data is stored in a database with Microsoft Excel. The dung count database contains data on: dung origin, freshness, location (coordinates) and date. The database contains 1062 entries.

Data is sorted per species in the database to calculate the frequency of dung droppings per species. The dung pellets of each dung count are summed up per species; this gives the total frequency of dung pellets per species.

The dung pellets are summed up per quadrant on each grazing lawn and divided by the size of the grazing lawn in m2. These numbers show which management treatments lead to an increase in grazing pressure on the grazing lawns. These numbers are stored into a table and converted in a graph with Microsoft Excel. Three quadrants on grazing lawn 4 are not managed, classified as “no management”, the average of dung droppings on these quadrants is calculated and shown in the results (figure 13).

An ANOVA (single factor) test is done over the dung count data, to indicate whether or not the grazing herds significantly differ between the grazing lawns in “Diepkloof”. The data was first filtered to only select species that regularly occur on the grazing lawns because species with a low number of dung droppings could bias the ANOVA test. All species with more than 150 collected dung pellets are classified as species that often occur, these species are Black wildebeest, Blesbok, Cow, Steenbok Antelope and Springbok. Five dung counts are performed during this research so the ANOVA (single factor) test is executed over three data set of five entries.

The dung pellets found on quadrants with the same management treatment are summed up together, this gives the total dung frequency per management treatment. However, it should be considered that not all treatments are executed on grazing lawn 4.

5. Results:

The data collected during the period of February – May 2016 in the CPE, South-Africa is used to produce these results. The results are produced by the data analyses presented in 4.1 and 4.2. The results are grouped per research question and presented in the following order:

- Q1. What is the grazing pressure on each grazing lawn in “Diepkloof”?
- Q2. Which large grazers make use of the grazing lawns in “Diepkloof” and what is the grazing pressure that each species exerts?
- Q3. Which management treatments lead to more intensive use of grazing lawns in “Diepkloof” by large grazers?

5.1 What is the grazing pressure on each grazing lawn in “Diepkloof”?

Table 4 shows the grazing pressure on each grazing lawn exerted by the grazing population of “Diepkloof”. The grazing pressure is based on recordings of both the camera traps and dung counts and is given in consumed grasses in kilogrammes per day per square metre.

Table 4: Grazing pressure on each grazing lawn in consumed kilogrammes of grasses per day per m2.

	Lawn 1	**Lawn 2**	**Lawn 4**
Grazing lawn area m2	2637	774	1444
Total frequency (camera traps)	258	261	331
Total frequency (dung counts)	802	519	605
Grazing Pressure (camera traps)	**0,002**	**0,008**	**0,005**
Grazing pressure (dung counts)	**0,008**	**0,017**	**0,010**

Table 4 shows the following results:

- Most animals (331) are sighted on grazing lawn 4.
- Most dung dropping (802) are collected on grazing lawn 1.
- The number of sightings and number of dung pellets of grazing lawn 2 are all relatively low.
- The sequence in grazing pressure of the grazing lawns in “Diepkloof” is the same for both the camera traps and dung counts. The sequence in grazing pressure on the grazing lawns is (from intense to less intense): grazing lawn 2, grazing lawn 4, grazing lawn 1.
- Grazing lawn 2 has the highest grazing pressure according to both the camera traps and dung counts.

5.2 Which large grazers make use of the grazing lawns in “Diepkloof” and what is the grazing pressure that each species exerts?

The nine species (see section 3.3) present in “Diepkloof” are divided into three categories: Common, uncommon and rare. The classification is based on the number of sightings or dung droppings, see section 5.2.1 and 5.2.2. The results regarding species frequency are shown in two figures (11 & 12) one figure is based on the camera traps and the other figure is based on the dung counts. Both methods lead to slightly different results, but also several similarities.

5.2.1 Camera trap:

Figure 11 shows the number of individuals per species that use the grazing lawns in “Diepkloof”. The figure is based on 45 days of camera trap data. The division in frequency is based on the following number of individuals: Common; >100 individuals, uncommon; 20 - 100 individuals, rare; <20 individuals. Further justification for the classification per species is given in bullet points below.

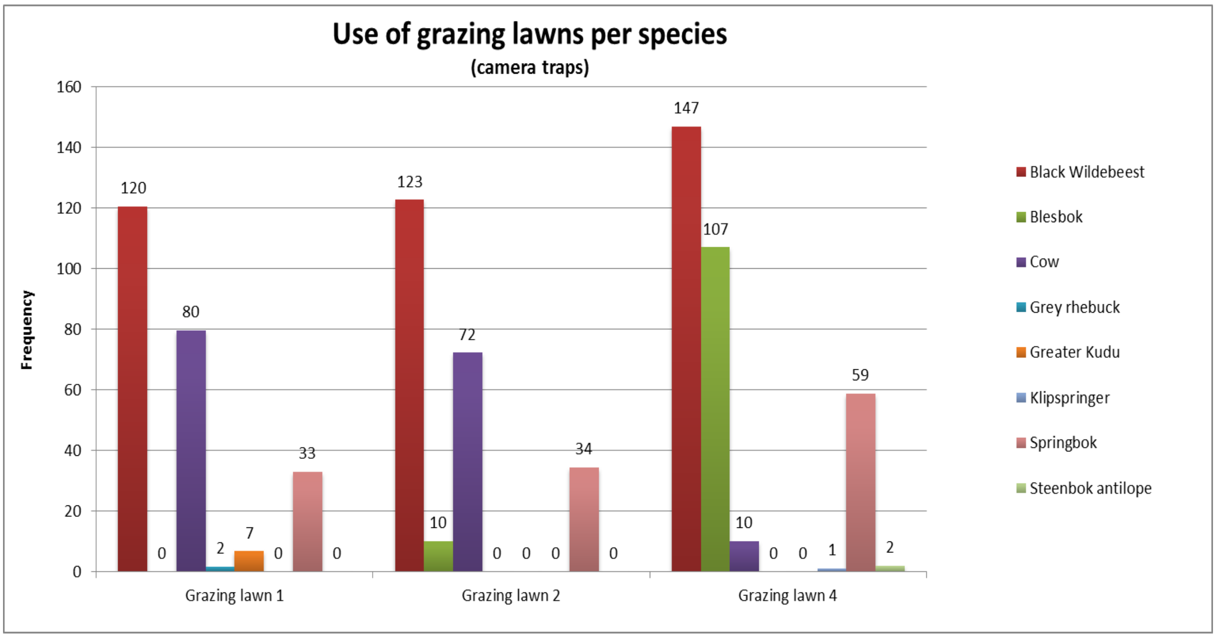

Figure 11: Total number of individuals using the grazing lawns in “Diepkloof”.

Black wildebeest and Blesbok are categorised as common users of the grazing lawns.

- Black wildebeest is the species that is most commonly observed on the all of the grazing lawns. The number of black wildebeests sighted on the different grazing lawns varies between 120 – 147 individuals. Black wildebeests have an exceptionally high frequency in comparison with other species.
- The number of Blesbok varies between the grazing lawns. Blesbok has a high frequency of 108 on grazing lawn 4, and a frequency of 10 on grazing lawn 2. Blesbok was not observed on lawn 1 at all.

Cow and Springbok are uncommon users of the grazing lawns.

- Springbok is observed on all three grazing lawns. The number of Springbok varies between 33 – 59. Springbok are most frequently observed on grazing lawn 4.
- Cows are observed with a frequency of 10 – 80 individuals. Cows are mainly observed on grazing lawn 1 and 2, but rarely on lawn 4.

Greater kudu, Grey rhebuck, Klipspringer, and Steenbok antelope are categorised as rare users.

- Greater, kudu, Grey rhebuck, Klipspringer, and Steenbok antelope are sporadically observed on the grazing lawns. The appearances of these individuals are a rare occasion and do not reach above ten sighted individuals.
- Mountain reedbuck is not observed at all with the camera traps, zero individuals are sighted.

Table 5 shows the grazing pressure that each species exerts on the grazing lawns. The grazing pressure is shown per species in consumed kilogrammes of grasses per day, per square metre (see section 4.1). Only species that are classified as common and uncommon users are displayed in table 5. The grazing pressure of rare users is close nothing and has no influence on the grazing lawns.

Table 5: Exerted grazing pressure of common and uncommon grazer species on the grazing lawns in "Diepkloof".

Local name	Latin name	Grazing pressure
Black Wildebeest	*Connochaetes gnou*	0,00624
Blesbok	*Damaliscus dorcas philipsii*	0,00091
Cow	*Bos Tauros*	0,00740
Springbok	*Antidorcas marsupialis*	0,00063

The grazing pressure of Black wildebeest and Cow are a lot higher in comparison with Blesbok and Springbok. The pressure exerted by Blesbok and Springbok is approximately 8-10 times lower than the pressure caused by Black wildebeests and Cows. Black wildebeests are observed in significantly larger numbers than other species, this logically results in a higher grazing pressure. Cows consume an extremely high amount of grass in comparison with other grazer species. Cows consume up to 10 kg of grasses per day, while other species do not consume more than 3 kg per day on average, see section 3.3. A consumption of this many kilogrammes logically results in a higher grazing pressure.

Table 6 shows an ANOVA (single factor) test; this table indicates whether there is a significant difference in the use of the different grazing lawns in "Diepkloof", based on the camera trap data. The probability value (P-value) indicates the probability and is strong when P=0,95. Table 6 shows that the P-value is 0,287964 which is a weak probability, this means that there is no significant difference in use between the different grazing lawns.

Table 6: ANOVA (Single factor) test is indicating if there is a significant difference in use between the different grazing lawns in "Diepkloof".

ANOVA (single factor)

Source of Variation	*SS*	*df*	*MS*	*F*	***P-value***	*F crit*
Between Groups	140.4799	2	70.23994	1.257925	**0.287964**	3.071779
Within Groups	6700.556	120	55.83796			
Total	6841.035	122				

5.2.2 Dung count:

Figure 12 shows the frequency of dung pellets found on the grazing lawns. The figure is based on 45 days of dung count data. The results are presented per species per grazing lawn. The division in frequency is based on the following numbers of dung pellets: Common; >120 dung pellets, Uncommon; 30-120 dung pellets, rare; <30 dung pellets. Further justification for the classification per species is given in bullet points below.

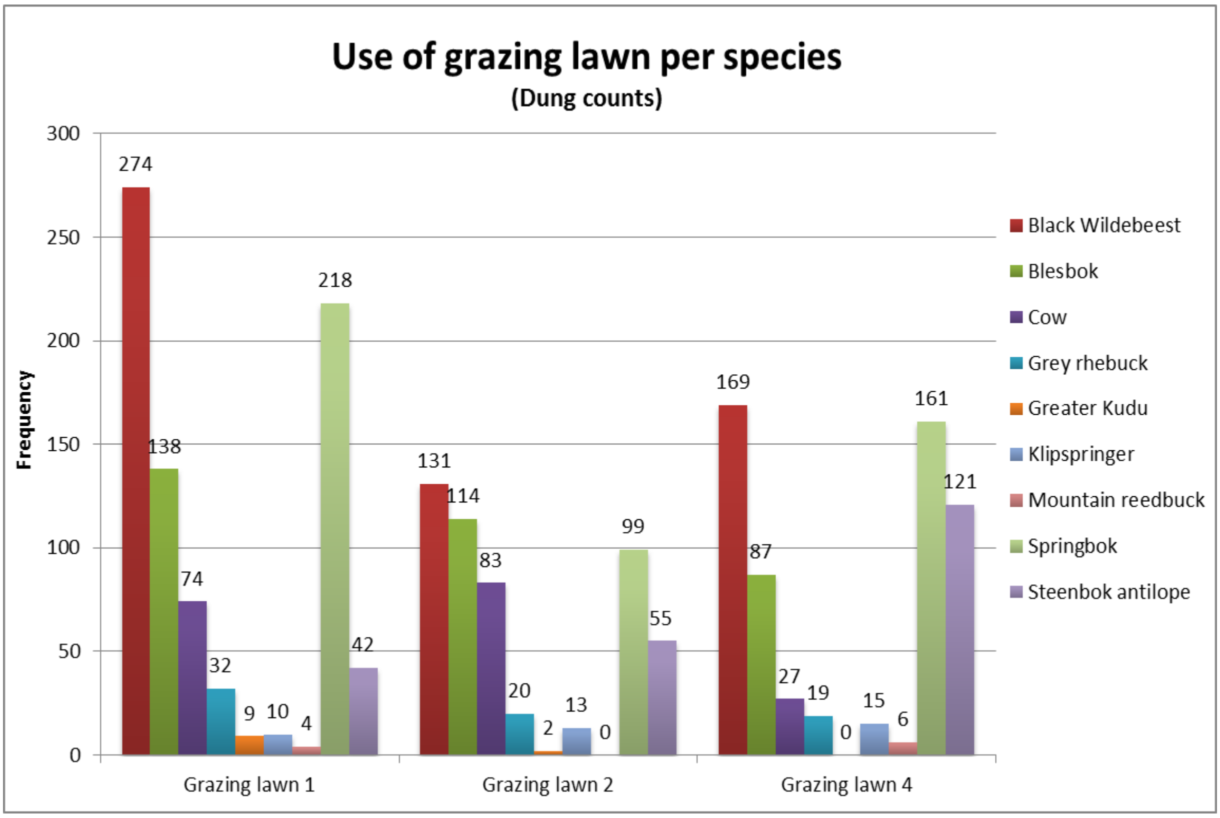

Figure 12: Total number of individuals using the grazing lawns in "Diepkloof".

Black wildebeest, Blesbok, and Springbok are categorised as common users.

- The frequency of Black wildebeest ranges from 169 – 274 between the grazing lawns. Black wildebeest is observed more frequent than any other species on all of the grazing lawns.
- Blesbok is observed on all grazing lawns with a frequency between 87 – 138. Blesbok is observed more frequent on grazing lawn 1 and 2 than on lawn 4.

- Springbok is observed on all grazing lawns, with a frequency varying between 99 – 218. This species is observed more frequently on lawn 1 than on lawn 2 and 4.

Cows and Steenbok antelope are categorised as uncommon users.

- Cows are frequently observed on grazing lawn 1 and 2 with a frequency of 74 –83. Cattle is less frequently observed on grazing lawn 4, with a frequency of 27.
- The frequency of Steenbok antelope ranges from 42 – 121. Steenbok antelope is occasionally observed on all grazing, but mainly on lawn 1.

Greater Kudu, Grey rhebuck, Klipspringer and Mountain reedbuck are categorised as rare users.

- Grey rhebuck, Greater Kudu, Klipspringer and Mountain reedbuck are observed at frequencies much lower than other grazer species. The number of dung pellets found for each species was between the 0 – 32.

Table 7 shows an ANOVA (single factor) test; this table indicates whether there is a significant difference in use between the different grazing lawns in "Diepkloof", based on the dung count data. The P-value indicates the probability and is strong when P=0,95. Table 7 shows that the P-value is 0,369443 which is a weak probability, this means that there is no significant difference in use between the different grazing lawns.

Table 7: ANOVA (Single factor) test to indicate whether there is a significant difference in the use of grazing lawns based on the number of dung pellet per dung count.

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	9112.167	2	4556.083	0.369443	0.701132	4.256495
Within Groups	110990.8	9	12332.31			
Total	120102.9	11				

5.3 Which management treatments lead to more intensive use of grazing lawns in "Diepkloof" by large grazers?

Figure 13 shows the number of dung droppings per m2 per day, found in each quadrant. Grazers usually defecate where they graze (Cromsigt, 2008), so more dung indicates a high usage by species. Use by many individuals creates a high grazing pressure this results into more intensive use of the grazing lawns.

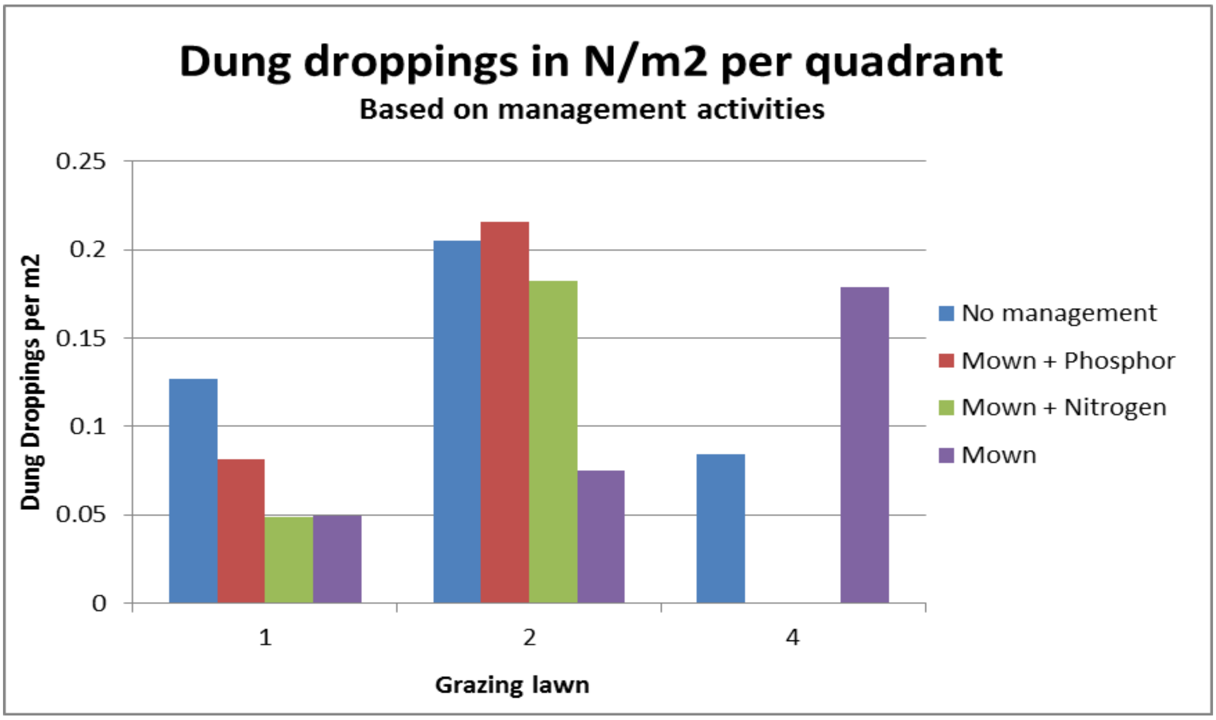

Figure 13: The number of dung droppings found per quadrant, per m2, per grazing lawn based on management treatments.

Grazing lawn 1 and 2 show similarities in the number of dung pellets found on quadrants that received the same management treatment. Four management measures were undertaken on grazing lawn 1 and 2, only two management measures are executed on grazing lawn 4. One quadrant is mown on lawn 4, and the other three quadrants received no management. The average of these three quadrants is calculated and shown in figure 13.

The results are described per grazing lawn

- Grazing lawn 1:
  - The activity that has the best results on grazing lawn 1 is by far no management, with a total of 0,12 dung pellets per m2.
  - Fertilising with phosphor in combination with mowing has a positive effect as well, but is severely lower than no management (0,08 dung pellets per m2).
  - A small effect is caused on the grazing lawns by: Fertilising with nitrogen in combination with mowing; and mowing. The number of dung droppings on quadrants were these treatments are executed is much lower than the other treatments, with a total of 0,048 and 0,049 dung droppings.

- Grazing lawn 2:

    - Fertilising with phosphor in combination with mowing has the highest effect on grazing lawn 2, with a total of 0,215 dung droppings per m2.
    - The effect of fertilising with nitrogen in combination with mowing and the effect of no management are almost equal on grazing lawn 2, with a total of 0,20 and 0,18 dung droppings per m2.
    - The effect of mowing has a significantly less effect on grazing lawn 2 than the other treatments.

- Grazing lawn 4:

    - Mowing has a huge effect on grazing lawn 4 compared to no management. A total of 0,17 dung pellets is found on the mown quadrant.
    - No management has a small effect on grazing lawn 4. No management has a weaker effect on grazing lawn 4 compared to no management on the other grazing lawns.

Table 8 shows the number of dung pellets per m2 per day on the total grazing lawn area (A). No management leads clearly to the most intensive use, with 0,41dung pellets per m2. The other three treatments have a much lower effect than no management. Fertilising with phosphor in combination with mowing, and only mowing have the second best effect on the grazing pressure. Fertilising with nitrogen in combination with mowing has the least effect on the grazing pressure exerted on the grazing lawns.

Table 8: The number of dung pellets that are defecated per m2, sorted per management treatment.

	Management treatments			
	No management	Mown + Phosphor	Mown + Nitrogen	Mown
Number of dung dropping per m2 on the total grazing lawn area	**0,41**	0,29	0,23	0,30

6. Discussion:

In the discussion the results obtained are compared with results found in other research and literature. The discussion is divided per research question, in the order: Q1, Q2, Q3. Literature used in this discussion are found on high-quality sites like Jstor (ITHAKA, 2000), research gate (researchgate.net, 2008) and Nature.com (Mc Millan Publishers). The commissioning organisation provided several documents as well that are used in the discussion.

6.1 Compared literature and explanation of results:

What is the grazing pressure on each grazing lawn in "Diepkloof"?

Table 4 shows the grazing pressure that large grazers exert on each grazing lawn. The results indicate that grazing lawn 2 has a much higher grazing pressure than lawn 1 and 4. The grazing pressure varies between the grazing lawns between 0.002 and 0.02 kilogram per day per square metre. These numbers indicate that the grazing pressure on the grazing lawns is very low (Prins, 2016), the grazing lawns are rather underused than overused. There is a strong chance that the grazing lawns are decreasing in size.

The following factors could explain the difference in grazing pressure between the grazing lawns:

- One of the factors that could cause a difference in grazing pressure is the species composition. Each grazing lawn is used by a different composition of species, as seen in figure 11 & 12. Milchunas and Lauenroth (2016) states that the composition of grazer species affects the grazing pressure and thus the vegetation composition. The grazing pressure increases for example when species that require many kilogrammes of grass use the grazing lawns, like Black wildebeest or Cow.
  However, species composition is not the reason for the high grazing pressure on grazing lawn 2, because tables 6 and 7 show that there are no significant differences in use between the grazing lawns. Roughly, the same species and herds make the same use of the lawns in "Diepkloof", so a difference in grazing pressure cannot be explained by the species composition.

- Another reason that could explain the difference in grazing pressure could be the location of the grazing lawns. D.Stock and J.Bond (2009) examined and proved that grazing lawns occur more often on certain soil types. The soil type affects the vegetation composition and soil characteristics.
  However, the location cannot be the reason for the difference in grazing pressure, because M.Reijers (2015) stated that all grazing lawns 1, 2 and 4 are located on the same soil type

- Recent research by M.Reijers (2015) shows that there is a difference between the grass species growing on the grazing lawns in "Diepkloof". There is a clear difference present between grazing lawn 2 and grazing lawns 1 and 4 (figure 14). *Eragrostis* is dominant on grazing lawns 1 and 4, while *Cynodon incompletus* is dominant on grazing lawn 2. The x-axis shows grazing lawn 1 – 5 in "Diepkloof", M.Reijers used the same numbering for the grazing lawns as this research. The y-axis shows the fraction of coverage that dominant (regularly appearing) grass species have on the grazing lawns

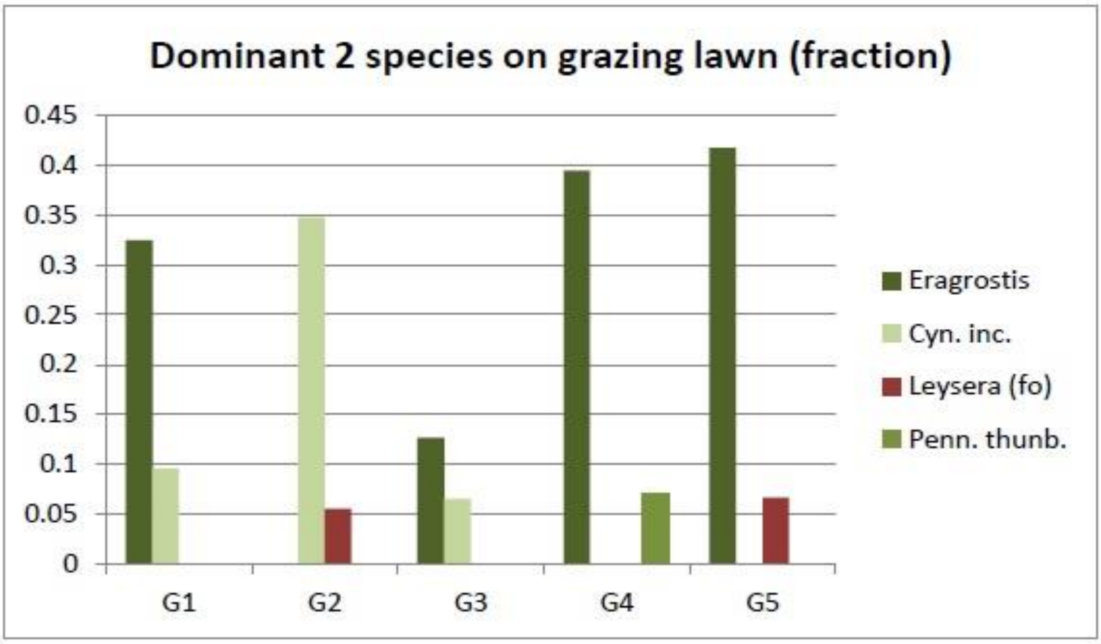

Figure 14: The grass species recorded on the grazing lawns in "Diepkloof". The green bars represent grass species (dark green = genus Eragrostis, middle green = Pennisetum thunbergii, light green= Cynodon incompletus), and the red bar represents the forb Leysera tenella. (Author: M.Reijers).

Grazers are rather attracted to lawn grasses that provide a high food quality, than bunch grasses that provide a low food quality. (Prins 2016). Both *Eragrostis* and *Cynodan incompletes* are lawn grasses of high nutritious value and food quality (Prins, 2016), thus many grazers should be attracted to these three grazing lawns. However, grazing lawn 2 has a different combination of grasses than the grazing lawns 1 and 4. The difference in grass species could cause a difference in the grazing pressure.

- M.Reijers (2015) also performed research on soil characteristics of the grazing lawns in "Diepkloof". Figure 15 shows that there are clear differences in soil moisture between grazing lawn 2 and the other grazing lawns. The x-axis shows grazing lawn 1 – 5, M.Reijers used the same numbering as this research. The y-axis shows the soil moisture in percentage.

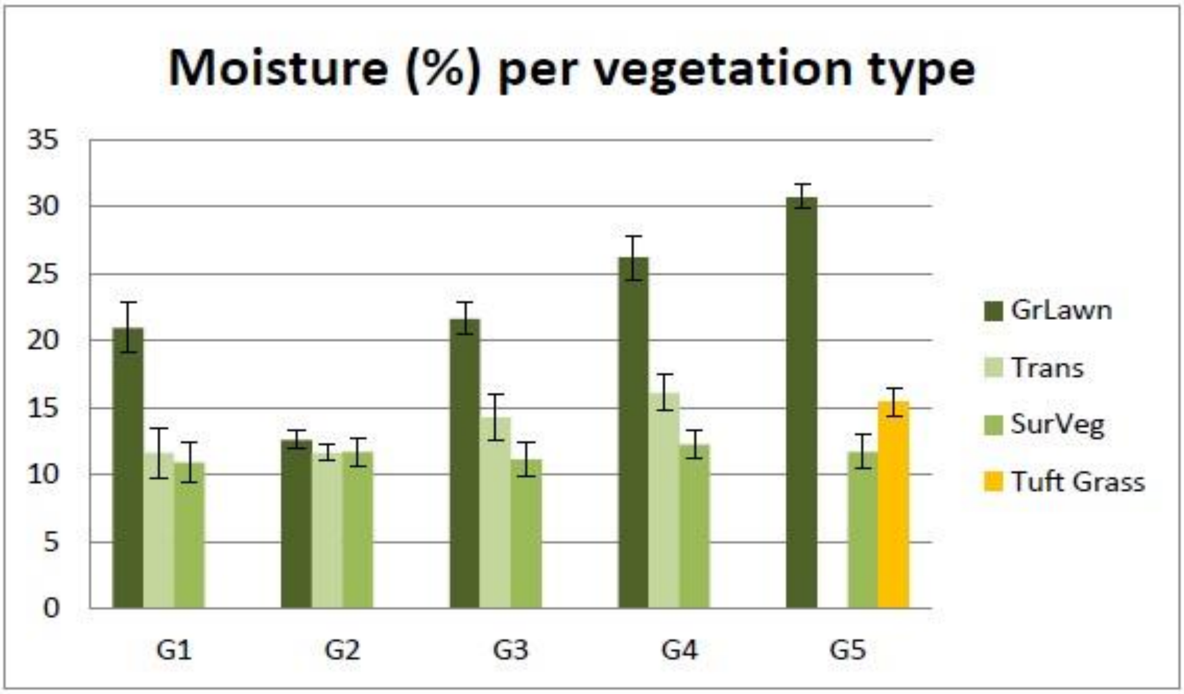

Figure 15: Volumetric moisture measured in the topsoil for four vegetation types (GrLawn= grazing lawn, Trans = transition zone, SurVeg = surrounding vegetation, Tuft grass). These are displayed on the five grazing lawns present in "Diepkloof. Error bars represent 95% confidence interval (Author M.Reijers).

Grazing lawn 2 is the only grazing lawn that is located in a flat area, where seepage or water lines do not seem to play a significant role (stewardship, 2013) (Reijers, 2015). Less soil moisture/water availability makes it harder for grazing lawns to expand in size and withstand grazing (McNaughton, 1984), this may result in a higher grazing pressure.

- Another reason that could explain the differences in grazing pressure is the size of the grazing lawns in "Diepkloof". Grazing lawns 2 is several times smaller than the other grazing lawns (3.2). The grazing pressure per m2 is automatically higher on a grazing lawn that is smaller. When a herd uses two grazing lawns that differ in size, the smaller one automatically receives a higher grazing pressure per m2. This fact also applies to "Diepkloof" and explains the difference in grazing pressure between the lawns.

Which large grazers make use of the grazing lawns in "Diepkloof" and what is the grazing pressure that each species exerts?

Nine species are observed which make use of the grazing lawns of "Diepkloof". These species are classified into the following categories:

Table 9: Grazer species of "Diepkloof" divided into categories based on sighting frequencies.

Local Name	Latin Name	Sighting Frequency
Black wildebeest	*Connochaetes gnou*	Common
Blesbok	*Damaliscus dorcas philipsii*	Common
Cattle (cow)	*Bos taurus*	Uncommon
Greater Kudu	*Tragelaphus strepsiceros*	Rare
Grey rhebuck	*Pelea capreolus*	Rare
Klipspringer	*Oreotragus oreotragus*	Rare
Mountain reedbuck	*Redunca fulvorufula*	Rare
Springbok	*Antidorcas marsupialis*	Uncommon
Steenbok antelope	*Raphicerus campestris*	Rare

Every area has a different composition of species; this also applies to the CPE and "Diepkloof". Several studies on grazing lawns such as Kraaij (2009), Hempson (2015) and Stock (2009) mention the grazer species that use the grazing lawns in the area that they studied. However, no study examines the number or density of grazers because grazers migrate between different areas; this makes it almost impossible to estimate the number of animals using grazing lawns. It is possible to estimate the number of individuals in this study because "Diepkloof" is an enclosed area where grazers cannot migrate or move over a large area. This resulted unfortunately in no literature to compare grazing herds and densities.

The CPE management plan (2013) and an interview with the owner of "Diepkloof" (Poeisz, 2016) confirm the results shown in table 9. It was confirmed by both sources (Poeisz, 2016) (stewardship, 2013) that Black wildebeest, Blesbok, Cow and Springbok appear in high densities in "Diepkloof".

The species that are classified in this research as either common or uncommon are all herd species, while the species classified as rare are solitary species (Park 2016). This factor explains why these species are sighted in higher frequencies. It takes for example five sightings of a solitary species to achieve the same frequency as a single herd of five individuals. Another factor that contributes to the high frequency of sighted herd species is the fact that camera traps detect movement of more individuals faster. A camera trap is sensitive to movement, see section 2.3, so it rather misses a single individual using a grazing lawn than a herd of grazers, this increase the difference between solitary and herd species in sighting frequency.

Table 6 and 7 show that there are no significant differences in use between the different grazing lawns in "Diepkloof". The fact that there are no significant differences can be explained by the fact that "Diepkloof" is an enclosed area. The same animals and herds make continuous use of the grazing lawns in "Diepkloof", so it makes sense that there is no significant difference between the different lawns.

Which management treatments lead to more intensive use of the grazing lawns in "Diepkloof" by large grazers?

Several differences are visible between the effects of the applied management treatments on the grazing lawns in "Diepkloof". The effects observed on grazing lawn 1 and 2 are rather similar, while the effects are different on grazing lawns 4. Only two management treatments are applied on grazing lawn 4, this makes a comparison between the different lawns difficult, but also explain why there is a difference between grazing l and 2; and grazing lawn 4. The sequence of management treatments that lead to an increase in intensive use are as follows (from high to low):

1. No management
2. Fertilising with phosphor and mowing
3. Mowing once a year.
4. Fertilising with nitrogen and mowing

The effect of the management treatments is mainly determined by Black wildebeest, Blesbok, Cow and Springbok because these species appear in higher densities in "Diepkloof".

More intensive use in sub-question three basically means an increased grazing pressure. This factor needs to be identified to ensure the continuous presence of the grazing lawns. It should be considered that grazing by large herbivores and mowing both increased the grazing pressure. Sub-question three shows the natural grazing pressure by calculating the number of dung pellets per quadrant. However, mowing increases the grazing pressure in a semi-natural way. Quadrants that received no management have the highest natural grazing pressure, but the grazing pressure on quadrants that are mown may be higher than calculated in the results.

It should also be considered that only two management treatments are executed on grazing lawn 4. So no management and mowing once a year is contain three values while than the other two management treatments only contain two values.

The huge amount of dung droppings on the mown quadrant on grazing lawn 4 (figure 13) is most likely biased by a "Milton". A Milton is a place where certain species often defecate is large amounts. Some species like Springbok do this and defecate in large number and frequencies (Milton, 1992). This may explain why the number of dung pellets is so exponentially high.

According to Colin Tucker, supervisor Living Lands: the treatments may take several years to have a visible effect. The study of Prins (2016) also confirmed that the treatments might have different effects over an extended period of time.

Prins (2016) executed a similar research (2.2) into the effect of management treatments on grazing lawns in South Africa. Figure 16 shows the main result of Prins'(2016) research. The figure shows six management treatments that are applied to the grazing lawns. A sub-plot is either fertilised with nitrogen, phosphor or not at all, these sub-plot are either mown or not. Figure 16 shows the nitrogen to phosphor ratio and shows which nutrient is the limiting factor for grazing lawn expansion. The figure shows which management treatments are most effective and result in an increase of use by large grazers. More grazers are attracted to areas that are not limited by nutrients, which means rich in nutrients.

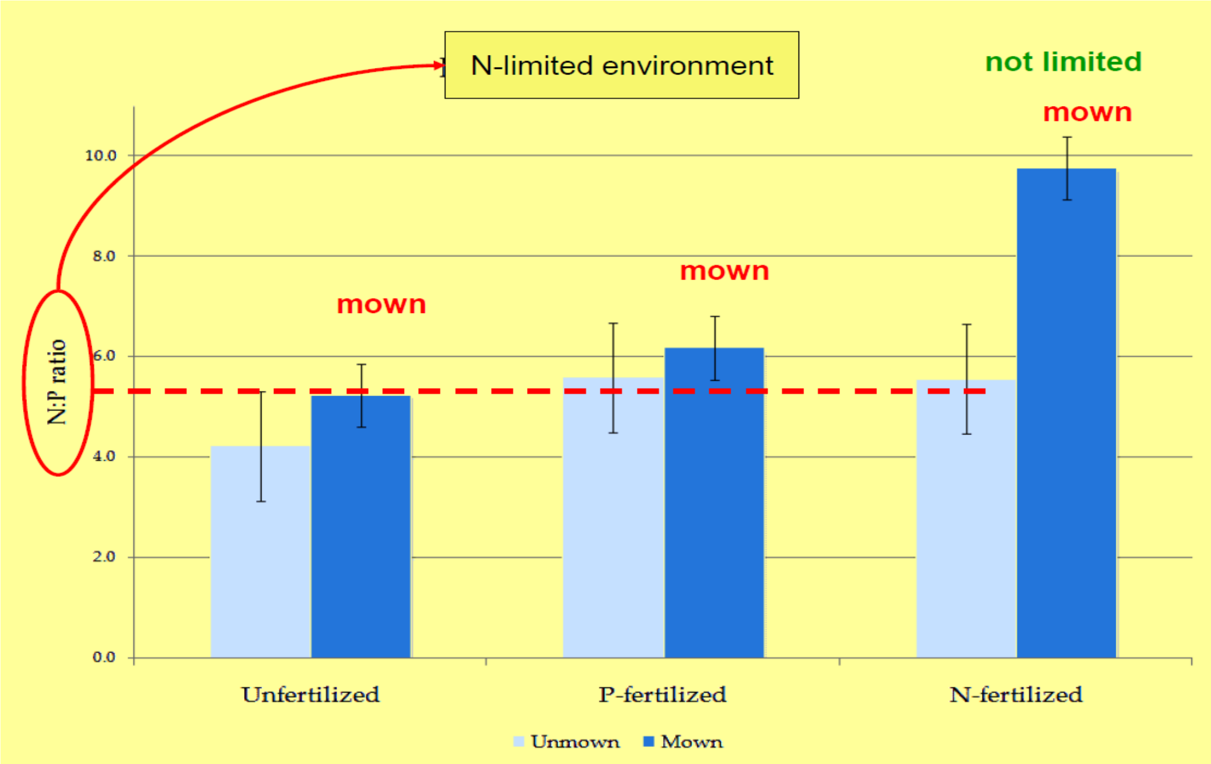

Figure 16: Nitrogen to Phosphor ratio on grazing lawns treated with several management measures.

- Fertilising a grazing lawn with nitrogen in combination with mowing leads to the highest grazing pressure on the laws. This result is the complete opposite of the results derived in this research.
- Areas fertilised with phosphor in combination with mowing, and areas that are only mown have nearly the same effect as each other. This result is the same as the results derived in this research.
- Areas that are not managed in Prins'(2016) research have the lowest impact and positive effect on the grazing pressure on the lawns.
- Prins (2016) executed two more treatments than Living Lands. Only fertilising with nitrogen or phosphor are additional treatments that are not applied in this research, and cannot be compared for this reason.

The results in Prins' research show that most management treatments have the same effect, the only difference with this research is that the effects of no management and fertilising with nitrogen in combination with mowing are swapped around. No management has the least effect in Prins' research while fertilising with nitrogen and mowing leads to the best effect.

The research of Prins (2016) is executed in a different area, which has different vegetation and soil characteristics, and a different composition of grazers. Nitrogen appears to be the limiting factor in Prins' (2016) research for grazing lawns to grow and develop, see figure 16.

6.2 Limitations:

Limitations are factors or events that occur during a research. These events bias the results and have a negative effect on research. The most important limitations that occurred during this research are described below:

- Several small species like Klipspringer and Steenbok antelope are not always detected on the camera traps. Camera traps should be placed close to the ground to detect small species; this was unfortunately not possible due to the presence of cattle. Multiple visits of these species are probably not recorded.
- We can state with certainty that an individual is present on a grazing lawn by using camera traps and dung counts. However, we cannot state with a hundred percent accuracy that an individual "uses" (consumes grasses) on a grazing lawn. That is why the term "potential use" is preferred.
- A dung count is executed once a week, on each grazing lawn. No grazers visit a grazing lawn when people are present on the lawns. Our presence probably decreased the number of visits slightly. However, our presence is limited to several hours per week.
- All the data is collected in a relatively short time frame. Enough data was gathered to perform the analyses. However, more data is desired to present more accurate results.

7. Conclusion:

The objective of this study is to identify the factors needed to develop a management strategy to reduce erosion in the CPE. These factors can be identified by answering the sub-questions, providing the answer to the main research question:

What is the effect of large grazers, fertilising and mowing on the grazing lawns in "Diepkloof"?

Q1. What is the grazing pressure on each grazing lawn in "Diepkloof"?

The grazing pressure on the grazing lawns in "Diepkloof" varies between 0.002 and 0.02 kilogrammes of consumed grasses per day per square metre, this is a relatively low grazing pressure. There is a high possibility that the grazing lawns in "Diepkloof" decrease in size if no actions are taken.

The location of the grazing lawns has no significant effect on the grazing pressure in "Diepkloof". The grazing pressure is partially affected by the large grazers that use the lawns and the treatments applied on the lawns. The difference in grazing pressure between the grazing lawns is for the most part determined by the size of the grazing lawns. A smaller effect is possibly caused by the combination of grasses and soil moisture.

Q2. Which large grazers make use of the grazing lawns in "Diepkloof" and what is the grazing pressure that each species exerts?

All species described in table 9 make use of the grazing lawns in "Diepkloof". However, each species exerts a different grazing pressure.

A high grazing pressure is exerted on the grazing lawns by Black wildebeest, Blesbok, Cow and Springbok. However, only Black wildebeest and Cow exert a grazing pressure that is important for the continuous presence of the grazing lawns in "Diepkloof".

No significant difference is determined between the use of the grazing lawns, so each grazing lawn is roughly used by the same animals and herds.

Q3. Which management treatments lead to more intensive use of the grazing lawns in "Diepkloof" by large grazers?

The sequence of management treatments that lead to an increase in intensive use are as follows (from high to low): 1. No management; 2. Fertilising with phosphor in combination with mowing; 3. Mowing once a year; 4. Fertilising with nitrogen in combination with mowing.

No management leads to the highest increase of intensive use on the grazing lawns. However, the other treatments consist partially of mowing, which is a semi-natural way to increases the grazing pressure thus increasing the intensive use of the grazing lawns as well. Fertilising with nitrogen in combination with mowing and fertilising with phosphor in combination with mowing are not applied on grazing lawn 4. So these treatments could have a higher effect than calculated. It may take several years for the effect of the management treatments to become visible and know the total effect. More research needs to be done to determine which management treatments lead to more intensive use of the grazing lawns in "Diepkloof".

8. Recommendations:

Several factors caused bias and influence the results, future studies should try to minimise these effects. Several knowledge gaps are present on grazing lawns properties and management, sees section 2.5. These knowledge gaps can be decreased by examining the following factors:

- The effects of soil temperature on grazing lawn properties such as vegetation.
- Hydrology has an influence on the presence and development of grazing lawns, but the exact effect of the hydrology on grazing lawns is unknown. More research needs to be done to get a better indication of the exact role of hydrology in the presence of grazing lawns.
- The exact effects of goats and sheep on grazing lawns is currently unknown.

Limitations can be reduced, and more accurate data can be collected on the grazing lawns in “Diepkloof” if a few adoptions are made in the methods:

- More cameras, in multiple angels, should be placed on the grazing lawns to identify more animals that are classified as unknown. The representation of the grazing herds will be more accurate once unknown individuals are identified.
- Camera traps should be placed lower in future research on a height of 40 cm above the ground. Smaller species are easier to detect when the camera placement is lower, this results in more accurate results. There should be experimented with a solid placement against the cattle.
- Grazing lawns should be monitored year round because there may be differences in use between the seasons because the lawns are richer during periods of rain.

Living Lands wants to develop a management strategy to combat erosion throughout South-Africa. However, the organisation should do more research into grazing lawns management in the CPE before they can successfully create a management strategy adaptable for other areas:

- The effect of management treatments on grazing lawn use in “Diepkloof” should be researched more to develop an effective management strategy for the grazing lawns. Aerial photographs should be used to monitor the effect of management treatments on grazing lawn use and whether the grazing lawns in “Diepkloof” are expanding or decreasing in size.
- Future research should use a plots design, rather than examining the entire grazing lawns. A plot design allows more statistical analysis on the collect data.
- Examine more grazing lawns, not only in “Diepkloof” but throughout the entire CPE. Each area within the CPE has a different species composition, this affects the vegetation and soil characteristics of the grazing lawns.
- The commissioning organisation should start to create and monitor new grazing lawns around the gullies by mowing or the with the use of Black wildebeests and cows. There may be several factors that have an unknown influence on newly created grazing lawns.

The best management treatments that lead to a more intensive use of the grazing lawns is fertilising with phosphor in combination with mowing. However, it takes multiple years for the effects of the management treatments to be visible. I recommend that organisation keeps monitoring these effects for several years.

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Appendixes:

Appendix I: Examples of camera trap recordings

Appendix I contains pictures of the observed species. This appendix show pictures different times during the day, as well as different types of weather. The pictures are meant to give a better impression of the photos taken by the camera traps and the challenges to identify individuals.

Figure 1: Three springbok sighted during the morning mist on lawn 4.

Figure 2: Couple of Black wildebeest sighted during the night on lawn 2.

Figure 3: A multi-species herd of Blesbok and Black wildebeest on lawn 4 during the day.

Figure 4: A rare sighting of a small Steenbok antelope

Figure 5: A couple of Blesbok at dawn, visible in black and white coloring.

Figure 6: A rare sighting of Greater Kudus

Appendix II: Dung count field form

This appendix shows an example of a field form used to collect data during dung counts. The top row contains general data like the recorder, lawn number, date, waypoint, remarks and quadrant number. The columns contain data regarding freshness, dung origin and photo id on dung pellets.

Name recorder	Lawn #	Plot #	Date	WayPoint	Remarks
Animal species (dung origin)	Frequency	Freshness	Raining	Photo #	Remarks