Population distribution and resources utilization of Roan antelope (*Hippotragus equinus*) and Sable antelope (*Hippotragus niger*) in relation to fire history at the Waterberg Plateau Park, Namibia.

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Declaration

I, Ailla-Tessa Nangula Iiyambula, hereby declare that the work contained in the thesis/mini-thesis, entitled Population distribution and resources utilization of Roan antelope (*Hippotragus equinus*) and Sable antelope (*Hippotragus niger*) in relation to fire history at the Waterberg Plateau Park, Namibia is my own original work and that I have not previously, in its entirety or in part, submitted it at any university or other higher education institution for the award of a degree.

Signature: Ailla-Tessa Iiyambula

Date: April 2018

Abstract

Both the roan antelope (*Hippotragus equinus*) and sable antelopes (*Hippotragus niger*) are listed on the IUCN Red data list as least concern. However, fragmentation and habitat, destruction, poaching, could cause the two species to be reclassified to near threatened or endangered if current populations are not better conserved. Some populations have become extirpated in some parts of Africa such as Burundi, and populations are declining in parts of Namibia. Various strategies to revive and conserve wildlife population ranging from proclamation of national parks, nature reserves as far as breeding population has been practised. In the middle 1970s roan and sable breeding populations were established at the Waterberg Plateau Park. The population has done reasonable well but recently, dramatic declines have been observed. This study aims to investigate the distribution of roan antelope and sable antelope in relation to fire, how fire history may have influenced the decrease of roan and sable population and resources utilisation between fire block 2a and 2b and the different years after fire at the Waterberg Plateau Park. Spatial data from game counts was used for roan and sable distribution mapping with QGIS. An Independent t-test and One-way ANOVA was used to test for the difference in resources utilisation between fire block 2a and 2b and between the years after fire. Results indicated that although not dominantly, fire did have an influence on the distribution of roan and sable antelope. Sable antelope was mostly observed around water holes while roan antelope was widely dispersed. There was not a significant difference in resources utilisation (grass and shrubs) between fire block 2a and 2b, but a statistical significant in grass utilisation between years after fire in block 2a and 2b. Herbivores utilised mostly the area burnt 4 years ago. Although the study does not give concrete evidence of what is currently happening to roan and sable antelope population at the plateau, resources utilization and selection is important for the conservation of vulnerable species.

Contents

1. Introduction

1.1 Identification

Sable antelope (Hippotragus nigger), and Roan antelope (Hippotragus equinus) are endemic to Africa and part of the ten antelopes species in Southern and middle of Central Africa from the genus Hippotragus (Stuart & Stuart, 2015b);(Matthee & Robinson, 1999a). There are four subspecies of sable antelope (*H.n.niger, H.n.kirkii, H.n.roosevelti, and H.n.variani*,) and six subspecies of roan antelope *(H.e.equinus, H.e.cottoni, H.e.langheldi, H.e.bakeri, H.e.charicus and H.e.koba* (Matthee & Robinson, 1999)(Alpers, Van Vuuren, Arctander, & Robinson, 2004). Roan and Sable are of the largest and most spectacular antelopes throughout the Sub-Sahara Africa, with sable slightly smaller than roan and roan seconding eland antelope (*Traurotragus oryx*) in size (Wilson & Stanley, 1977); (Martin, 2003);(Alpers, Van Vuuren, Arctander, & Robinson, 2004).

1.2 Ecological distribution

Roan and Sable antelope are still distributed in large parts of Africa, particularly sable antelope in the savannah areas of eastern, central and southern Africa while roan antelope is found in the open-lightly wooded countries of central and western Africa (Wilson & Stanley, 1977) (IUCN, 2016). Although widely distributed throughout Africa, roan distribution is patchy and discontinuous. (Alpers et al., 2004) (Matthee & Robinson, 1999b). Erb, (1998) describes the species as occupying woodland savannas and grasslands of sub-Sahara with a distribution closely linked to *Burkea africana,* a typical broadleaved woodland savannah plant species (Erb, 1998).

The greatest abundance of roan and sable antelope are in relatively high rainfall areas (400mm and above) and dystrophic soils (Harrington et al., 1999). Roan have occurred naturally in the north-eastern Namibia with average rainfall exceeding 400mm annually but these species distribution has been extended to game reserves, communal and commercial farming areas with rainfall below 400mm (Erb, 1993);(Ministry of Environment and Tourism, 2003). Roan and Sable antelope are water dependent and their success in an environment is more dependent on water availability than other factors such as botanical composition. (Matthee & Robinson, 1999b).

1.3 Social structure

Like most African bovid, roan and sable antelopes are gregarious. Roan associates in herd of 10-20 individuals, a harem group during breeding season while groups of sable about 20-25 individuals have been observed in sable with territorial bulls during breeding season, while young males associated in bachelors groups (Erb, 1993)(Capon, 2011). Roan antelope at Waterberg Plateau Park, Namibia were observed to be in clans with a home range of about 4800ha for two clans and a territorial male with a home range of 1200ha(Erb, 1993).

1.4 Population status over the years

The two species have been eliminated from large parts of their native home range, as a result of pressure from hunting activities, increasing human populations, habitat fragmentation through agriculture and development. The species susceptibility to zoonotic diseases such as anthrax has also contributed to their population decline in many areas for the past decades (Matthee & Robinson, 1999a);(Wilson & Stanley, 1977);(ALPERS et al., 2004) (Capon, 2011) . Roan and sable are "rare and endangered" species in Namibia although currently of **least concern** on the International Union for Conservation of Nature Red list of threatened species (IUCN Red data list) (IUCN, 2016). This could change based on habitat destruction, fragmentation and poaching.

1.5 Conservation measures

Roan and sable antelope are widely used as game ranch species. They contributes significantly to the economies of developing countries in the Sub-Sahara Africa but, their populations are declining (Oosthuizen, Allsopp, Troskie, Collins, & Penzhora, n.d.; Kimanzi, 2011;Alpers et al., 2004). As a measure to reverse this in Namibia, they have been introduced on private wildlife reserves but with little success, partly due to rainfall vulnerability in these areas(Martin, 2003). Conservationist argue that the only possible to reveerse the population declines is to tighten management, protection and conservation of the species (IUCN, 2016).

1.6 State of roan and sable population in Namibia.

Ministry of Environment and Tourism (2003) estimated that the population of roan in Namibia is about 800 and sable 1 200. About half of this population is found in areas with mean annually rainfall below 400mm which does not bode well for their long term survival. The numbers are low and it is threatening because the species are meta populated (dispersed and in small isolated groups) (Ministry of Environment and Tourism, 2003). In 1975, 93 roan antelopes were introduced into Waterberg Plateau Park for safe breeding and re-introduction to areas where locally extinct (Erb, 1998). This population increased to 275 by 1984 (an annual population growth of over 14% percent assuming exponential growth) and 77 roan antelopes were trans-located in 1985 to other conservation organisations. Sable antelopes were about 90 at Waterberg in 1975 (Erb, 1998). (Stein, Fuller, & Marker, 2008). Despite interventions, roan and sable still remain rare species in Namibia, that requires proper management and conservation which is quite a challenge. The demand for breeding stock, from both nature conservation bodies and game farmers is high (Erb, 1998).

1.7 Resources utilization and fire as a management tool.

Roan and sable antelope are largely grazers, preferring medium to tall perennial grasses such as *Eragrostis jeffreysii* and *Aristida stipitata* and browse dry season on species including Acacia as

observed at the Waterberg plateaus park by Erb (1998). The use of fire as a management tool has been practised in many parts of the world during the late dry seasons to stimulate grass and tree regrowth and alleviate the nutritional stress for grazing ungulates (Parrini & Owen-smith, 2009) (Kreye et al., 2014) (van Rooyen, 2010). Recent studies of wildfires and the environment in which they occur has expanded our understanding of the important role that fire plays in many terrestrial ecosystem and its influence on herbivores (Parrini & Owen-smith, 2009). Amputu (2016) highlights that fire history of the Waterberg Plateau Park is well documented and provides an opportunity to investigate its effects on vegetation structure and composition. But the extent to which burning influence and benefit rare antelopes such as sable and roan which prefers medium height grass (Gureja & Owen-smith, 2002)(Kreye et al., 2014)**.**

Waterberg has 6 fire zones that have burnt at an interval ranging from 6.2 to 18.3 years (Dave Joubert, personal communication). The park has undergone a range of fire frequencies which are both naturally and human caused (Amputu, 2016). The time since last burnt at the Waterberg Plateau Park ranges from 4 to 27 years. (Aindongo, 2016). Fire maintains grasslands savannahs but reduced fire recurrence leads to thickening of woody species and reduction in palatable grass species such as *Anthephora pubescens, Brachiaria nigropedata* and *Digitaria seriata*. *Terminalia sericea* and less palatable coarse grass species such as *Eragrostis pallens* are now dominating the plateau (Amputu, 2016). Unfortunately, no surveys prior to this quantified the species composition, with Jankowits (1983) focusing on community studies through classification. The intervals in fire events could be a leading cause of population declines of roan and sable antelopes. Results from the study could help in providing insight as how fire intervals influence resources utilization in roan and sable antelope.

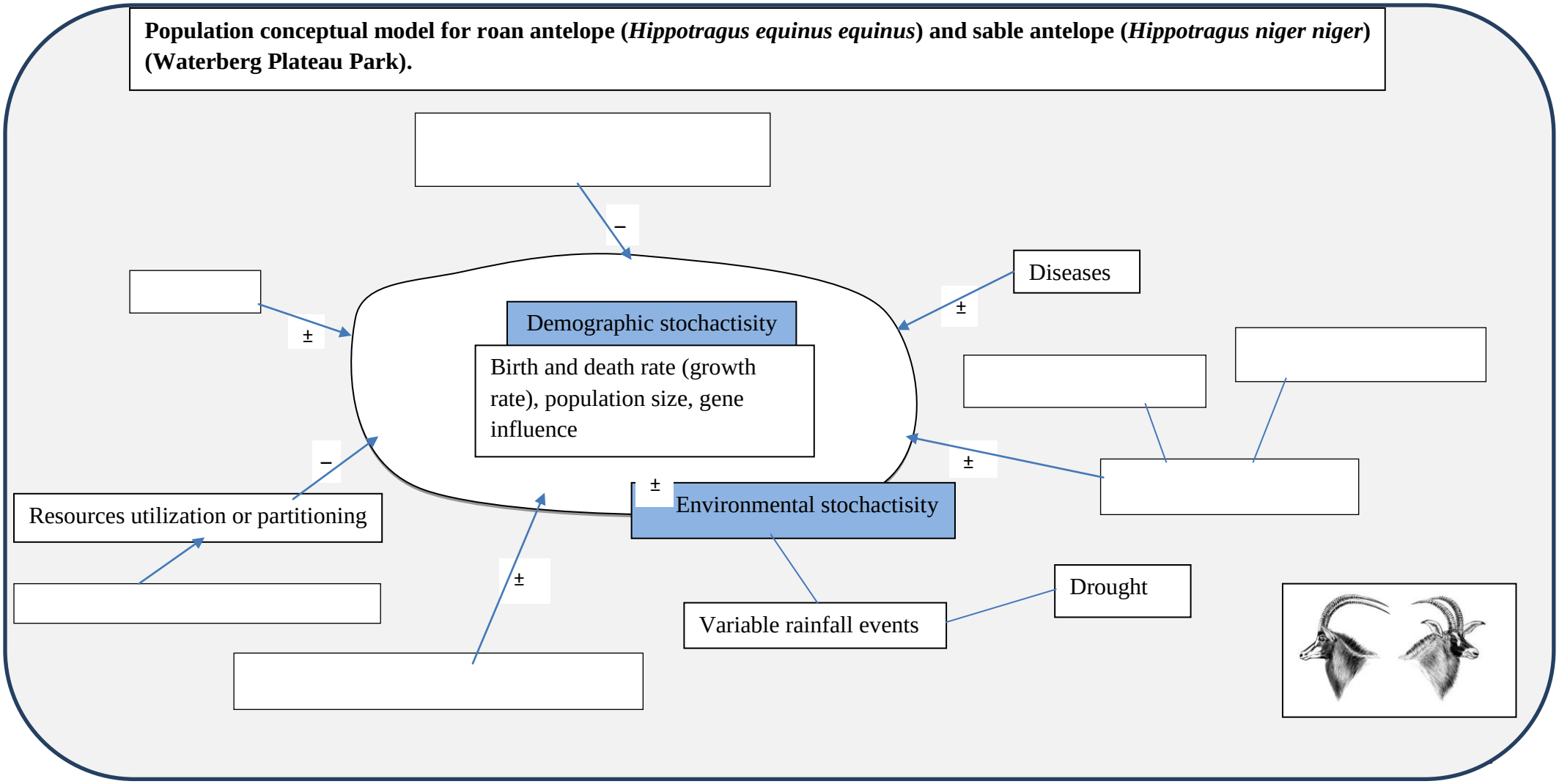
Population declines must be halted before further negative demographic and environmental stochasticity effects occur to non-viable populations. (Funston et al., 2014). Understanding the population distribution and response to the environment and management is crucial in the conservation of declining species. The study of these dynamics provides knowledge and insights might provide solutions to the current dilemma (Capon, 2011)

1.8 Conceptual model

Conceptual diagrams or models have been used in many studies to simulate possible processes, changes, causes and their impacts in a scenario (Robinson, Arbez, Birta, Tolk, & Wagner, 2015). Conceptual diagrams are a lead to follow a series of events or changes and interaction, making it easier to understand the problem and find solutions (Deblinger, Field, Finn, & Loomis, 2004). In wildlife management, conceptual models help managers to understand the link between wildlife and their response to environmental and demographic stochactisity and improve wildlife management practises. In this study a variety of factors that influence the population size and growth of two rare

antelopes: roan and sable have been derived from similar researches as predictions to what could be currently happening at the Waterberg Plateau Park. Not all factors are included but the ones mentioned are just possibilities and any other cause of decline not mentioned does not make it the least.

Population conceptual model for roan antelope (*Hippotragus equinus equinus*) and sable antelope (*Hippotragus niger niger*) (Waterberg Plateau Park).



changes can be futile to population (Goodale & Stenhouse, 2016)**.**

1.9 **Current state of roan and sable at the Waterberg Plateau Park, problem statement aims of the study and hypothesis**.

Four decades since roan and sable antelope were introduced to the plateau their populations have severely dropped to 51 and 40 individuals respectively (unpublished aerial count data from MET) Because of this half the number of both species has been moved to a new nearby farms and only less than 25 individuals of each species survives in the original park.

The aim of the study is to investigate how important fire history might be in the distribution and decline of roan and sable population at the Waterberg Plateau Park.

Research questions

1. Is the distribution and decline in roan and sable antelope population on the Waterberg Plateau Park influence by fire history?
2. Is there are difference in resources utilisation of roan and sable antelope between fire blocks with different fire history

The objectives are as follow:

1. To determine the temporal and spatial dynamics of roan and sable populations, and relate this to fire history
2. Relate recent measures of resource utilization (2014, 2015 and 2017) in relation to fire history.

Hypotheses (o) – there is no significant difference in resources utilisation between fire blocks 2A and 2B and time since last burn.

2. Literature review

Fire influences resources utilisation, grazing and browsing preference of herbivores. A habitat selection comparative study was carried out between roan antelope, tsessebe, Lichtensttein'hartebeest, sable antelope and zebra before and after burning at Madrid Game Ranch. Different antelopes react to fir differently, roan, sable and zebra grazing was intensely on burnt areas, with roan selecting high level grass and denser areas compared to other antelopes. Roan and hartebeest were abundant on bottomlands while the other preferred midslopes and uplands of the valley. The study concludes with an ecological separation between the species in habitat preference even within burned areas (Gureja & Owen-smith, 2002).

Many of the studies conducted on roan and sable were as a result of concern for the population declines observed. This is proof that roan and sable are species that requires extensive understanding

at conserving them. Previous study at Waterberg Plateau Park by Erb (1998) on the ecology of roan antelope (*Hippotragus equinus)* and its ecology assessed the population dynamics of roan from the time of the species introduction into park (1985). Factors that influence and play a major role in the population growth of roan at the plateau are soil nutrient availability at different sites within the plateau. During the rainy seasons roan prefer rocky sites with high protein content and move further in land of the plateau into the deep Kalahari sands during summers. The minimum viable population of roan at the plateau should be 200 and maximum about 300 to prevent further stress that could arise from high populations, which requires game capture of at least every three to four years (Erb, 1998).

The feeding routine of sable is associated with a large utilization area during the early wet season, compared to other seasons. In dry season the sable forage close to water sources and concentrated on calcareous and clay soils. The species is known to select grass that retain greenness throughout the dry season. This feeding routine during the dry season and options of browsing new leaves helps sable antelope to maintain its required nitrogen and phosphorus levels (Hensman, Owen-smith, Parrini, & Bonyongo, 2013).

Fire was shown to be beneficial to sable antelope Owen-Smith and Parrinni (2009). Roan antelope foraging is mostly concentrated on recently burnt areas especially when there was regrowth and continued green growth during the dry season. With the fire interval of the Waterberg Plateau Park (minimum of about 7 years), is it adequate to support the sables nutritional needs?

Capon, (2011) Studied the ecology and potential factors limiting the success of sable antelope in southern eastern Zimbabwe. The decline in sable antelope numbers in the Lowveld region of Zimbabwe and South Africa from 237 animals in 1994 to a population of 62 in 2005, became an issue of concern to managers involved with the conservation of the species. Through monitoring and the use of a VORTEX population viability test, it was shown that the population of roan antelope could persist but any naturally caused pressure on the female adult population could have serious effects on the success of sables.

A similar roan population decline from 450to 45 individuals was experienced in the Kruger national park between 1986 and 1993. Although several hypotheses were given such as drought, intraspecific competition, habitat deterioration, predation and diseases outbreak, Conclusions indicate that drought was not sufficient of a driver to cause such a decline but grassland deterioration also contributed. The main causes of population decline were shown to be decreased survival within adults groups and calves. Predation on adult roan from an increase in lion numbers due to the dispersal of zebra and wildebeest into the area seems to be the main cause of the sudden population decline (Funston et al., 2014). Sable and Tsessebee populations were also recorded to be declining even after closure of waterholes that might have lured other bovid species into the area that increased competition.

Although countries through Africa have different management situations these countries may have other more serious threats to wildlife conservation to contend with other than game ranch translocations, such as habitat destruction, uncontrolled poaching, excess hunting and civil unrest. What is required is a sensible and practical management plan that joins together science, game ranch economics and social history (ALPERS et al., 2004).

3. Study area

The Waterberg Plateau Park was established in the early 1970's and is managed by the Ministry of Environment and Tourism as a wildlife sanctuary for protection and breeding of rare and endangered species and covers an area of approximately 470km² (Stein et al., 2008). Waterberg Plateau Park 1650-1700m above sea level is located in the Otjozondjupa region 20 15' to 20 25' S. latitude and 17 5' to 17 28' E. longitude, 64 kilometres east of Otjiwarongo (Jankowitz & Venter, 1987; Aindongo, 2016). The park is surrounded by commercial farms practising livestock management and wildlife conservation. The plateau rises about 200m above the plains of the surrounding Thorn bush Savannah (Stein et al., 2008).

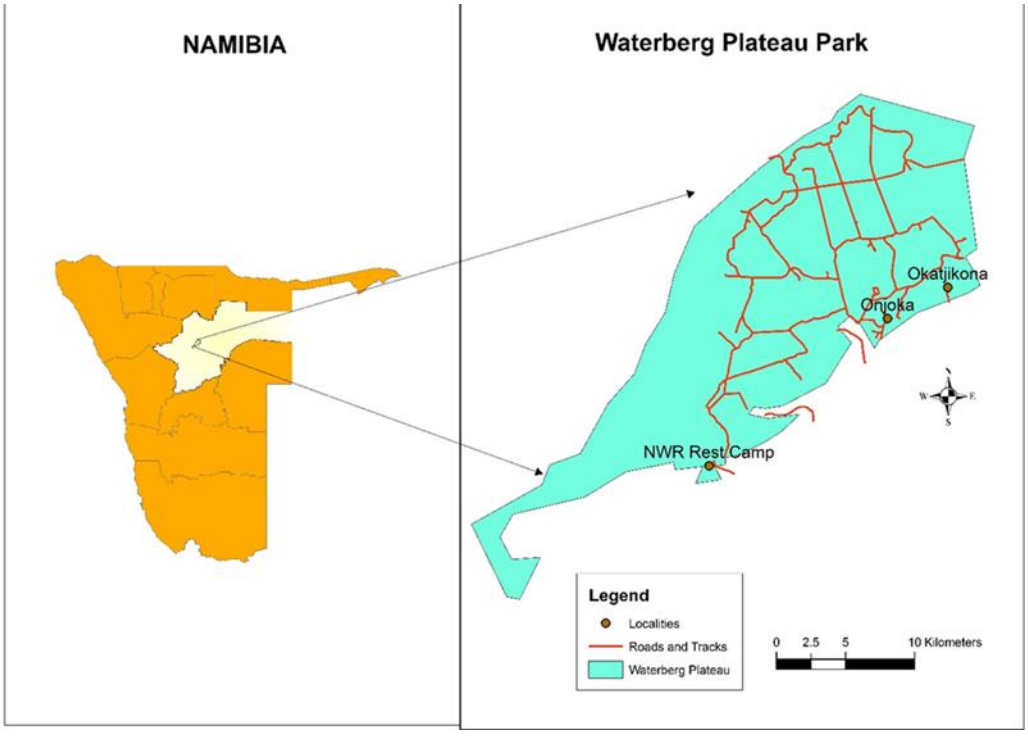


Figure1. Waterberg Plateau Park map (Aindongo, 2016 unpublished data)

3.1 Fauna

The park was originally proclaimed to protect Africa's largest antelope eland *(Taurotragus (Tragelaphus) oryx)* but later, as human and farming encroachment increased more endangered species were introduced to establish breeding populations. The park is refuge to endangered species such as the second largest mammals black rhino (*Diceros bicornis)* and white rhino (*Ceratotherium simum*) and rare species such as sable antelope (*Hippotragus niger* and roan (*Hippotragus equinus*). Other wildlife species include Cape buffalo (*Syncerus cafer),* Giraffe (*Girrafa camelopardalis*), Kudu (*Tragelaphus strepsiceros),* Red hartebeest (*Alcelaphus buselaphus),* Wildebeest (*Connochaetes taurinus),* Tsessebe (*Damaliscus lunatus).* Small antelopes like Klipspringer (*Oreotragus oreotragus)* Duiker (*Sylvicapra grimmia)* and Steenbok (*Rhaphicerus campestris*) are also present in the park (Erb, 1998; Stuart & Stuart, 2015). Many of the herbivores were trans-located to the park between the periods of early 1970s and late 1980s (Amputu, 2016).

Small mammals such as Hairy footed-gerbil (*Gerbilliscus paeba*), Brush-tailed hairy-footed gerbil (*Gerbilliscus vallinus*), Desert pygmy mouse (*Mus indutus*), Pouched mouse (*Saccostomus campestris*) and Bushveld gerbil (*Gerbilliscus leucogaster*) have been recorded (Aindongo, 2016).

Over 200 bird's species have been recorded in the park, of which 33 are birds of prey. The birds of prey population includes Cape vulture (*Gyps coprotheres),* Verreaux eagle (*Aquila verreauxii),* and Bateleur eagle (*Terathopius escaudatus*) (Simmons, Brown, & Kemper, 2015)(Cillie & Oberprieler, 2012). Of the 11 endemic birds in Namibia 7 are found at Waterberg Plateau Park, Rock runner (*Achaetops pycnopygius*), Hartlaub's francolin (*Francolinus hartlaubi*), Rüppell's parrot (*Roicephalus rueppelli*), Bradfield's swift (*Apus bradfield*), Monteiro's hornbill (*Tockus monteiri*), short-toed rock thrush (*Monticola brevipes*), and Carp's tit (*Parus carpi*) (Ministry of Environment and Tourism, n.d.)

3.2 Flora

The vegetation of Waterberg Plateau Park, on the plateau, is a homogenous deciduous woodland tree savannah with shrub layer thickets of mainly *Acacia ataxacantha* and *Ochna pulchra* (Jankowitz & Venter, 1987). Waterberg Plateau Park vegetation structure is similar to thae woodlands savannah or the Northern Kalahari sands, with some species missing from the assemblages, due to the lower rainfall and frequent occurrence of frost. The woodland savannah on the plateau occurs on thick Kalahari sand which is highly permeable allowing rainwater to infiltrate to underground springs, but is also nutrient poor (Stein et al., 2008).

The Waterberg plateau park has a diversity of grass species typically of nutirnet poor sands, such *as Eragrsotis pallens, Digitaria seriata, Eragrostis jeffreysii, Aristida stipitata, Aristida meridionalis,*

Brachiaria nigropedata, Eragrostis rigidior, Eragrostis jeffreysii and Panicum kalaharense (Uunona, Joubert, & Stolter, 2016, Muller, 2007 and Amputu, 2016 unpublished data).

4. Methods

The study was done in two fire blocks with different fire history (2a burnt 4 years ago and 2b burnt 17 years ago).

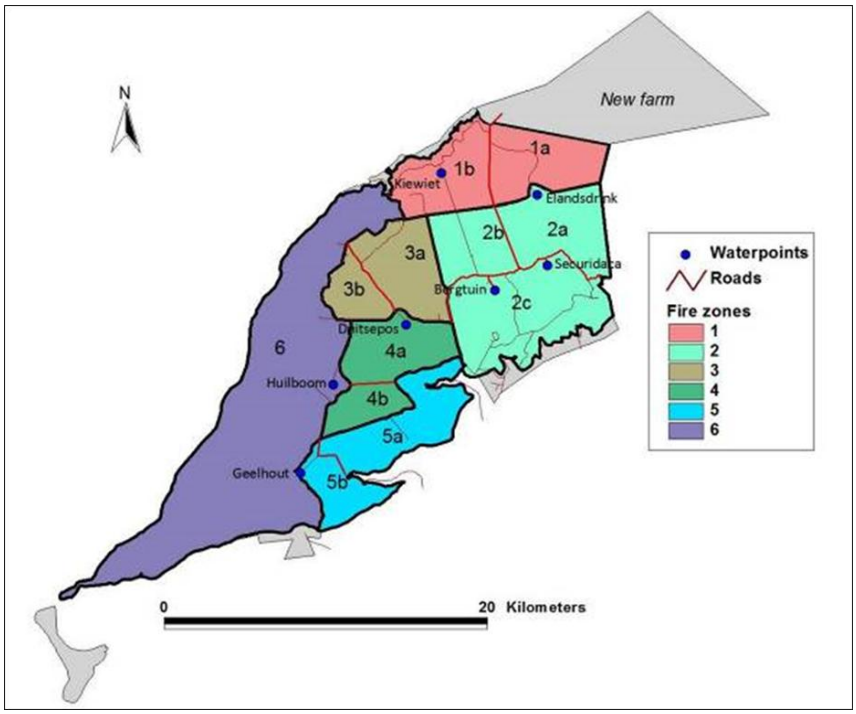


Figure3. Map of Waterberg fire zonation (Aindongo, 2016 unpublished data)

Table1. Summary of fire history up to 2017

Fire zones	Fire .intervals (Years)	time since last burn (years
2a	6.2	4
1a	9.3	5
2b	9.3	17
1b	18.5	27

4.1 Population distribution

A species spatial and temporal distribution map for Roan and Sable antelope was produced using Quantum Geo Information System (QGIS). This was done with the use of aerial game count spatial

data for roan and sable antelope between the years 2011 to 2016 from the Ministry of Environment and Tourism.

4.2 Resources utilization

Data collected along 6 randomly located 200 m longs transects in each fire block. At every 20m along the transect, a 4 m x 8 m quadrat was laid out. At every corner of the quadrat each nearest shrub and grass was identified and its utilization recorded. Grasses and shrubs had to have 2 or more missing, fresh marks on leaves/twigs to be recorded as utilized. This study is a follow up on resources utilization study that was conducted previously in 2014 and 2015.

4.3 Pellet counts

Pellets count have been used widely for distribution, density and forage utilization of large mammal species (Novaro, Capurro, Travaini, Funes, & Jorge, 1992) (Mandujano, 2014). In this study pellets counts are used to determine the presence of herbivore in the fire blocks and constitute for the inability to identify which species browsed and grazed by the look at the bite mark on the plant. Within each quadrat, dung of each species identified and counted.

Pellets counts were standardized as follows: Dung pellets in groups of less than 20 and old scoured pellets were not counted. Pellets less than 20 were not counted to avoid sampling animals that were basically roaming and not utilization the area in which the pellets were found. While old pellets were avoided as they might have been included in previous utilization studies or they are just too old to include in the sample.

4.4 Data analysis

Data was analysed with SPSS (Statistical Package for the Social Sciences) and Excel. To test for differences between fire block 2a and 2b an Independent T-test was used. Testing for significance difference between the years after fire a One-Way ANOVA test was used and further a Post hoc for difference within the different years after fire.

5. Results

5.1 Distribution maps

Coordinates from aerial games counts of 2011 to 2016 were exported into QGIS to map the distribution of were roan and sable antelope have been observed. The Game counts were conducted between 07/09/2011/, 26/07/2012, 02/10/2013, 02/09/2014/, 02/10/2015/ and 10/10/2016. Fire happened between. Waterberg vegetation 2011-2016 NDVI was used for mapping background and fire shapefiles adapted from Afis fire (2010-10, 2012-10, 2013-09 and 2014-04).

For roan antelope the most evident response to fire was in fire block 1a that burnt 2010, in 2011 the block had about 20% of the roan population. It is again observed in 2014, block 2a which burnt in 2013 had the highest proportion of the roan population, about 46.9%.

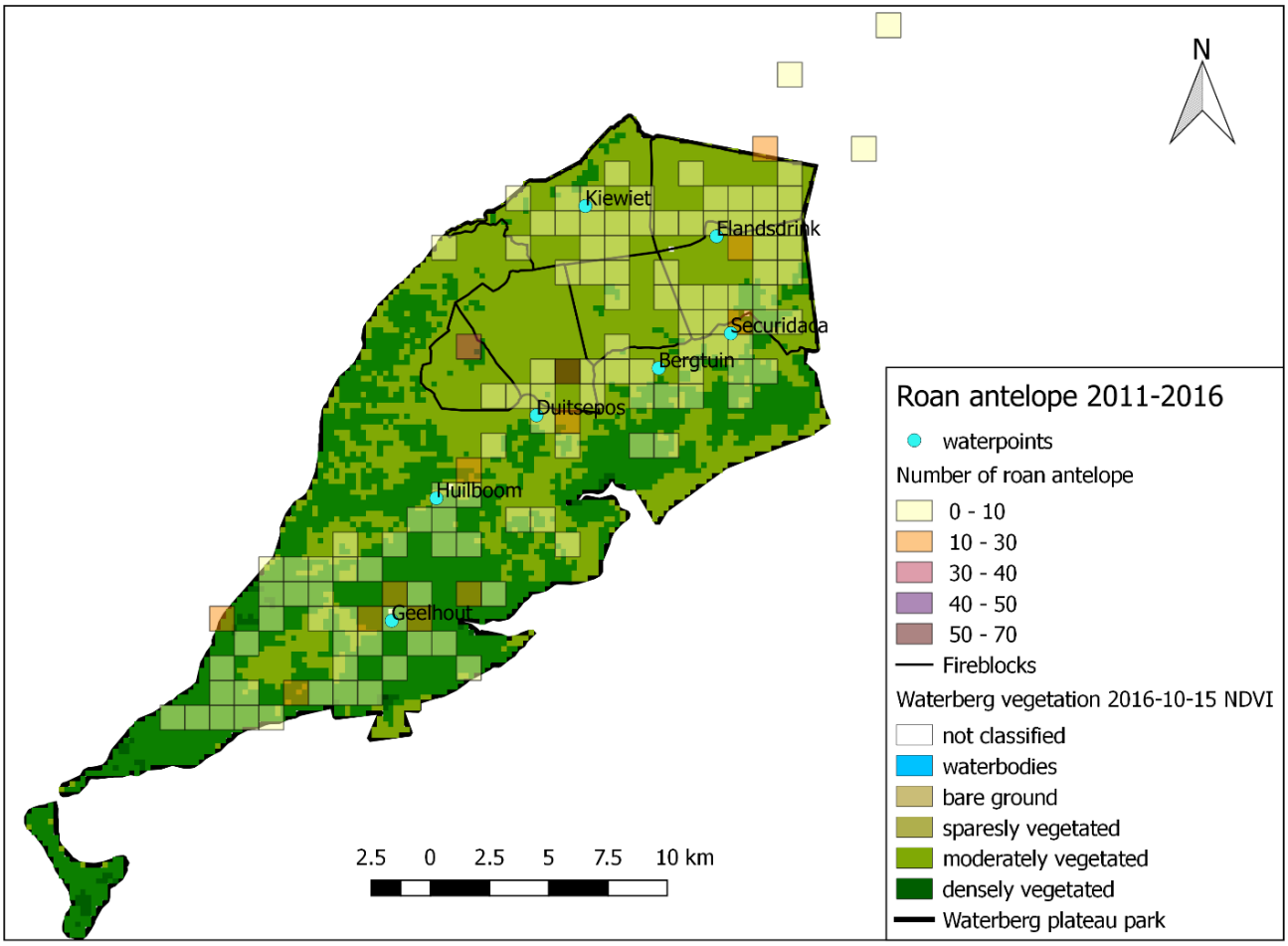


Figure 4. Roan antelope 2011-2016 distribution in relation to fire at Waterberg Plateau Park, Namibia. See appendix for each separate year roan movement/distribution in relation to fire.

Sable antelope movement in relation to fire although not evident in many block that burnt, rare cases were observed in 2013. During this year after 2012 fires in block 3a, 49% of the population have been observed.

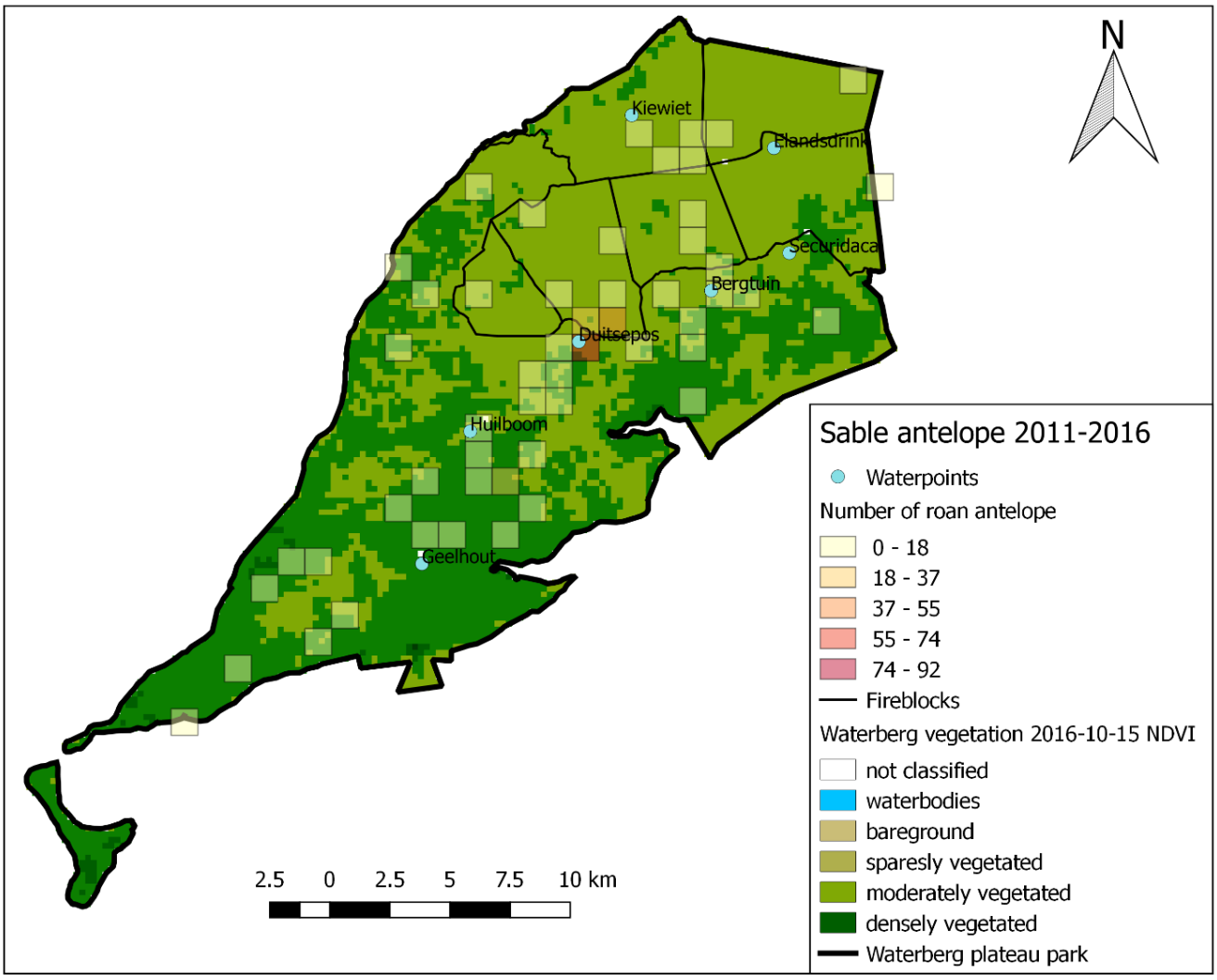


Figure 5. Sable antelope 2011-2016 distribution at Waterberg Plateau Park, Namibia. See appendix for each separate year sable movement in relation to fire.

5.2 Resources utilization

A total of 14 grass species, 15 trees and shrubs species and 40 herbaceous species were recorded at the sites. Of these only 4 grass species, and 8 trees and shrub were utilized. Grass abundance in both sites was dominated by *Digitaria seriata*, making up 37% of the sample in 2A and 29% in 2B. Some species were present in one site and absent in the other, for instance the least occurring grass *Panicum coloratum* was observed once in fire block 2A and not in 2B. *Bauhinia petersiana* was most abundant

among trees and shrubs with 19% in 2A and 25% occurrence in 2B, followed by *Terminalia sericea* in 2A.

A total of 240 grass species have been recorded from the fire block 2a and 2b. *Digitaria seriata* had the highest proportion of utilization in both fire blocks (0.08 in 2a and 0.11 in 2b). *Brachiaria nigropedata* was recorded three times and utilized on both occasions thus the high proportion of utilization.

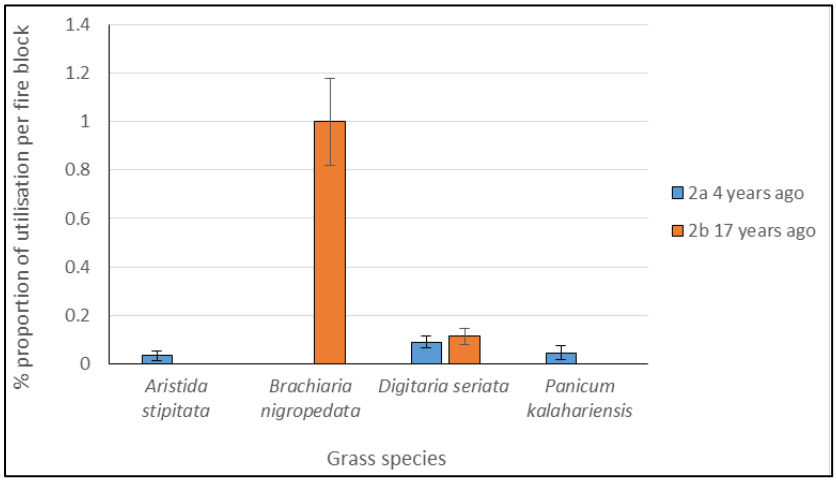


Figure 6. Proportion of utilized grasses in each fire block.

There was no statistical significant difference in grass utilization between fire block 2a burnt 4 years ago and fire block 2b burnt 17 years ago (Independent t-test, p.value 1.00>0.05, n=6).

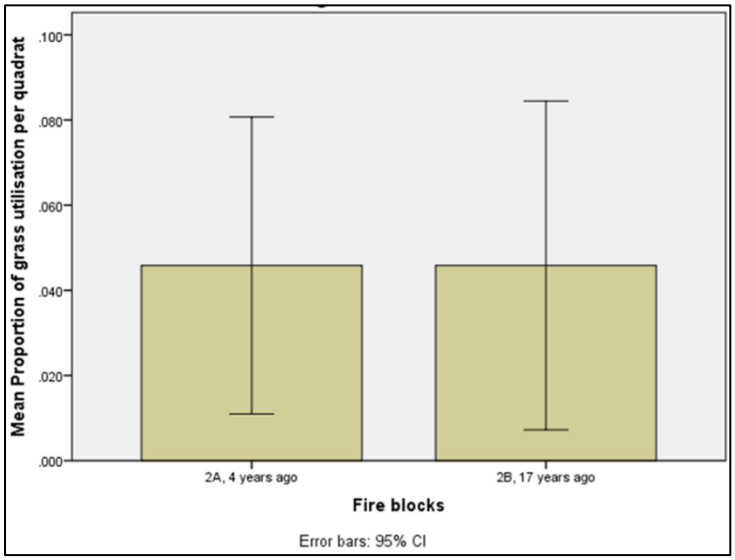


Figure 7. Proportion of all grass species utilization or total grass utilization in each fire block.

Results shows that there is a statistical significant difference in block 2a grass utilization across the different years after fire (One-Way ANOVA, p.value 0.005<0.05). A Post hoc test further indicates that there significant difference is between 9 months, 2014 and 4 years, 2017 after the fire (p.value = 0.008) and between 3 years, 2015 and 4 years, 2017 after the fire (p.value = 0.016).

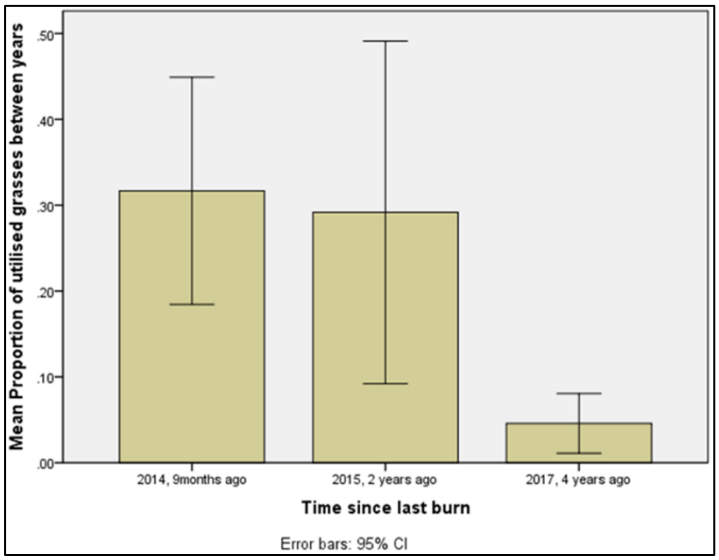


Figure 8. Proportion of grass utilization in fire block 2a between three periods after fire.

There is a significant difference in block 2b grass utilization across the different years after fire (One-Way ANOVA, p-value 0.004<0.05, n=6). A Post Hoc further indicates that the difference is between 14 years, 2014 and 15 years, 2015 (p.value 0.004<0.05).

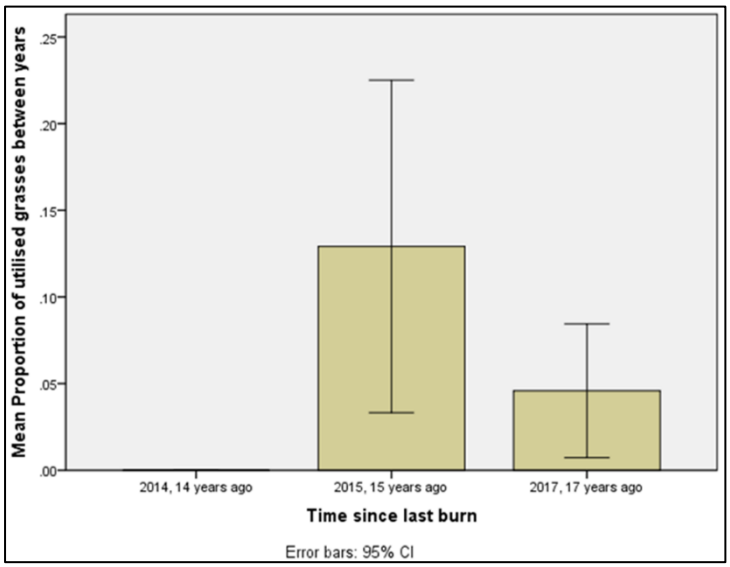


Figure 9. Proportion of grass utilization in fire block 2b between three periods after fire.

A total of 240 trees and shrubs species have been recorded from the fire block 2a and 2b. *Acacia ataxacantha* had the highest proportion of utilization in both fire blocks (0.40 in 2a and 0.46 in 2b). *Terminalia sericea* was the least utilized with a proportion of 0.02 in 2a and zero utilization in 2b.

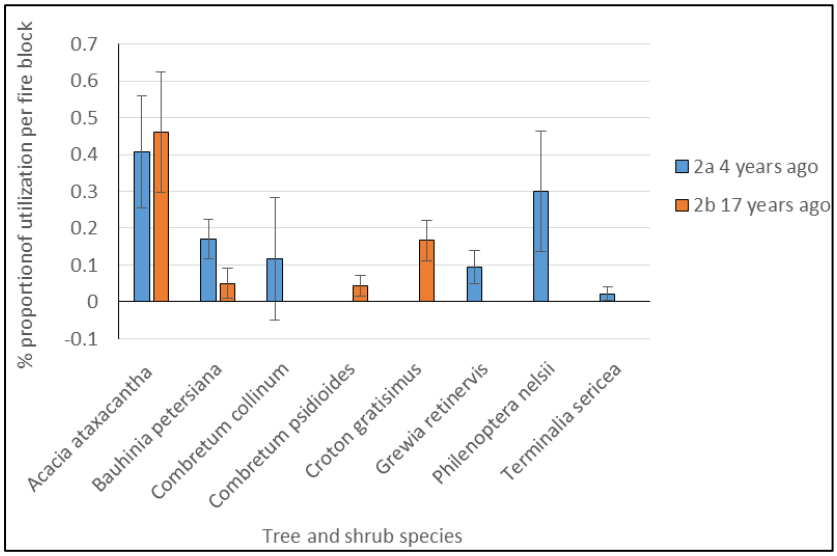


Figure 10. Proportion of utilized trees and shrub in each fire block.

There is no significant difference in trees and shrubs utilization between fire block 2a and 2b (Independent t-test, p.value 0.57>0.05, n=6)

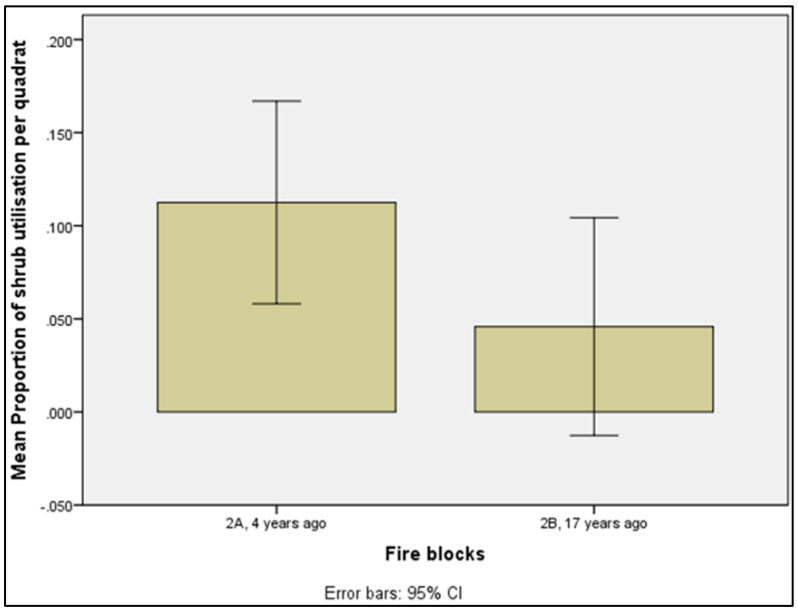


Figure 11. Proportion of all trees and shrubs species utilization or total trees and shrub utilization in each fire block.

There was no significant difference in trees and shrub utilization in fire block 2a and 2b across the different years after fire. Fire block 2a (One-Way ANOVA, p.value 0.28>0.05, n=6), Fire block 2b (One-Way ANOVA, p.value 0.55>0.05, n=6)

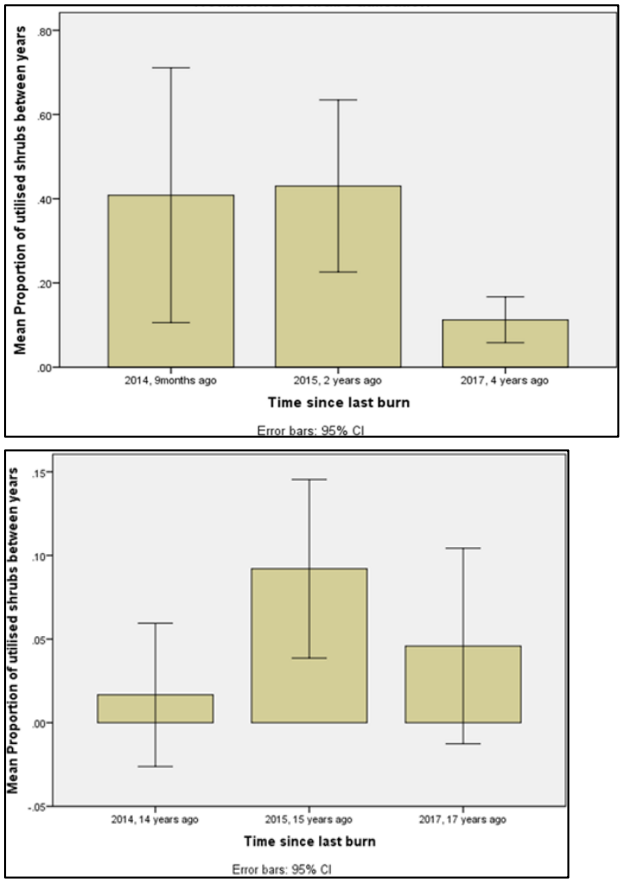


Figure 12. Proportion of trees and shrubs utilization in fire block 2a and 2b between three periods after fire.

5.3 Pellet counts

Giraffe pellet count dominated with a proportion 0.05. Roan, sable and eland had a proportion of 0.016. Fire block 2a, 9 months after fire had the highest proportion of roan/sable dung so as in 2b, 14 years after fire.

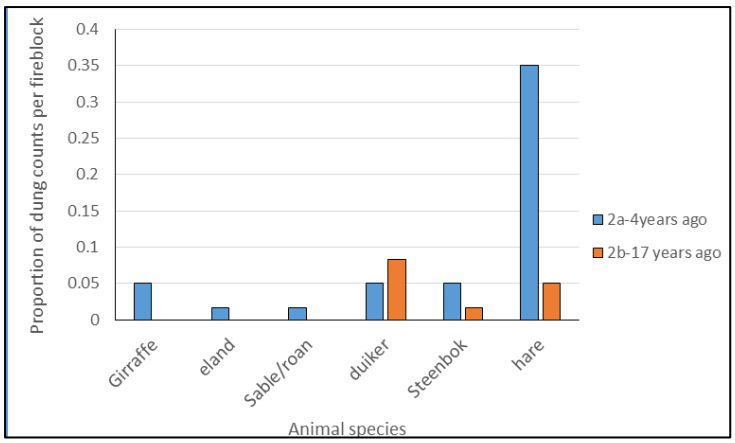


Figure 13. Proportion of dung count in each fire block

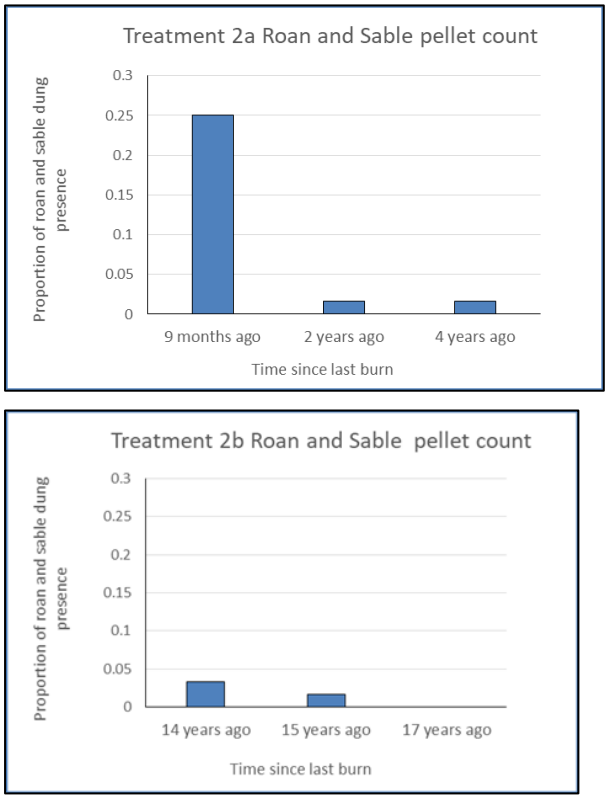


Figure 14. Proportion of roan and sable dung count in fire block 2a and 2b between three periods after fire.

5.4 Aerial survey population trend

The project was prompted by a decline in roan and sable population. There has been an incredibly high increase in roan population from 81 in 2014 to 304 in 2015.

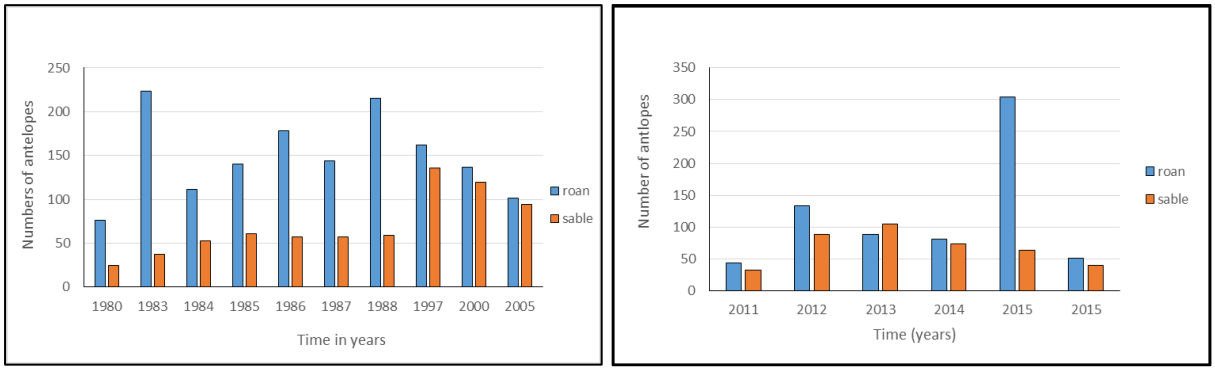


Figure 15. Aerial population estimate trend of roan and sable antelope over the years. The counts for these years (1981-2, 1989-1996, 1998-9, 2001-4) do not appear because there was no data available.

6. Discussion

Roan and sable antelope were not dominantly distributed on the burnt areas. Their distribution in fire blocks time after fire and no fire varied. Although utilizing burnt areas roan has been observed to continue using unburnt areas (Gureja & Owen-smith, 2002). The game surveys were conducted in the late dry season after fire from previous season therefore it was not possible to observe the immediate response of the species right after fire following the rains and regrowth.

The movement or distribution of roan and sable in response to fire was mostly observant within herds. Roan and sable are territorial and have home ranges (Erb, 1993 and Capon, 2011). Although regrowth after fire attracts herbivores (Vermeire, Mitchell, Fuhlendorf, & Gillen, 2004), territory could influence movement and distribution. The burnt areas might have been outside the home ranges of some herds (Gureja & Owen-smith, 2002).

Roan antelope had wider distribution on the plateau other than sable antelope with a restricted distribution. Roan covered habitats forming larger areas unlike sable which is narrowly confined to small habitats (Ben-shahar, 1990). But, (Magome, Cain, Owen-smith, & Henley, 2008) says during the months of October and November sable moved out of their home ranges to take advantage of the green growth which we would expect a wider distribution in sable antelope. Roan antelope had the highest number of individual compared to sable antelope thus probably another reason for the wide distribution by roan. Findings by (Wilson & Stanley, 1977) conclude that the size of activity is rarely linked to the size of the herds but food availability.

In many cases sable antelope has been concentrated at water points especially at Duitsepos. This is confirmed by Ben-Ashar (1990) that roan were observed to be far from water points and sable antelope preferring areas that are not less than a kilometer away from the water point. Even so, Hensman et al (2013) concludes that although water dependent sable can travel several kilometers to and from water holes and a drinking interval of 3-5 days. The difference in distribution, distance and

water preference of this ungulates could be dependent on the habitat in which they are found or were the study was conducted.

Among the grasses recorded as what has been utilized by herbivores in the fire blocks. *Brachiaria nigropedata* has a high grazing value, *Digitaria seriata* being of the palatable and climax grasses in Namiba, *Panicum kalahariensis* palatable in young stages but as it grows and becomes coarse it is less palatable, *Aristida stipitata* has less forage value over long periods (Muller, 2007). Of these grasses, although not identified as to which animals were responsible for utilization, *Brachiaria nigropedata* was among the species browsed by sable antelope during April – September in the Pilanesberg Game Reserve (Magome et al., 2008).

Fire block 2a in 2014 which burnt 2013 had the highest grass utilization, abundance of roan and the highest dung counts of roan and sable. Over all 2a burnt 4 years ago had the highest utilization compared to 2b burnt 17 years ago. These is because post fire green lush vegetation resprout and high nutrient content attracts herbivores. As years increase from when last an area burnt, resources utilization decline. Herbivores prefer areas burnt not more than five years ago (Novellie, 2010)

Acacia ataxacantha had the greatest utilization proportion of 0.4 in fire block 2a and 0.5 in fire block 2a. Roan and Sable antelope browse at the end of the dry season to meet the nutrient requirement although not identified which animal species utilized the species, Acacia species were among the trees browsed by roan and sable at the Waterberg Plateau Park (Erb, 1998).

The decrease in resources utilization for 2017 could be an indication that animals might have moved to other fire blocks. The observation of zero utilization in fire block 2b, 14 years after fire and suddenly utilization 15 years after fire, might be a result of animals moving into the area, because part of fire block 2b burnt in 2014.

A roan antelope study at Waterberg Plateau Park by Erb 1998, the minimal viable population for roan population at the park is 200 individual to sustain the species. Since 1980 the population of roan and sable at Waterberg has been below 150 with exception of 1983 and 1988 were roan population went above 200. These trend below viable population could be contributing to the decline, it could be that the populations are no longer viable to sustain species.

The increase in roan antelope population from 81 in 2014 to 304 in 2015 might have been an error in during game count e.g. double count when animals flee it could be to the next counting strip. During aerial counts animals are frightened and they flee (Ebedes, Rooyen, & Toit, 2002) It is not biologically possible that 81 individuals taking into account sex ratio, fecundity, predation would have increased to three times more. The difference in time of year might have caused the difference in number of animals counted.

7. Conclusion

From the distribution map, roan and sable antelope occupied all fire blocks regardless of whether burnt or not. Fire had little influence on the distribution of roan and sable antelope, but rather territory and herds that influenced the movement of the species in relation to fire.

From the resources utilization results, herbivores favored areas burnt 4 years ago, data was not sufficient to show whether fire could have caused the decline. In this study aerial count was not an accurate estimate of resources utilization because the counts are for the dry season and lacks where the species are distributed during the wet season (it could be misleading when data on the feeding habitats of the related animal species are insufficient or lacking). It appears that aerial surveys do not provide accurate or precise enough estimates to easily detect trends, particularly since the fluctuations observed are largely attributed to coincidental counts of animals at waterholes.

There are no strong conclusions from the study on resources utilization because of a lack of appropriate habitat variables such as grass nutrient content, relationship with other ungulates, and predators at the Waterberg Plateau Park. Although the study does not give concrete evidence of what is currently happening to roan and sable antelope population at the plateau, resources utilization and selection is important for the conservation of vulnerable species. A follow up study should include all parameters that influence resources utilization and affect the distribution of herbivores at the park and a comparison study of aerial and ground counts for accurate estimate of population trends.

8. Acknowledgments

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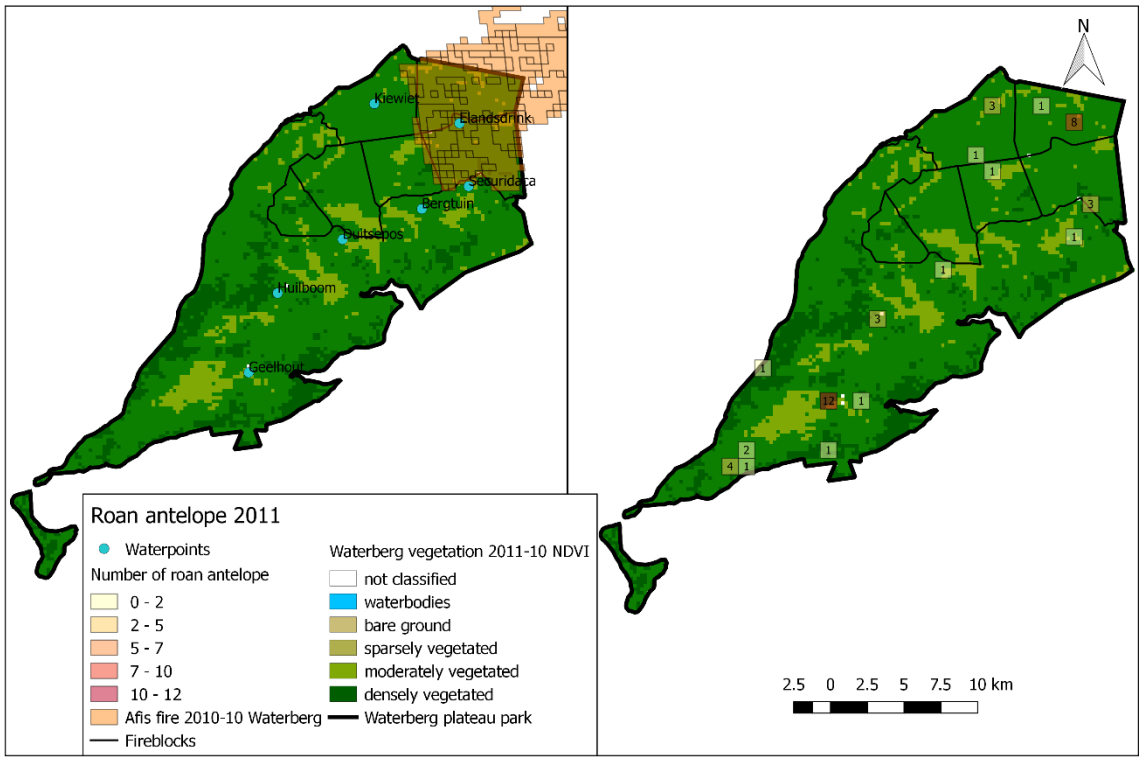
10. Appendices

Roan antelope 2011 distribution in relation to fire, Waterberg Plateau Park, Namibia



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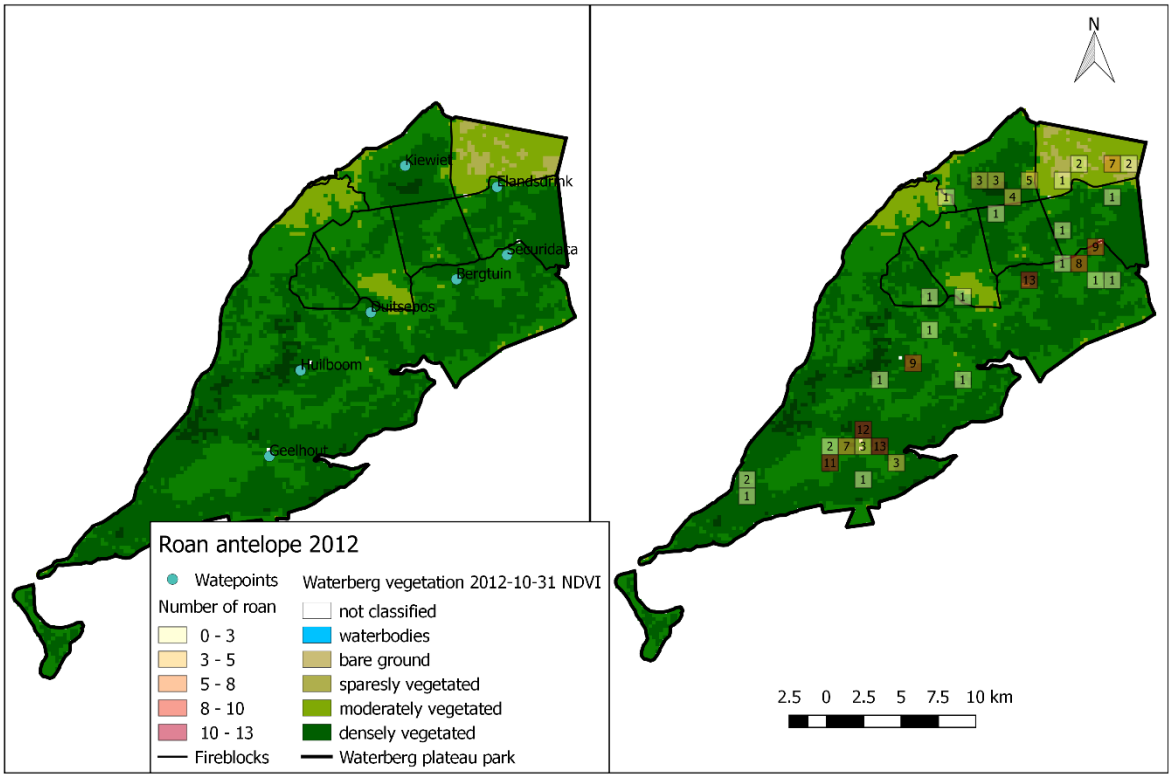

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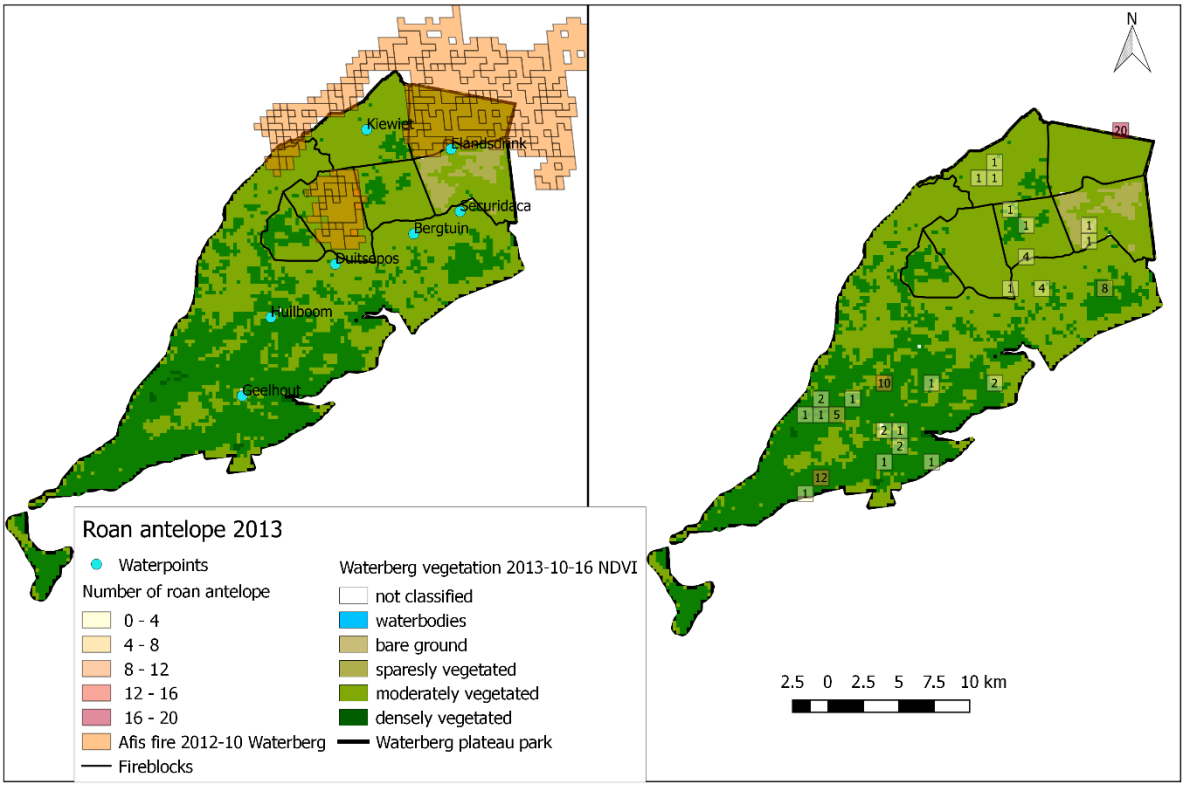

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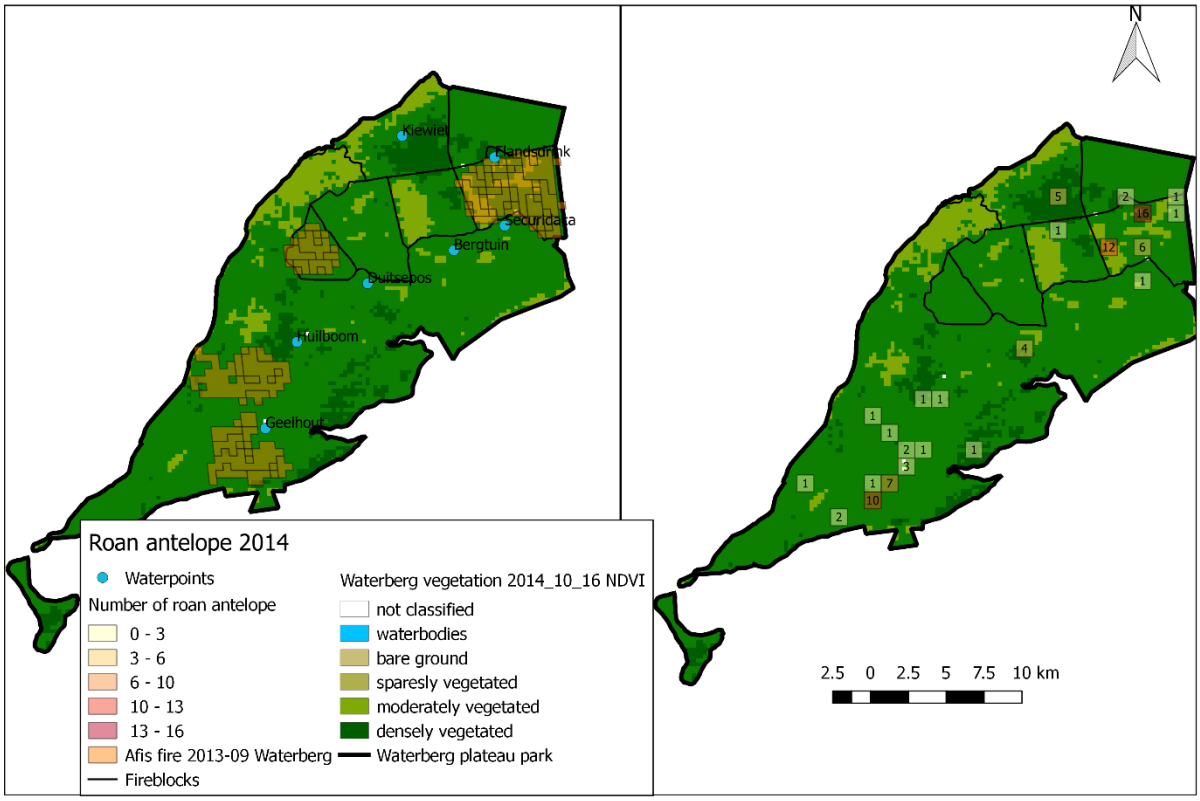

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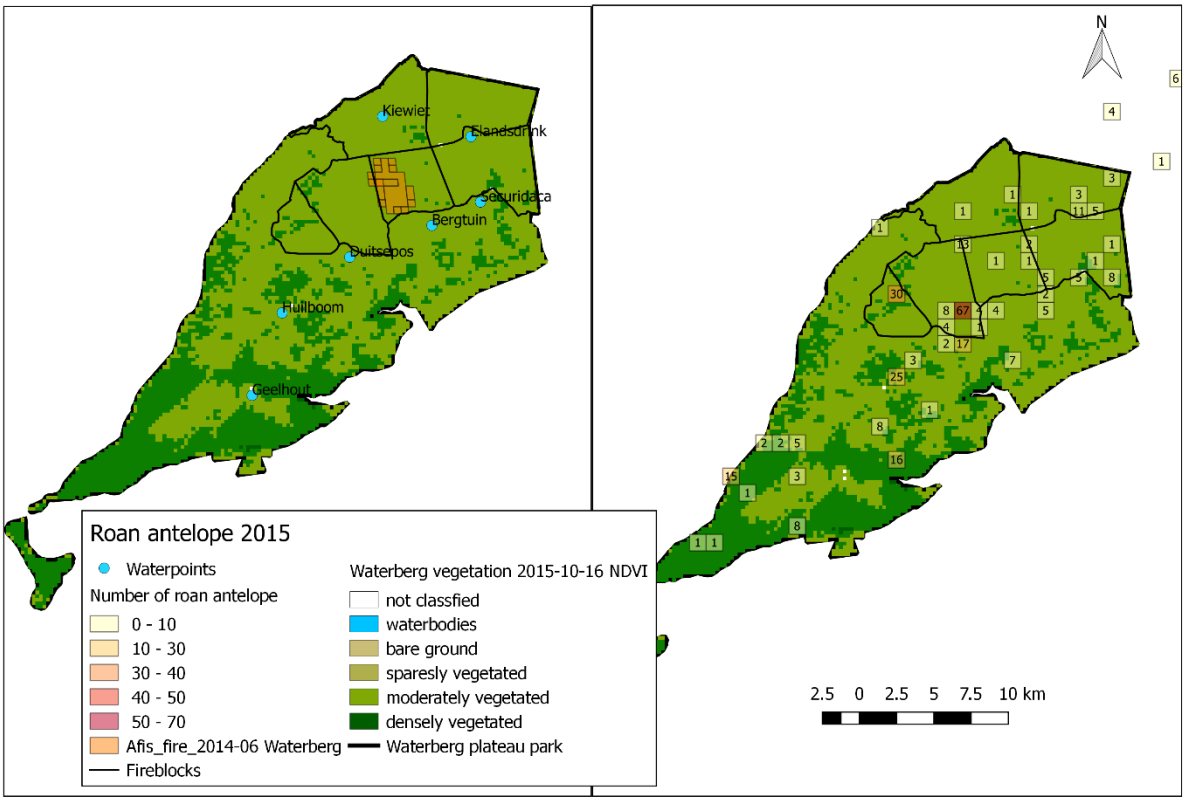

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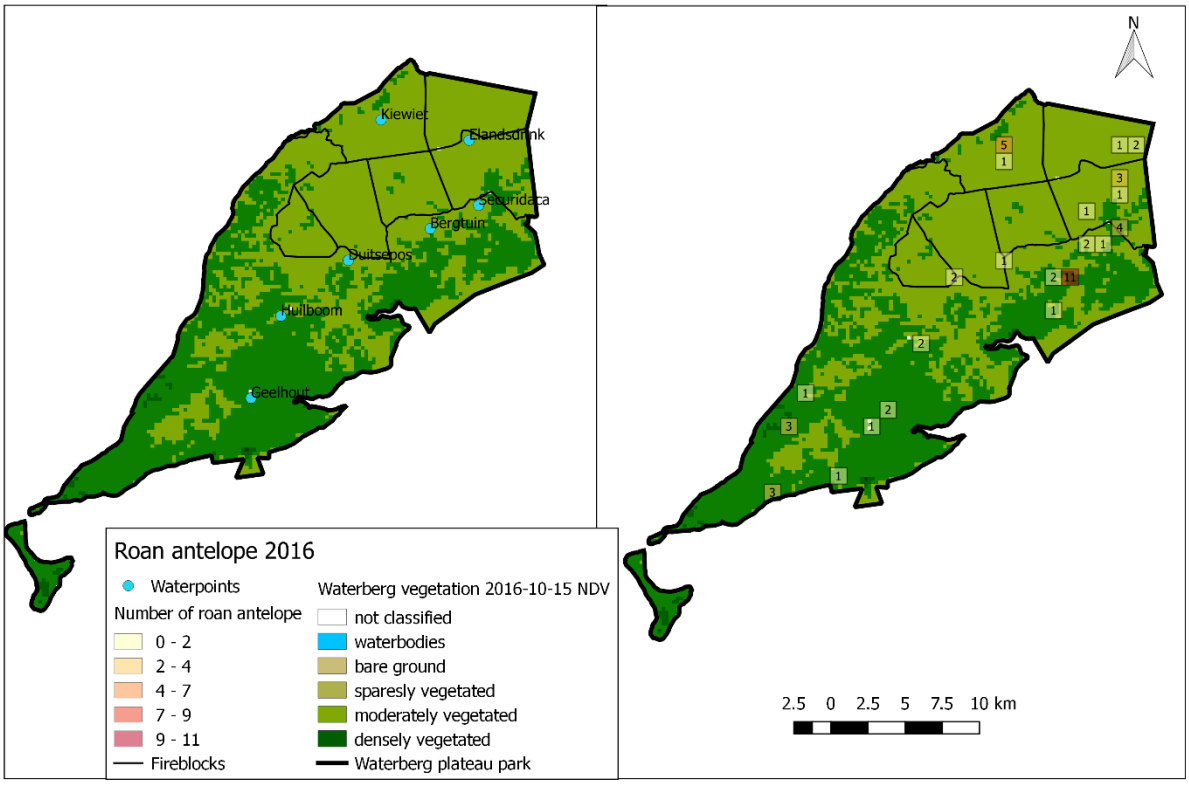
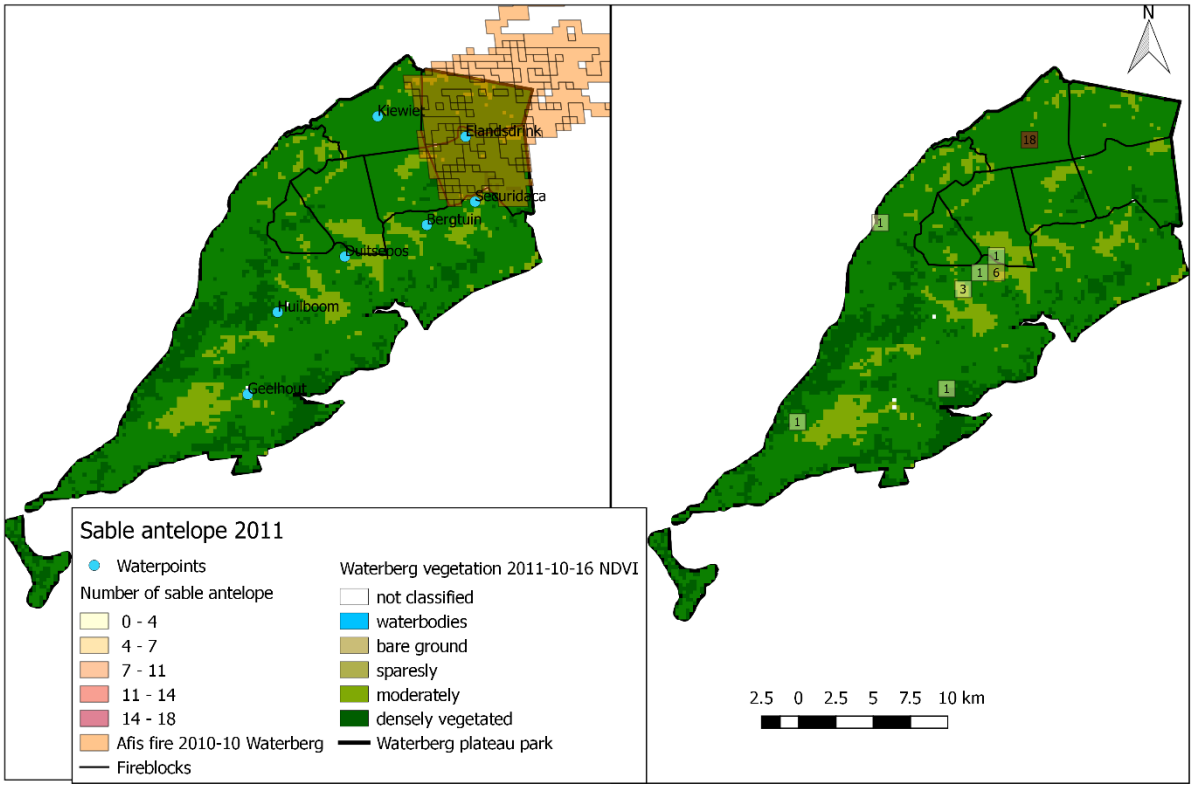


Sable antelope 2011 distribution in relation to fire, Waterberg Plateau Park, Namibia



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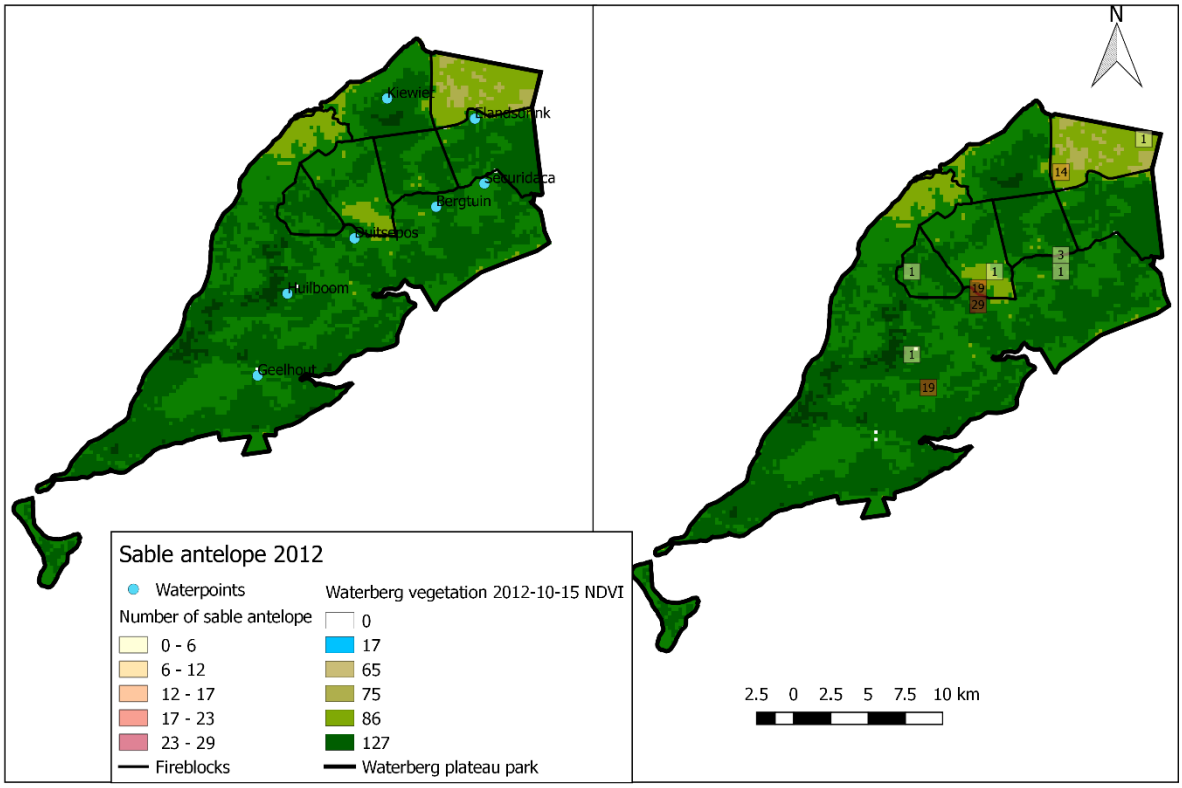

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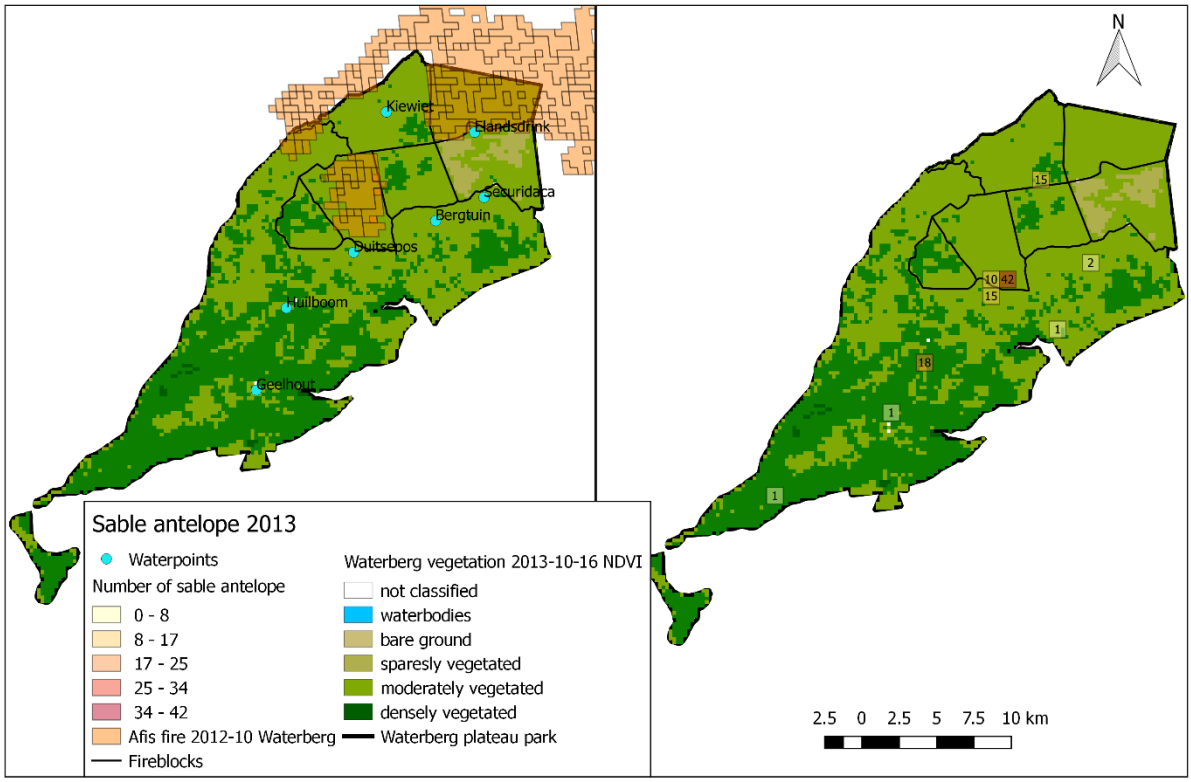

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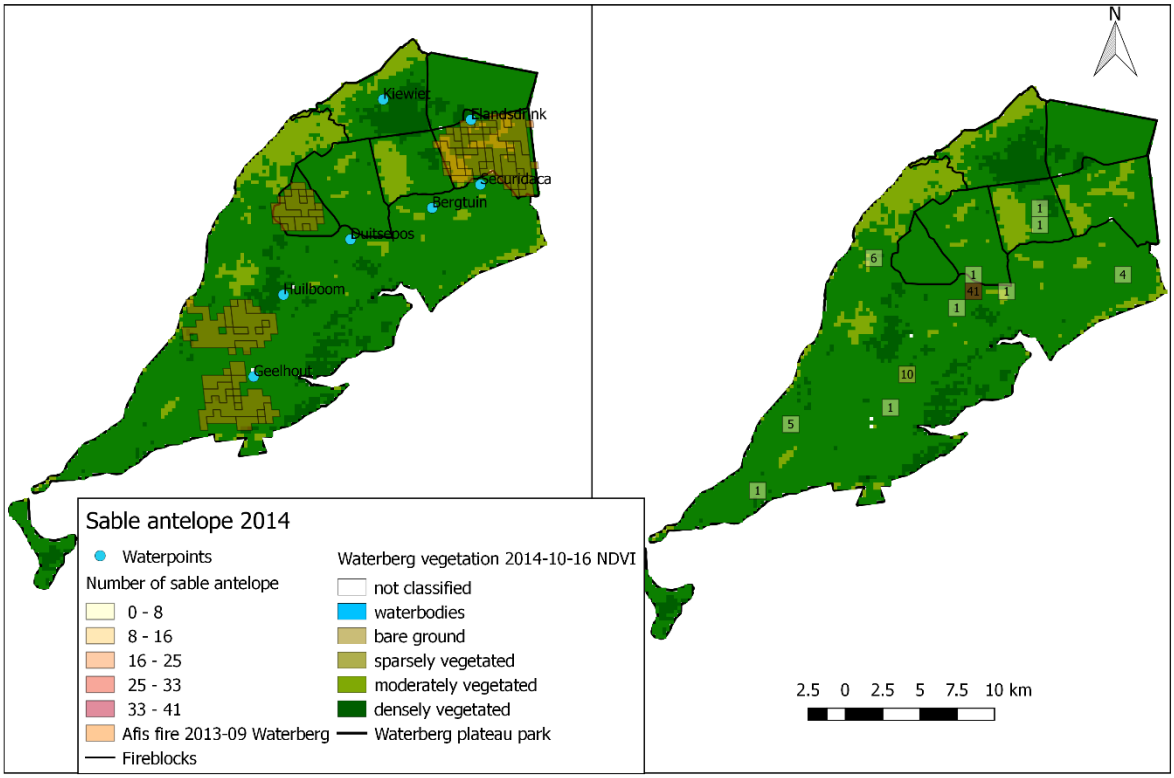

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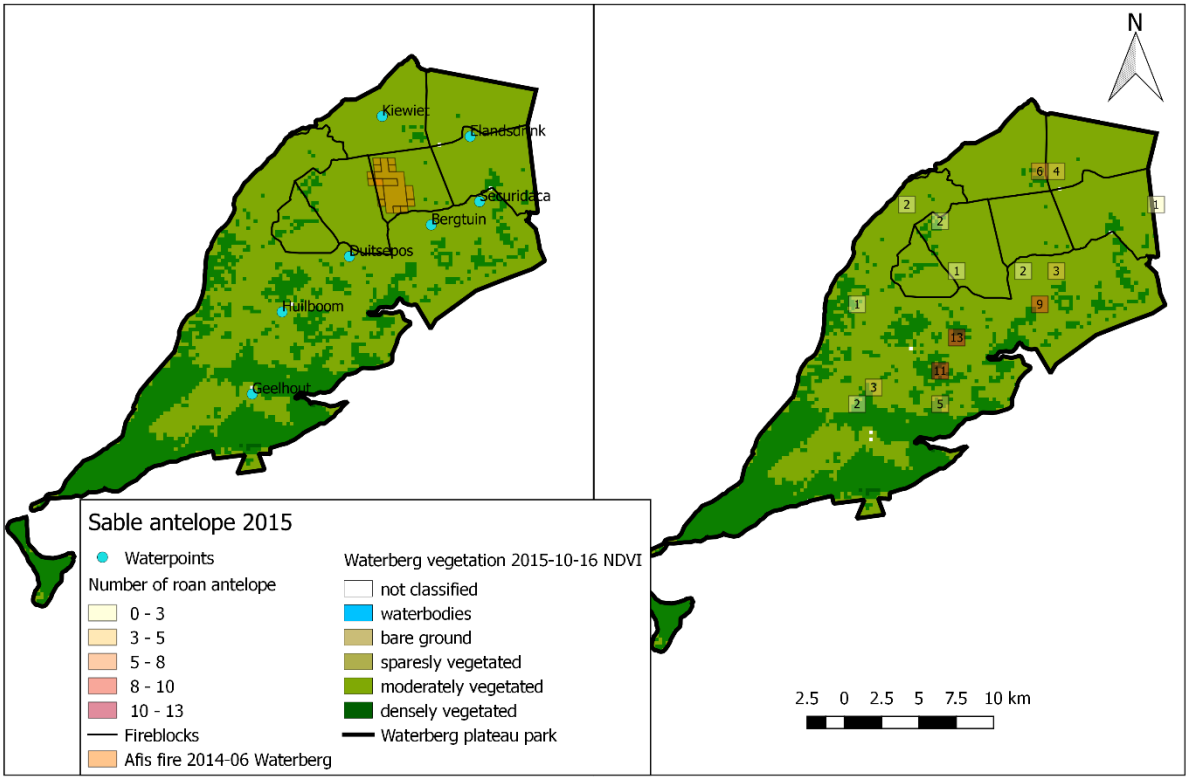

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