Camera Trapping Table Mountain and Constantiaberg

Larger Terrestrial Mammals Approaching Metropolitan Cape Town, South Africa

Thesis in Fulfilment of the Degree "Master of Science"

by

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Für meinen Vater

Dr. med. Dieter C. H. Meyer

Ich wünschte, er könnte dieses Buch in seinen Händen halten.

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1 Introduction

1.1 Objective

During the past decades, non-invasive sampling techniques such as camera traps gained widespread interest in ecology to estimate population density and relative abundance of wildlife diversity.

Since the estimations of tiger abundance with individual capture-recapture models by Karanth (Karanth, 1995), knowledge of statistical usability of photographic images as well as the commercial availability and affordability of suitable equipment for camera trapping increased dramatically (Rovero, et al., 2010). The objective of this study is to use camera traps to determine species richness of medium- and large-sized terrestrial mammalian wildlife in Table Mountain National Park, Cape Town (33°58′00″S, 18°25′30″E) in respect to habitat diversity bordering heavily urbanized spaces. A special focus of the study lies on the disturbance of wildlife by human activity.

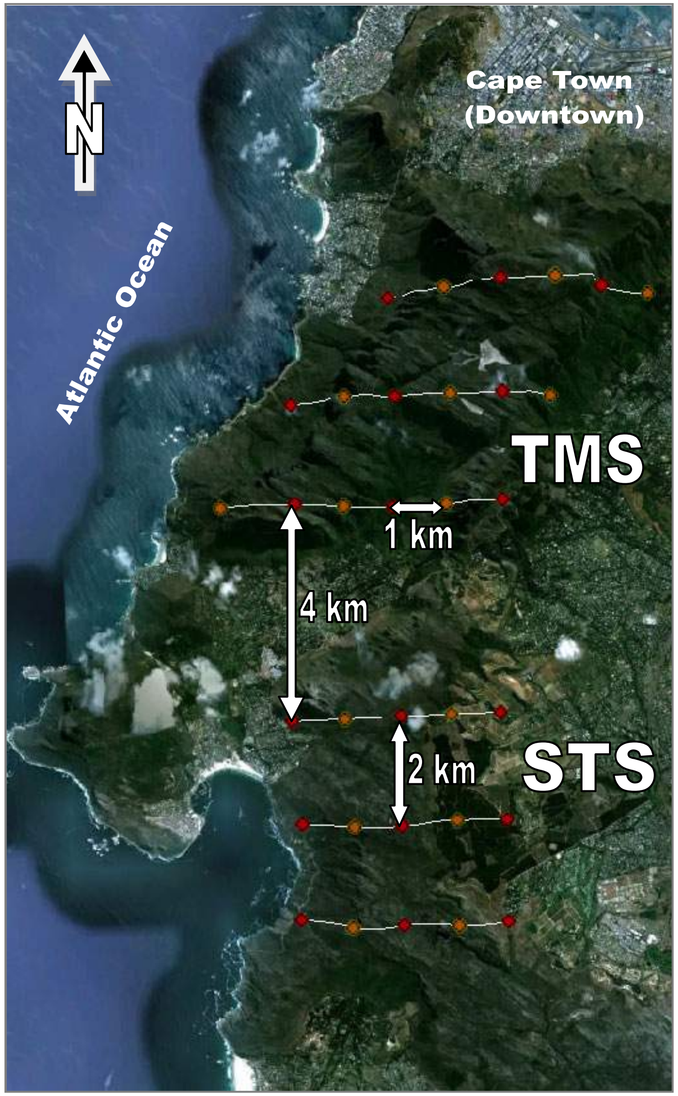
As long as just anecdotal evidence of many medium- and large-sized mammals on the Northern Cape Peninsula exists in the form of citizen sighting reports and occasional photographical evidence, only limited scientific conclusions can be drawn concerning abundance, density and habitat distributions of mammal biodiversity. This is especially true for insights into elusive and nocturnal activity patterns of mammalian wildlife on the Cape Peninsula.

This study will not only contribute to the accessibility of relevant information to wildlife managers and biodiversity management boards, but will also serve the public's interest in the occurrence of mammalian species by contributing the capturing data to a digital photographic atlas on the internet (MammalMap, 2014). By these means further awareness for common and uncommon taxa can be raised, leading to a wider understanding of the effects of habitat type, conservation status and human disturbance (O'Riain, 2012).

The answering of the following questions will be the main objective of this study:

- Which mammal species of medium and larger size exist on Table Mountain and Constantiaberg?
- How strong are their populations and where are their habitats?
- Which mammals are missing and why?
- How strong is the impact of humans and their pets on the local mammal biodiversity?
- Which conversation measurements can be taken to ensure the future coexistence of wildlife and the metropolis?

1.2 Study Design



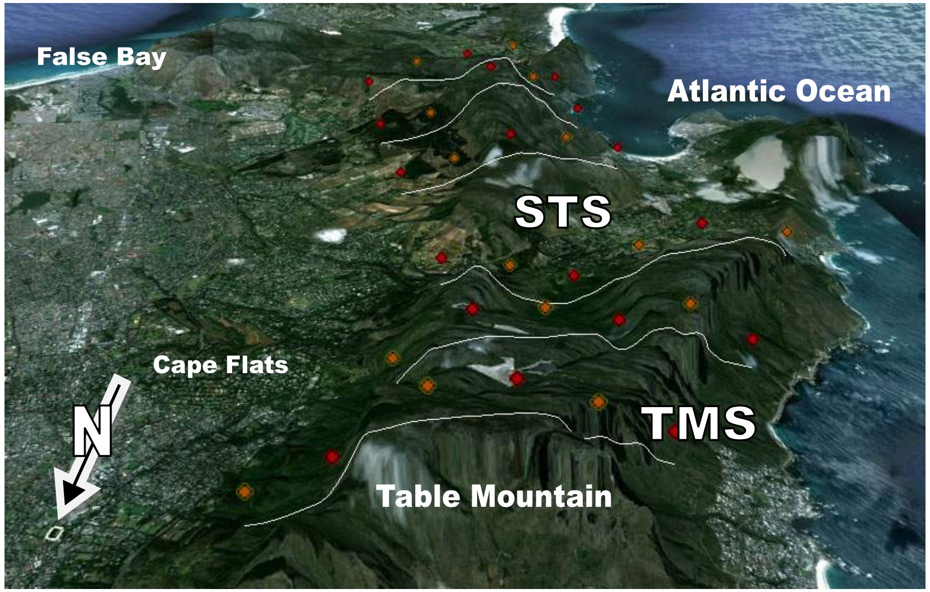
Map 1 - Proposed Grid of Camera Traps. Red dots show the locations of camera traps of the basic 2km grid, yellow dots the refinement into 1km profile transects across the two mountain ranges TMS (Table Mountain Section) and STS (Silvermine - Tokai Section) 1:100 000, Aerial imagery source: Google Earth 33°58'38"S, 18°24'18"E, (C) 2014 DigitalGlobe, SIO, NOAA, U.S. Navy, NGA, GEBCO 28.06.2013

The grid of camera traps is embedded in a proposed larger project analyzing not only the Table Mountain Range, but also close completely urbanized areas to determine a mammal biodiversity overview of the whole metropolitan area of Cape Town (O'Riain, 2011). The study area covers approximately 60 km^2 south of the "City Bowl" downtown district of Cape Town. In six West-to-East mountain profile transects (white lines, Map 1) the proposed quadratic North-to-South 2 km base-grid (red points, Map 1) is refined to 1 km distances (yellow points, Map 1), to allow for an in depth analysis of topographical and vegetation effects. The West-East layout enhances comparability of the mountain transects by their lateral meteorological similarities (→2.2; →2.6.3). Assuming that the mammal populations of the two study areas involved are largely independent and show negligible population dynamics or migration (at least during the study time), the two mountain ranges of Table Mountain Section (TMS) and Constantiaberg/Silvermine-Tokai Section (STS) can be compared to each other due to their similarities in topography.

The two investigated mountain ranges are separated by a belt of urban settlement, thus allowing for the assumption of closed habitats for most species on each mountain range. A sequential data collection of both mountain ranges took place, while all cameras used in one mountain range ran parallel. Due to the larger quantity of camera traps needed (18 units) on TMS, the study started there, encompassing a data recording schedule of at least 30 days. After these 30 days, the nine least promising camera traps were moved to STS to form the second basic 2 km grid.

Six additional cameras were needed to set up 1 km resolution transects on STS. These 15 camera units recorded at least for another 30 days. In total, 18 camera traps were used during the first phase of data collection and 24 camera traps were used during the second phase of data collection. Due to spatial and temporal overlap in data collection, data from six additional camera traps operated by Mrs. Nicola Okes (Department of Biological Sciences, University of Cape Town) could be included in the study setup.

Map 3 - Position of Cape Town.



Map 2 - Approximate 3D Rendering of the topographical transect profiles. Viewing direction is from North to South.
Topographical and aerial imagery source: Google Earth 33°58'38"S, 18°24'18"E, (C) 2014 DigitalGlobe, SIO, NOAA, U.S. Navy, NGA, GEBCO 28.06.2013

1.3 Relevance

Although close monitoring of mammalian wildlife is considered to be undertaken by the National Park offices in the study area, all management decisions at the urban edge were so far based on the anecdotal evidence of sighting reports. Landscape level biodiversity assessment can be taken to a much higher level of precision in the presence of comparable quantitative datasets. The Biodiversity Report of the City of Cape Town (Holmes, et al., 2008) lists special difficulties in the study area to observe mammals due to their nocturnal and secretive habits. The most prevalent tool is a spatially undifferentiated species list. The mere existence of a larger mammalian species is used to describe the wellbeing of the ecosystem and the flagship character of those species often serves the justification of administrative consolidation and conservation plans. The often-cited "secretive behaviour" is used as a justification of a lack of specific data that could actually provide answers to the effects of urbanization on wildlife, such as changes in behaviour or increasing/declining mammal population levels. Additionally, questions on the reintroduction of lost species are raised on a regular basis by multiple actors in the environmental planning sector. Without the knowledge of baseline data on abundance, occupancy and other factors of population density on the existing species, no conclusions should be drawn on the possible implications of reintroduced species.

Conservation measurements, which are based on a solid data background, generate higher acceptance of management decisions by the general public. Medium and top level predators are considered to be missing widely in the current picture, forcing population control measures to ensure an ecological equilibrium. But only repetitive tracking of population numbers and abundance can provide the data necessary for appropriate intervention. Also, farmers need the information on possible threats to ensure the security of their yield and livestock. A transparent, fact-based communication and subsidy system encourages the coexistence of agricultural and conserved wildlife spaces. The unique situation of the enclosed nature reserve in the metropolitan area therefore requires the availability of baseline biodiversity data to create common ground for the discussion of conflict resolution.

The manifold metropolitan impact on mammalian wildlife can also shift the responsibilities to take action between different authorities and stakeholders, where only unbiased research methods are able to ensure transparent information policies. On the urban edge, conservation management is not only confronted with traditionally defined tasks like being a mediator between land-owners, farmers, nature reserves and decision carriers, but is also influenced on a large scale by over-exploitation, invasive species, individual and industrial pollution, crime, (mass-)tourism and the development of urbanization. All these actors and their interests matter in the process of conservation management and only reliable data resources allow for extended cooperation (Jokimäki, et al., 2011).

A camera trap survey can serve this need of unbiased data in the most fundamental way imaginable: Instead of relying on occasional sighting reports, the landscape level mapping can show, which species still exists in which areas and - up to a certain degree - how their interaction with humans might look like in reality. Camera traps record day and night, unravelling the "secretive behaviour" (Kelly, 2008). They can show, how many top and medium level predators still manage to survive and how much potential prey exists outside of farms. Camera traps also offer a relatively unbiased estimation of human activity in the semi-natural areas and therefore allow to see shifts and adaptations in behaviour of the studied species when compared to data obtained in similar studies of more natural areas.

The analysis of count data gives information on the effect of covariates such as vegetation types, human disturbance and resource availability and provides a necessary framework to show where conservation intervention is truly needed, but also where the need for intervention was possibly overestimated. The results can be used for a more efficient and sustainable system of guidance and intervention leading to ecological and economical benefits on multiple levels.

1.4 Camera Trapping in Ecology

1.4.1 Advantages and Difficulties

Whereas direct observation of alive individuals can provide highly detailed (and even interactive) data on certain non-elusive species, the main advantage of camera trapping as a method (to obtain reliable objective records on elusive and non-elusive terrestrial mammals) is its non-invasive character. Typically the traps generate a minimum of disturbance in the natural behaviour of the observed species. Due to comparatively long durations of camera trapping studies the method seems particularly suitable for the detection of rare, elusive and nocturnal animals (Rovero, et al., 2010).

Furthermore, the obtained data is considered direct evidence of an animal's presence and identifications can easily be reviewed and confirmed by different researchers. Covariates of the detection events like the picture timestamp and the trap coordinates allow for a detailed analysis of activity patterns, population density, group size and also disturbance by human habitat penetration.

The trapping success of an individual camera trap mainly depends on its positioning in the field and the technical reliability of the equipment. As most camera traps use thermal motion sensors to trigger image recording, extreme weather conditions might dramatically change the event detection rate. Hot arid climate will make an typically warm animal body contrast less to its environment, leaving the sensor untriggered, thus lowering (daytime) event detection rate. On the other hand, strong and unsteady wind patterns, as well as strong precipitation can change the trap's environment so quickly that ceaseless non-animal triggering events fill the cameras memory and empty the batteries quickly. Fortunately, many modern cameras allow for a limited setting of the sensor's responsivity dependent on the specific environment.

Besides the controllable factors like full memory and empty batteries, accidental covering of the camera by foilage, software malfunction, wrong setting by the study conductor, tampering of the equipment by animals and human vandalism, as well as destruction by mechanical force also have to be considered as possible reasons to unusable datasets. Due to the large scale nature of a camera trap study setup, malfunctions are often only discovered by the researchers after long running times. To reduce the need of excluding datasets from the analysis, regular visits to the trapping site are needed. Especially when density calculations demand grid-type setups with trapping locations in topographically inaccessible areas, regular visits can be impeded. Additionally, constant presence of researchers at the trapping site can leave scents or other disturbing factors, which possibly stop certain species from visiting the trapping site and therefore bias the dataset.

1.4.2 Alternative Field Methods

The most ancient and intuitive form of information collection on terrestrial animal demography (apart from the direct observation of alive individuals) is tracking and tracing. foot print analysis, feeding leftovers, scratch marks, lost hair and the manifold characteristics of faeces provide a set of clues that allow for direct interpretation. In the best case scenario even detailed information can be obtained encompassing not only the species, number of individuals and size, but also age, gender, feeding habits and recent activity. However, this information is difficult to categorize and rarely allows for a statistical analysis of distribution, abundance and density. The data acquisition success of the tracking method is highly dependent on the personal skills of the tracker and is therefore biased by the obstructions of limited reproducibility.

Similar issues have to be addressed when animal demography is estimated from the analysis of dead animal bodies or body parts, when sampling is not undertaken by scientific standards. Hunted "bushmeat", as it is sometimes offered on local markets, can serve as proof of the existence of a single species, but can never be used as a measure for demographic parameters. Especially when species are compared with each other, hunting methods and hunting success vary too much for meaningful comparison. Additionally, this method has to be considered questionable by ethical standards, as the scientific demand for bodies could lead to an unpredictable impact on population levels of endangered species (Albrechtsen, et al., 2007).

In the case of unthreatened species, "Harvesting" (managed interval killing) was used as a demographical method in the past to estimate essential demographic parameeters (Van Aarde, 1987).

Before the upcoming of VHF radio telemetry in the 1960s, direct field observation of behaviour and activity patterns was the predominant technique of choice. While still being used widely today for specific ecological questions its advantage lies in the possibility of observing complex behaviour in its context. Data is typically recorded manually by researchers in the field filling in prepared questionnaires. Social group interaction, countability of individuals and recording of environmental stimuli can be more easily assessed by a researcher being physically close to the animals. On the other hand, human presence is known to alter the behaviour and activity of many animals drastically which leads to loosing the reproducibility of generated results. The sample size is also often limited in observational studies due to its time-consuming nature and logistical difficulties (Bridges & Noss, 2011).

Direct observations can be supported by live traps of animals and marking the caught individuals (e.g. ringing of birds). Recaptured individuals in distant traps prove individual travelling distances. Frequent live capturing and anaesthetics on the other hand are highly likely to disturb an animal's natural behaviour (Arnemo, et al., 2006). Statistical Capture-Recapture-Methods (or less intervening, but classically more difficult Sight-Resight-Methods) allow an estimation of the overall population size. Based on the assumption that the number of marked individuals in the second sample is proportional to the number of marked individuals in the whole population (and assuming a closed population with reproduction/replacement rates not overextending the study period), the overall population size can be calculated by multiplying the proportion of marked individuals in the second sample by the number of totally marked individuals in the first sample.

With progressing technology direct observations and recapturing could be replaced in some cases by telemetry. Hereby, individuals that are going to be studied, are firstly caught in live traps. Typically covariates like the animal's appearance, age, sex, dimensions and weight are catalogued, before it gets equipped with a sending unit that is designed as least disturbing as possible, but cannot be removed by the animal itself. When this technology was invented, the sending unit emitted radio waves that allowed position information by terrestrial triangulation. Today, mostly GPS receiver or combined GPS receiver/radio sender units are used and precise triangulation is accomplished by satellite technology. Miniature video cameras can be mounted on large enough animals (e.g. affordable necklace cameras for domestic cats). The advantage of telemetry over direct observation is that, most of the time, human disturbance on the animal's behaviour is limited. Additionally, researchers do not have to be present in the field all the time and the misidentification of an individual is highly unlikely. Still, the bias of capturing and handling the animals limits the explanatory power of the method.

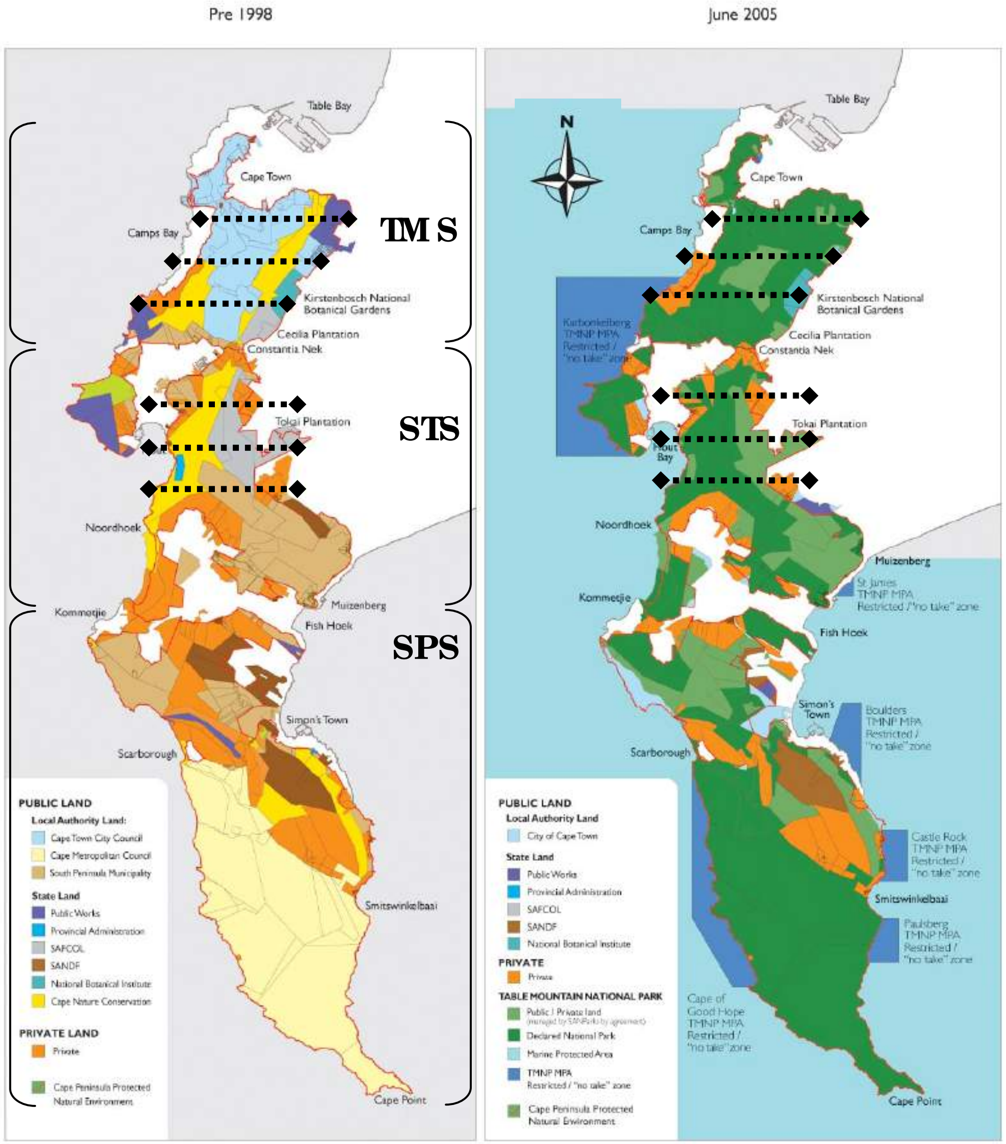
Finally, the collection and (laboratorial) analysis of droppings is considered a widely used approach to determine habitat distributions and population sizes, as well as obtaining dietary information. New genetic analysis techniques (e.g. microsatellites) can attribute droppings to single individuals. Together with the location of collection and the estimated time of defecation, movement patterns can be linked with feeding habits. This method is especially useful when one or only few species are involved in the analysis and samples are comparatively easy to obtain. Behavioural patterns of studied species like burying of droppings can hinder the sampling. If baseline biodiversity population data is missing for the study area, exclusively analyzing droppings will probably not generate this type of overview data, because defecation habits appear in a large variety and sampling would be extensively time-consuming.

2 Methods

2.1 Study Site

Table Mountain National Park is a protected area extending 221km² on the south-westernmost tip of Africa (33°58′00″S 18°25′30″E) situated in close proximity to the highly urbanized Cape Town metropolitan centre and suburban environment. The park runs along a North-to-South mountain chain starting with Table Mountain itself next to the downtown business district of Cape Town in the North and ending with the famous Cape of Good Hope at the southernmost tip of the Cape Peninsula. Generally the area cannot be seen as a coherent near-natural biotope environment but is divided several times by urbanization into at three distinct areas with presumably almost no wild population exchange: (From N to S)

Table Mountain Section (TMS),
Silvermine-Tokai Section (STS),
Southern Peninsula Section (SPS)



Map 4 - 1:200 000 - Cape Peninsula with Table Mountain National Park (green) and private property (orange) before and after the creation of the National Park. Black dotted lines represent trapping transects.
(South African National Parks, 2005)

The sections "Table Mountain" (TMS) and "Silvermine-Tokai" (STS) were chosen as the two distinct study areas, because of their geomorphologic similarities:

- the steep, ocean facing, western slope of the central mountain chain heavily exposed to the fast changing sea climate
- a central peak plateau area being relatively secluded from human civilization
- the generally more gentle eastern slope, rich in precipitation, dominated by forests and (due to its proximity to the metropolis) also exposed to an generally higher abundance of humans.

All sections predominantly show the typical fynbos vegetation, an highly endemic and diverse floral composition of a semiarid character. The main vegetation types, "**Peninsula Sandstone Fynbos"** (plateau) and "**Cape Granite Fynbos"** (mountain slopes) generally grow on inaccessible topography in loose acidic soils, which are poor in nutrients and historically often proved unusable for farming and settling. This generated a retreat area for the local fauna even before the construction of the national park in 1998. On the more fertile eastern slopes additional encountered vegetation types can be found mainly being composed of remnant patches of indigenous moist subtropical **"Afrotemperate Montane Forest"** in the Table Mountain Section and intensely cultivated vineyards or pine forest plantations in the Silvermine-Tokai Section.

The "Southern Peninsula" section of the park (SPS) was not covered in this study due to multiple reasons. Generally it is less comparable to the other sections in its topography and amount of human impact. It has been managed as a wildlife reserve by South African National Parks (SANParks) for a much longer time resulting in a closer monitoring of wildlife and different (more planned) human intervention. The more connected and less urbanized spaces of the southern peninsula were part of camera trap studies already and are currently analyzed by different researchers while this study was conducted. In fact, the wildlife management boards are already able to access baseline datasets in this section, whereas scientific data in the other two sections is still missing. Additionally, regular and semi-controlled bushveld fires occur more often on the southern peninsula and result in a different ecological pressure on the fauna. The fires could also put the equipment at risk of damage. Furthermore, as one of the main objectives of this study is to analyze the influence of the direct steep topography on wildlife distribution, the undulating hills of the southern peninsula do not allow for such a clear categorization of habitat types as the northern section does.

2.2 Climate and Seasonality

Overall the climate of the south-westernmost tip of Africa can be described as Mediterranean-type composing of rather shorter and cool winters (June to August) with high amounts of precipitation and longer, arid summers (November to April). The study therefore took place from March to June, covering a possible wide range of weather phenomena.

Typically, temperatures range from 7°C to 15°C during winter (July) and 15°C to 25°C during summer (January), although due to the maritime influence on the climate there is as little as 10% average difference between winter and summer temperatures, resulting generally in less extreme temperatures than further inland, where snow as well as temperatures over 40°C are more frequent. (Rebelo, 2006)

Most precipitation can be considered approaching the Cape area from the Atlantic direction, leaving the western mountain slope facing the Atlantic ocean with the drier climate, subsequently condensing to clouds while passing the mountain plateau (fog precipitation) and eventually rain down on the eastern slopes. This weather system also forms the well known "table cloth", an elongated cloud flowing from the mountain plateau towards the city, usually forming under humid conditions. According to the estimations of the South African Weather Bureau fog precipitation on the mountain over the course of a year is about 3294mm, double that from rainfall (World Wildlife Fund, 2013). Furthermore, overall precipitation levels on the eastern slopes are considered four times higher than on the western slopes. On the higher plateau surface, the table cloth is considered to be the main source of precipitation, supplying water condensing as fog precipitation on plants making it available for both, flora and fauna (Nagel, 2007).

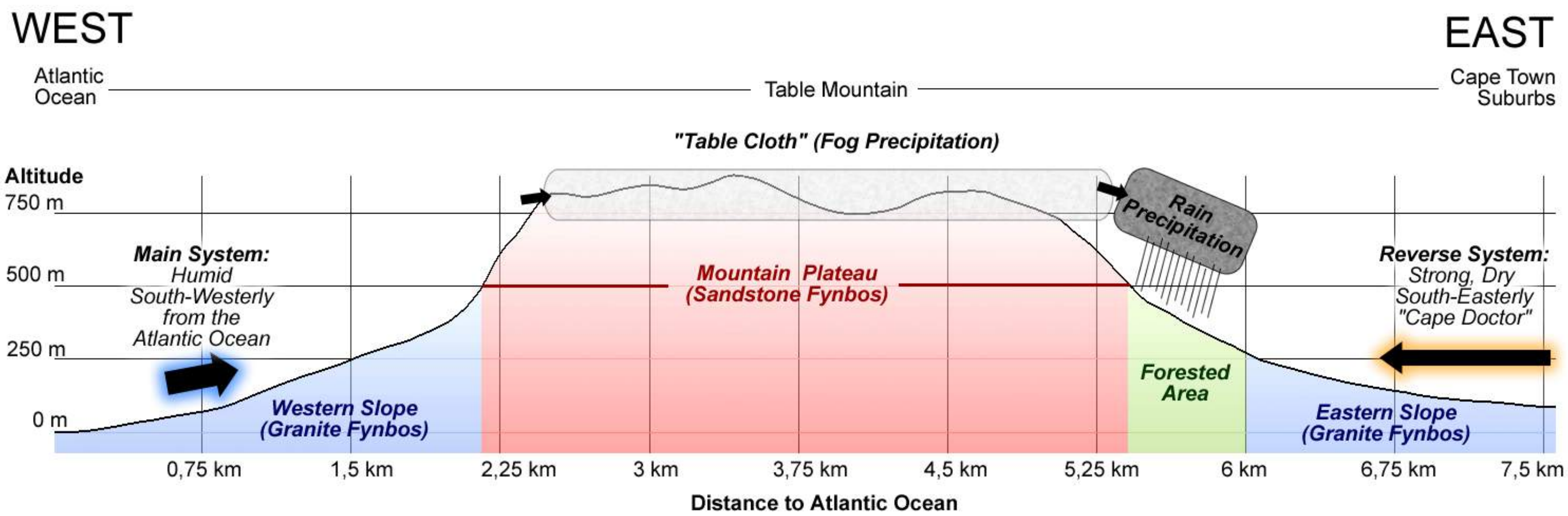


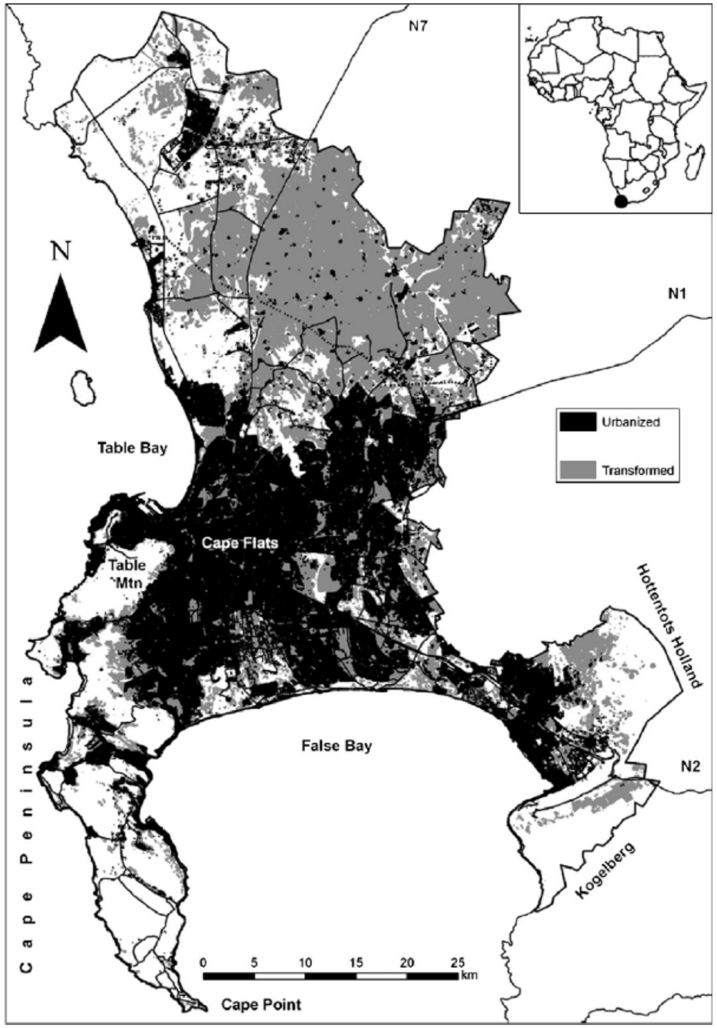
Figure 1 - Schematic overview of the dominant weather systems in the study area. The graphics display the situation on Table Mountain. Constantiaberg displays very similar but less extreme conditions.

Source of the mountain profile: Google Earth 33°58'38"S, 18°24'18"E, (C) 2014 Digital Globe, SIO, NOAA, U.S. Navy, NGA, GEBCO 05.10.2013

2.3 Urbanization, Tourism and Safety

Compared to many other possible areas for wildlife camera trapping studies in South Africa, the Cape Town metropolitan environment is considerably strongly transformed. From a conservational point of view it was at least neglected until 1958, when Table Mountain was declared a National Monument. While the City of Cape Town was already established in 1654, by 1700 no animals larger than 50 kg were left within a 200 km radius around the city. Urbanized space is still growing and large parts of land fell into private ownership. Since 2000 the amount of agricultural area declines slightly as the amount of proclaimed reserves increases. Since 1940, the amount of unproclaimed vegetation dropped from almost 150'000 ha to approximately 75'000 ha in 2000 and is decreasing even more rapidly (Rebelo, et al., 2011). Around 3,5 million people are nowadays considered residents of Cape Town and in total 60,2% of the metropolitan area is transformed. The transformation from "City within natural vegetation" to "Natural vegetation within city" occurred in the 1970s and temporally correlates with seasonal fires brought "under control" (Sinclair-Smith, 2009).

Moreover, modern mass tourism has a strong impact on wildlife, especially in the two northern sections of the National Park that border heavily urbanized spaces. From July 2012 to June 2013 a total of 855'595 visitors accessed the front plateau (northern end) of Table Mountain by cable car alone. On operational days (sometimes service is suspended because of weather conditions) the average visitor rates range around 3000 cable car customers per day. In total, all sections of the national



Map 5 - Location of the City of Cape Town, showing the urban extent of 2004 (black) and the area transformed by agriculture, afforestation and dense aliens (grey).

(Rebelo, et al., 2011)

park receive approximately 4,2 million visits annually (TMNP, 2014). The local authorities invest strongly into the promotion of the well known touristic destination to increase visitor numbers (Cable Car Management, 2013) and therefore the growth of the city's economic service sector.

The wealth of the tourists, who can afford the relatively expensive cable car rides, possibly attracts criminals. Poverty and low education lead to an intense challenge to ensure the safety of researchers in the field, as well as the integrity of the technical equipment and therefore gathered scientific data.

A 2010 study of the safety perception of visitors on Table Mountain demonstrated, that 70% of respondents considered Table Mountain National Park a safe destination. Frequent visitors of the park generally have a higher awareness of crime than first time visitors and also felt more likely to fall victim to crime. While in 2007, the complete park received approximately 4,3 million visits (including repeat visitors), only 30 related crime incidents were recorded in the same time span (George, 2010).

Where the perceived risk of personal safety (primarily mugging and theft from parked cars) can be reduced by conducting field work in teams and using only daytime for checkups, the cameras themselves always remain unprotected. Many previous studies (also in the same area) struggled with the loss of equipment (stolen camera traps) and moreover the loss of essential long-term data (WWF-Global, 2006).

Cameras positioned amidst or close to fully urbanized environments are especially at greater risk of theft. Therefore, possible locations sometimes have to be left out from the study in the first place due to the impossibility to disguise the traps properly. In other cases, second choice locations (with an obviously lower trapping rate than possible) have to be selected to prevent the discovery of the traps.

Locations predominately visited by paying tourists can be considered safer even in the case of accidental discovery, whereas topographically challenging locations (like steep cliffs or far distances to the next trail) can be considered very safe. Sometimes, the trap imagery proves foreign discovery and therefore the relocation of the trapping equipment is necessary. Disguising the system as well as possible has to be part of the standard setup procedure. Locations, where human contact with the trapping system is likely, should be equipped with trap models that use infrared flashlight instead of full spectrum white flashlight to avoid discovery during the darker hours.

Using a simple, regular grid of camera traps with very short inner distances (eg. 200m) can also prove critical, as the discovery of the grid pattern by criminals allows for the removal of many traps at once. The likelihood for this to happen is low, but not negligible. Longer trap distances reduce the risk.

2.4 Types of Camera Traps

Recent technical developments furthered the availability and variety of camera trapping equipment. Early conductors of camera trapping studies struggled with several difficulties, like quickly filled and expensive analogue films, over- or underexposure, bulky and heavy equipment, energy consuming flash lights combined with weak batteries, limitations of triggering sensitivity and time consuming archiving processes (Karanth, 1995). Most of these problems are solved by progressing digital technology. Developed mainly as hunting and surveillance equipment for the mass market, single camera trap units can range between 80 CHF and 1000 CHF. Top models in the highest price range are solar powered, possess multiple integrated sensor systems and are able to connect wirelessly to upload and distribute video evidence of a triggering event in almost real-time to remote servers. Standard battery powered models consist of a sensor, a flashlight and a camera unit that saves imagery onto an SD card. Usually, study design, risk of tampering and material budget limit the choice. Additionally, camouflage, armoured housing and water-proofing have to be applied to the camera according to specific conditions in the field.

General categorization of camera trap types is possible in many ways, but most authors consider the way of triggering as the highest priority in choosing a trap model:

- Non-triggered systems are programmed to take pictures in set, regular time intervals. This is especially useful, if the recorded animals have a high visitation rate (for example a feeding place or a bird's nest), if absence of animals has to be documented or the study layout requires continuous data. These systems are cost effective, but have high electricity demands (thus often requiring a power chord) and produce vast amounts of data that require large amounts of time for analysis (Cutler & Swann, 1999).
- Motion or Heat-in-Motion passively triggered systems take pictures when the presence of movement is detected. These systems are by far the most commonly sold and are especially useful for the detection of warmth emitting bodies of larger mammals, as well as infrequent or discontinuous events. Passively triggered cameras have a high risk of false-positive triggerings or technical failure due to changing environmental conditions. On the other hand, low power consumption and small size prove optimal for remote areas, rare species and long study periods (Swann, et al., 2011).
- Actively triggered systems use a laser barrier or a mechanical switch to detect animal presence and trigger the camera unit. Typically, these systems consist of multiple devices (sender, receiver, transmitter, camera), need an extensive setup procedure and have to be adapted to the properties of few study species. In multipart systems, the failure of one part can lead to the malfunctioning of the whole system. Active systems are suitable for the detection of non-mammalian species, for analysis of nest predation or when baiting is used (Sequin, et al., 2003).

Furthermore, camera traps can be categorized according to their mechanism of image generation:

- Analogue cameras with bright white night time flash lights are no longer used by the majority of researchers. The laborious and costly process of film development is considered impractical in the digital age (especially for trouble shooting) and the storage of imagery is space- and time-consuming. Nevertheless extreme environmental conditions that could easily damage digital equipment still can demand the usage of this technology.
-
- Digital cameras can be controlled by intelligently programmed operating system that allow the user to choose between video and still image recording, bright white xenon or infrared flashlight, non-triggered time-lapse functions or sensor triggering, artificial refraction to save battery life or multiple images per triggering event. Another advantage can be the automatic generation of time stamps and the logging of environmental data like temperature and humidity. Not all models include all named functions and sometimes less functions can mean a higher reliability for the actual implemented functions.

Necessary functional features and their settings completely depend on the proposed study layout:

- Xenon flashlights or strobe flashlights might disturb animals such as tigers (Wegge, et al., 2004), bears or elephants, resulting in behavioural disturbances and even demolition of the trap unit, but they also generate night time colour imagery that easily allows identification.
- Infrared flashlights are harder to detect and therefore less invasive, but often result in poor night time image quality.

Because power consumption is generally higher in digital than analogue systems, some thought has to be put into the choice of the energy source. Alkaline batteries are very dependable and have to be replaced less often than rechargeable NimH accumulators, which are on the other hand more cost-effective and environmentally friendly. Lithium accumulators in combination with photovoltaic systems are the most convenient and most expensive solution, but solar panels can also increase the risk of discovery (Swann, et al., 2011).

2.5 Equipment

Two types of camera traps with similar detection cones were used to conduct the study. Both types are heat-triggered by medium- and large-sized animals at a theoretical distance of 700 cm if attached at a height of approximately 40 cm (ground to sensor distance) (Swann, et al., 2011).

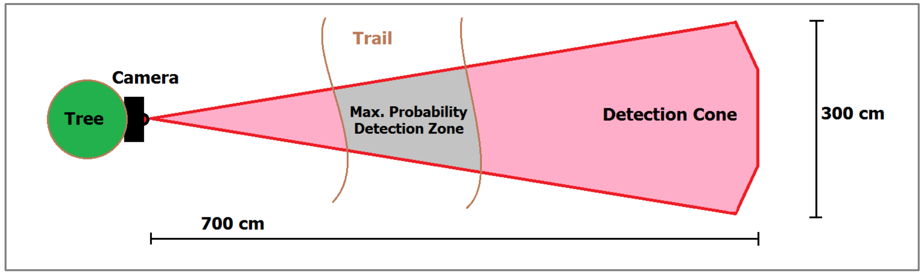


Figure 2 - Detection Scheme of the used camera types

2.5.1 Cuddeback

Cuddeback Digital Capture (R) units are whole-system, 6V D-Cell battery powered, passive, heat-in-motion (combined) sensor triggered, digital camera traps. They were used at locations with open terrain or clear animal paths and lower chance of human activity. Vegetation was roughly cleared in front of the camera and the camera's predefined testing mode was used to achieve maximum coverage. A 30 second recapture interval prevented too many multiple triggering events by the same individual. Wherever possible, cameras were set up viewing the mountain slope in profile, preferably facing South to prevent sunlight lens aberrations. To allow nocturnal captures, the cameras are equipped with an automatic daylight sensitive one stroke flashlight. This ensures colour images through the night, which makes identification easier, but increases accidental human discovery at the same time.

Figure 3 - Cuddeback Digital Capture camera trap unit new (small picture) and mounted in the field (large picture)

Figure 4 - Bushnell Trophy Cam camera trap unit new (small picture) and mounted in the field (large picture)

2.5.2 Bushnell

Bushnell (R) Trophy Cam units are whole-system, 6V AA-Cell battery powered, Infrared (IR) active, pure IR motion sensor triggered, digital camera traps. They were used on human pathways and wide-angle areas without clear animal paths. Vegetation had to be cleared thoroughly in the detection zone, because wind can easily trigger the sensor, creating a response to the cameras own IR light source.

Due to longer exposure times, fast movement -especially in animals - is often shown blurred out in the resulting black-and-white pictures. To ease identification of the animal, this camera therefore was set to a three-stroke-in-a-row setting, meaning that each individual triggering event consists of three consecutive pictures. The same 30 second recapture interval as in the Cuddeback camera type was set. Wherever possible, cameras were set up viewing the mountain slope in profile, preferably facing South to prevent sunlight lens aberrations. Because of the more compact shape and the invisibility of the IR-light to the human eye, this model was preferably used in areas where human discovery was more likely.

2.5.3 Setup

The cameras were fixed with thick coated wire and cable ties on tree stems wherever possible. If no usable stem was nearby, an iron fence post was hammered into the soil. All vegetation penetrating the detection cone in proximity to the trap had to be cleared. A sculptor was employed as a fieldwork assistant to use the cut-off foliage as disguise material for the camera units. The material was fixed with wire and cable ties as a preventive measure for accidental discovery.

The detailed technical Setup-Procedure can be found in →Appendix 9.1.

For readout and analysis, a triggering event was considered independent from a previous one showing the same species, if at least 5 minutes have passed between them as seen on the picture time stamp.

2.6 Camera Trapping Methods

2.6.1 Capture-Recapture

Capture-Recapture models were adopted early by camera trapping research pioneers, as soon as the method gained widespread interest in ecological research. To estimate tiger abundance, individual animals were identified by their stripe patterns and the individual's reoccurrence allowed the modelling of population dynamics (Karanth, 1995). For landscape-level biodiversity studies with an undetermined number of species detected, capture-recapture models cannot be easily applied, because they rely on the repeated recognition of individuals by traits such as fur pattern. To allow for consistent fur pattern recognition, trapping location setups have to be adapted to the behavioural and physiological properties of one or few species. For example, using multiple cameras from different angles, specific triggering systems or unusual positioning of trapping locations are necessary for the identification of individuals of one species. This might however bias the triggering frequency for other species resulting in disproportional abundance densities in a biodiversity study. Furthermore, when the study layout is not specifically set up for recapturing, the identification of individuals on trapping imagery turns increasingly difficult, as only parts of an animal might be observable on the captured images. For these reasons, this study did not use Capture-Recapture models (Harmsen & Foster, 2010),(Sunarto, et al., 2013).

2.6.2 Baited vs. Unbaited

Baited camera traps are an universal tool to increase the chance of triggering events of those species the bait appeals to. If the study focus lies on a distinct species, baiting can greatly enlarge the number of obtained images and the explanatory power of the dataset. Baits can be pieces of food, artificial lures, carcasses, scent or pheromone applications, sound signalling or even an attractant animal substitute. Even in single-species studies the effect of the bait on the animal's behaviour cannot be fully predicted. A large bias in the activity budget and in spatial distribution has to be considered when using baits, which has to be corrected for during analysis (Fisher & Burton, 2012).

Subsequently, many nature conservation reserves (such as Table Mountain National Park) forbid the usage of baits, because baiting is believed to possibly interfere with the equilibrium of the ecosystem, giving an unnatural advantage to species excessively feeding on bait. Thus, "unwanted" species might be attracted or others might be disturbed by the bait and the target species' behaviour therefore can be dramatically altered. For these reasons, especially for baseline biodiversity camera trapping studies, unbaited traps are in most cases more likely to produce reliable, meaningful results for ecological research, as long as detection probabilities are high enough. The use of baits or lures was not attempted during this study.

2.6.3 Distribution Patterns

The objective of the study largely defines the type of distribution of trapping locations in the study area. Firstly, the distance of locations depends on the average daily travelling distance of the study subjects. Great care is usually taken to ensure statistical independence of triggering events by large distances between camera stations. Recent findings showed, that - in the open field - a minimum distance of 25m between camera stations is usually sufficient to avoid autocorrelation (Kays, et al., 2011). Depending on the statistical models used, larger distances can become necessary.

The estimated abundance of the studied taxons in a specific area influences the density of positioned traps. Elusive and predatory species require a wider spacing (with longer running times) than frequent, stationary ones. For biodiversity surveys a medium value, considering the animal's expected day range, has to found.

A: Intuitively, quasi-random placement of camera traps results in the least biased distribution pattern for a landscape level analysis imaginable: While all terrain-types are covered (considering a large enough setup) an average spacing still allows for an overall estimation of densities, the model is very robust for missing data points and allows for statistical density estimations by Random Encounter Model REM (Rowcliffe, et al., 2008).

B: Transect-type or other regular grid types still are chosen more often, because they reduce the risk of autocorrelation by habitat range, allow for a more reliable local understanding of spatial abundance (Güthlin, et al., 2014) and can be set up along an elevation gradient (TEAM Network, 2011) reducing the need to correct for altitude differences as all altitude levels are represented equally.

C: Feature-related distribution patterns are especially common, when analyzing only one or few species to answer questions specifically surrounding the feature's environment (roads, rivers, feeding grounds, etc) by increasing the detection rate for the surveyed species. For landscape level biodiversity surveys they are prone to create a substantial bias.

Because of the strong elevation profile of the study area and the landscape-level nature of the survey, a transect-type model (B) with a minimum of 500m in-field distance between stations was chosen.

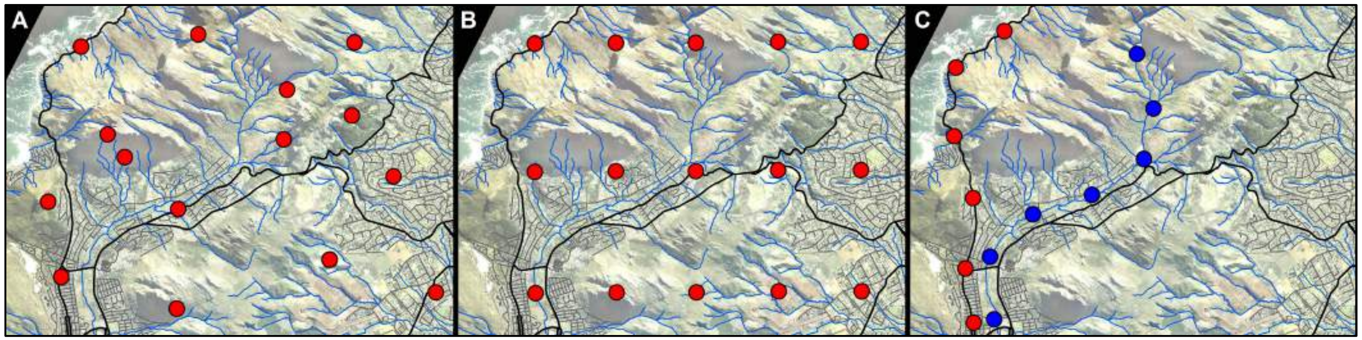


Figure 5 - Distribution Patterns of Camera Traps.
A: Pseudo-Randomized Distribution.
B: Regular Grid/Transects.
C: Feature-Related Distribution (Red=Road, Blue=River).

2.7 Positioning of the Traps

2.7.1 Generation of Transects

Transects and locations were generated using GIS aerial imagery and elevation profiles to correct for altitude distances. Average East-West distance between points on a transect equals 1 km ground distance. North-South distance from one transect to the next is 2 km.

Both mountain ranges (Table Mountain Section in the North and Silvermine-Tokai Section in the South) are analyzed by a set of three transects covering the full mountain range from the western to the eastern slope. While transects of 6 km are needed for Table Mountain to acquire data on all mountain surface aspects, transects of 5 km are sufficient to cover Constantiaberg (Silvermine-Tokai) without penetrating urban settlements.

The traps are placed around their calculated coordinates in a 50 m tolerance radius to allow for appropriate camera hiding, a large enough sensor detection field (height and distance from target range), as well as vegetation removal.

Additional off-grid camera stations (if placed not closer than 500m to predefined ones) can be easily integrated into the transect model without affecting statistical usability of the generated data.

2.7.2 Final Positions

Due to topographical limitations the traps could not always be set in the desirable 50m radius around the initially generated location. In these cases a morphologically similar location was selected in the field, estimating comparable vegetation coverage as well as the topographical parameters such as altitude, slope and aspect. The shoreline, as well as the urban edge formed the borders of the study area.

The final positions of camera traps can be found on the overview map provided in the book cover, as well as on →Appendix 9.4, Map H.

2.7.3 Study Schedule

The study took place in the transitional autumn phase between the seasons from 2013-March-03 to 2013-June-11. June was considered the last month to operate, because camera performance is known to decrease in rainy winter conditions by reducing the detection distance (Kays, et al., 2011). Trap data by Mrs. N. Okes integrated into this study was surveyed in spring of the same year (August to December 2012) offering similar weather conditions and including the assumption that migratory effects over both survey periods are negligible.

2.8 Covariate Selection

Each of the 38 trapping locations was attributed with a set of covariates. The covariate data was collected during the setup-procedure in the field or by GIS-based distance analysis on aerial imagery and map layers. Numeric values were sorted into classes for grouped analysis and comparison. Camera stations, which had to be excluded from the analysis due to technical reasons are shown in brackets. (See →3.1 Trapping Success for further information)

2.8.1 Camera Trap Type

Although preliminary trials showed a similar triggering probability of both camera types for humans and human hands (simulating smaller mammals), the trap type used might bias the trapping results. To compare the trapping efficiency of both cameras, the trap type used for each location was registered as a covariate. Because both types were only available sequentially, more Bushnell camera traps were used in the Silvermine-Tokai Section than on Table Mountain. Significant differences in a species' abundance between the camera types, can therefore be explained by the preference for a specific mountain range rather than by a bias because of a specific trap type. A sum of 21 traps were categorized as "Cuddeback" (2 excluded); 17 traps as "Bushnell" (1 excluded).
An overview can be found on → Appendix 9.4, Map I.

2.8.2 Mountain Range

To be able to compare the mountain ranges of Table Mountain and Constantiaberg separated by the road M63 at Constantia Nek, all camera traps were classified into one of them. A sum of 17 camera traps South of 34,01°S were considered part of the Silvermine-Tokai Section (1 excluded) and 21 camera traps North of 34,01°S part of the Table Mountain Section.
An overview can be found on →Appendix 9.4, Map H.

2.8.3 Altitude

Altitude is a topographical key parameter for biodiversity throughout the study area. Not only do human settlements tend to appear on lower altitudes, but also vegetation and other forms of land usage differ severely on altitude levels. Moreover, climatic parameters, connected to the proximity from the seashore, change with altitude. Altitude was measured with a GPS device in the field and confirmed on a 3D model.
An overview can be found on →Appendix 9.4, Map A.

Table 1 - The categorization was undertaken as following:

Class	Limits (meters above sea level)	Number of traps
0	0 m - 150 m	7
1	>150 m - 300 m	9
2	>300 m - 450 m	7 (1 excluded)
3	>450 m - 600 m	6 (1 excluded)
4	>600 m - 750 m	5 (1 excluded)
5	Higher than 750 m	4

2.8.4 Slope

The studied area offers a wide range of terrain formations, from flatland to sheer cliffs. As the occurrence of animals will change with the degree of slope, mapped steepness at a recording location can serve as an covariate to describe behavioural differences and habitat ranges.

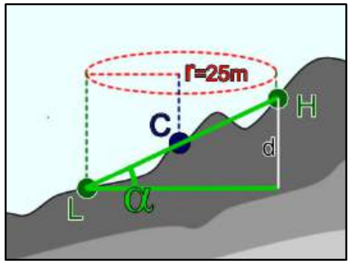


Figure 6 - Calculation Scheme for Degree of Steepness. Mountain (grey) is shown in profile.

The slope was calculated by using a spatial 3D model of the Cape peninsula: The steepness angle (α) to flatland was measured between the two opposing points (L-H) with the highest altitude difference (d) found on a 25m radius circle (r) around the GPS coordinates of a camera location (C) measured in the field.

An overview can be found on →Appendix 9.4, Map B.

Table 2 - The steepness of terrain was categorized as following:

Class	Limits (degree of steepness)		Number of traps
0	Very Flat	0° - 4°	10
1	Flat	>4° - 10°	4
2	Moderate	>10° - 16°	8 (1 excluded)
3	Steep	>16° - 25°	9
4	Cliffs	Steeper than 25°	7 (2 excluded)

2.8.5 Mountain Aspect

Comparing the sides of the mountain chain allows the investigation of climatic influences. **Aspect Class "Plateau"** was defined as a flat part (*Slope Class "1"* or lower) of the central mountain range on an *Altitude Class* higher than *"0"*. **Aspect Class "Flatland"** therefore was defined as a flat location (*Slope Class "1"* or lower) being part of *Altitude Class "0"*. All steeper locations (*Slope Class "2"* or higher) were distributed into the **Aspect Classes "Eastern Slope"** and **"Western Slope"** depending on the individual mountain aspect surface degree (0°/360°=North facing) of the trapping location. The limit values were adapted to the individual topography of the studied mountain ranges, which line up along a NNW/SSE-chain, rather than direct N-S.

An overview can be found on →Appendix 9.4, Map B.

Table 3 - The mountain aspect classes were distributed as following:

Class	Limits		Number of traps
Flatland	Lower than 150 m	0° - 10° steep	5
Moutain Plateau	Higher than 150 m	0° - 10° steep	9
Eastern Slope	Mountain Aspect 335°-360°; 0°-154° ~NNW→N→E→~SSE	>10° steep	10 (2 excluded)
Western Slope	Mountain Aspect 155°-334° ~SSE→S→W→~NNW	>10° steep	14 (1 excluded)

2.8.6 Permanent Freshwater

Freshwater is one of the most essential resources for mammalian wildlife and its unavailability forces animals to migrate or to develop new strategies of water intake. On Table Mountain and Constantiaberg the constant coastal winds generally secure freshwater availability throughout the seasons, although many streams and rivers dry out in summer and refill in autumn. With the permanent presence of freshwater, specific wetland areas and "vegetation prone to seasonal water-logging", the Cape Peninsula is not considered a water stressed environment (Hoffman, 2011). To correct for a seasonal effect in freshwater availability the closest rivers found in the field were looked up on current GIS layers provided by the municipality to check for their permanence. If the stream that was found in the field, was not listed as permanent in the GIS layer, the closest permanent one was used as a reference to determine the actual distance to freshwater. An overview can be found on →Appendix 9.4, Map C.

Table 4 - The distance to permanent freshwater was categorized as following:

Class	Limits (distance in meters)		Number of traps
0	Water on Location	0 m - 25 m	9
1	Close Proximity	>25 m - 75 m	9
2	Moderate	>75 m - 150 m	9 (2 excluded)
3	Distant	>150 m - 300 m	8 (1 excluded)
4	Unrelated to Location	More distant than 300 m	3

2.8.7 Vegetation Type

Vegetation is a key parameter for the single individual mammal to choose its habitat. Behaviour, body size, appearance and colouration, predation pressure, as well as resource availability determine the demands of an animal towards its vegetation environment. Some animals show a high specificity for vegetation, whereas others can be considered generalists because their presence was recorded in multiple biomes. Although complex and diverse classification systems exist for the fynbos environments (Rouget, et al., 2004), the natural biome in the study area can be divided into the following general classes, all hosting various plants endemic to the City of Cape Town:

- Afrotemperate Forest
- Lowland Granite Fynbos
- Montane Sanstone Fynbos
- Sand Fynbos

Following general classes of transformed environments can be found:

- Alien Invasive Vegetaion
- Agricultural Transformation (including Pine Plantations)
- Urban Transformation

Afrotemperate Forest (7 traps, 1 excluded), also called Afromontane Forest, is the most dense vegetation type found on the Cape Peninsula. Although it once covered vast portions of the study area (before the settlers arrived) it can now only be found on the steep eastern slopes of the Table Mountain section, as well as on the eastern slopes of the protected Orange Kloof area. Because of its position, it receives a large portion of the precipitation carried by the Atlantic winds. This type of forest can only grow in locations protected from seasonal fires.

Lowland Granite Fynbos (7 traps) is a vegetation type found encircling both sides of the mountain chain and is considered highly endemic to the city of Cape Town. Its ability to cope well with seasonal arid conditions allows it to thrive better on the western slopes being exposed to the dry, warm falling winds. Granite fynbos grows on richer soils being a result of the higher infiltration by freshwater streams, especially when compared to sandstone fynbos. Therefore it is spatially endangered by the growing amount of farms, plantations and vineyards, which need the comparatively rich and fertile soils. It grows relatively dense and individual protea plants can reach tree size.

Montane Sandstone Fynbos (16 traps, 2 excluded) is predominant and very endemic to the higher central parts of the peninsula's mountain chain, generally found on poor, acidic soils. It grows less dense, mainly covering the ground and shows a high diversity. Only occasionally, do protea scrubs grow taller than 50 cm. On the highest altitudes, none of these taller scrubs can be found anymore. Due to its inaccessible topography and sandy soils, it is found to be more conserved from farming and settlements than granite fynbos.

Sand Fynbos (1 trap, counted as Urban) (Hangklip Sand Fynbos and Cape Flats Sand Fynbos) are special types of lowland fynbos and are considered critically endangered. They grow very low and appear in isolated remnant patches. One camera trap (#ZZ, see Map 8) which was placed according to the GIS layer in "sand fynbos", was found to be set up in the border area between Sand Fynbos, Wetland swamps and urban settlements. Because this location was very closely related to transformed environments it was counted as Urban.

All other camera traps were positioned in fully transformed environments. Where these cameras were concerned, the study focussed on habitats located directly on the edge of **Urban Transformation (4 traps)** and not within the urban areas themselves.

Additional transformed locations were selected in the **Pine Forest Plantations (4 traps)** of Tokai, enclosing a small dense recreationally used forest consisting of alien vegetation (mainly Eucalyptus) and bordering suburban gardens.

No positioning of camera trap was attempted in vineyards because the local vineyards are strongly fenced off (close mesh, high-voltage) due to the proximity to urbanisation. This security fencing made the appearance of baboons and therefore any larger mammals very unlikely, but research is currently undertaken on this topic (Richardson/HWS, 2014).

The vegetation type was estimated in the field and confirmed on a GIS-based grid map of the Cape Peninsula (Hoffman, 2011).

An overview can be found on →Appendix 9.4, Map G.

Figure 7 - Examples of Different Vegetation Types in the Study Area.

2.8.8 Distance to Settlement

Settlements provide a drastically altered habitat space, where the amount of human influence on wildlife reaches its climax in metropolitan settings.

Reasons for wild mammals to enter urban spaces include(Luniak, 2004):

- Garden arthropods or other small garden animals, as well as digestible garden plants, serve as a local source of semi-natural food
- Easy availability of rubbish and other opportunistic human-derived food sources like pet or bird food serve as nutrition replacement
- Availability of prey such as farmed animals, pets or (unconsciously) tolerated garden animals such as small opportunistic scavengers
- Availability of freshwater in dry seasons
- Availability of protected or warm retreat spaces
- Unavailability/Loss of natural food sources
- Loss of natural habitat spaces
- In exceptional cases: Availability of a mating partner

Stimulatory factors that increase with proximity to settlements and typically deter wild terrestrial mammals, include(Forman, et al., 2013):

- Night-time active light sources
- Traffic and machinery noise
- Direct presence of humans and pets
- Droppings and scent markings of pets
- Different types of pollution

Consequences of wild animals in the urban areas include (Bradley & Altizer, 2006):

- Wildlife traffic accidents
- Fighting or preying behaviour results in injury or killing of pets and farmed animals
- Death or injury of wild animals by pet fights or consumption of inappropriate food
- In rare cases: Risk of human injury
- Spread of intra- and interspecific infectious diseases and parasites
- Noise disturbances
- Household disturbances like scattered trash bins, droppings of wild animals, damaged plants, scuffed gardens
- Damages of vehicles, machinery, infrastructure, buildings
- Forwarding of adaptive behavioural changes to wild offspring
- Familiarization of the wild animals with human presence ultimately could result in poaching and bush meat hunting even in urban areas

Due to these manifold interactions, the distance to settlements is a key covariate in understanding the penetration and behavioural adaptation of the wild mammals remaining in the study area.Distance to Settlements was measured as the smallest ground surface distance in an aerial imagery 3D model between the trap location and permanent buildings.

An overview of land usage and settlement distance can be found on →Appendix 9.4, Map D.

An overview of motorized traffic distance can be found on →Appendix 9.4, Map E.

Table 5 - The camera trapping location's distances to urban settlements were categorized as following:

Class	Limits (distance in meters)		Number of traps
0	Urban Edge	0 m - 50 m	5
1	Close Proximity	>50 m - 300 m	5
2	Moderate	>300 m - 700 m	7 (2 excluded)
3	Distant	>700 m - 1200 m	13 (1 excluded)
4	Remote from Urban Settlments	More distant than 1200 m	8

2.8.9 Distance to Hiking Trail

Hiking trails form a dense network in the study area and were suspected to generate a two-sided impact on the wildlife of the Cape Peninsula shifting their function depending on the time of the day: During daytime they have to be considered a source of disturbance to mammalian wildlife by providing easy access for humans and dogs to reach parts of the national park far away from settlements. During the night though, hiking trails can enable nocturnal animals to travel much further distances than they would have been able to travel naturally through vegetated bush or thicket.

Unfortunately, the camera traps could not be placed with an even distribution throughout the two mountain ranges. Traps on the Table Mountain Range were at a substantially higher risk of human discovery than traps in Silvermine-Tokai, considering mass tourism and accessibility. Therefore, the Table-Mountain traps had to generally be placed further away from paths. The controlled access by a toll plaza/national park guard, allowed the positioning of traps closer to hiking paths in Silvermine-Tokai. Additionally, off trail areas in the low growing mountain fynbos vegetation of the Table Mountain plateau were more easily accessible than in the higher grown fynbos thicket of Silvermine ("Bundu Bashing").

Distance to hiking trails was measured as the smallest ground surface distance in an aerial imagery 3D model between the trap location and permanent pathways considered usable by the general public during field work.

An overview of public hiking trails can be found on →Appendix 9.4, Map F.

Table 6 -
The camera trapping location's distances to hiking trails were categorized as following:

Class	Limits (distance in meters)		Number of traps
0	Camera on Trail	0 m - 15 m	14 (1 excluded)
1	Close Proximity	>15 m - 40 m	5
2	Moderate	>40 m - 80 m	9 (1 excluded)
3	Distant	>80 m - 120 m	6
4	Unrelated to Hiking Trail	More distant than 120 m	4 (1 excluded)

3 Results

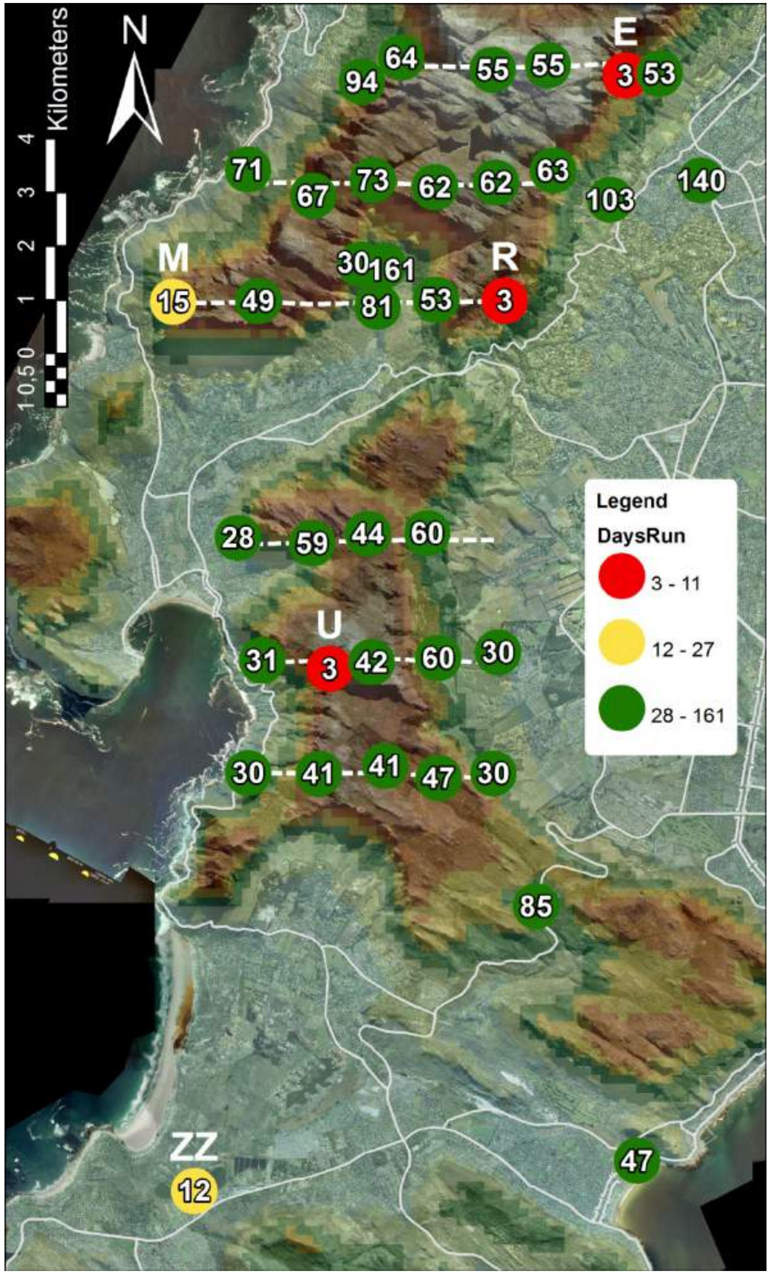
3.1 Camera Trapping Success

3.1.1 Running Time

Estimating a minimum running time of 28 days for full-scale analysis, most datasets can be considered complete. Of all 38 trap stations running, three (see red dots in Map 7) had to be excluded from the analysis completely due to technical failure:

- Traps Number "E" and "R" (both Cuddeback) showed an exceptional software error, producing initially good imagery for a few hours, then miscoloured, untriggered images for three days and thereafter stopped recording completely. Both these traps were positioned in topographically difficult locations, so the malfunction was only discovered when no replacement equipment was available anymore.
- Trap Number "U" (Bushnell) was excluded from the analysis: Strong winds filled the SD card with thousands of images consisting of three days continuously moving plants during multiple attempts.

Another two camera traps ran for shorter periods (yellow dots in Map 7), making the data less reliable for quantitative density and relative abundance analysis. For other analytical methods such as the list of species, occupancy and hourly activity patterns the datasets are still valid.



Map 6 - 1 : 100 000 - Running Time of Camera Traps in Days Throughout the Complete Study Area.

- Trap Number "M" (Cuddeback) stopped recording too early for unknown reasons with both, batteries and SD-card still fully functional. The imagery was still used in the analysis, because repeated mammal triggering events were recorded during the working time-span.
- Trap Number "ZZ" (Bushnell) stopped recording too early, because the camera was dismounted - as imagery evidence shows - by a group of Cape Clawless Otters. Being dragged into the grass, no usable imagery was produced after the 12th trapping day.

On average, camera traps ran for 53,87 (±5,40) days including all cameras. Excluding malfunctioning units, camera traps ran 58,23 (±5,24) days. Cameras in the Table Mountain Section ran for 59,19 (±4,63) days, in the Silvermine-Tokai Section for 41,77 (±3,32) days. The six cameras of Mrs. Nicola Okes, which were integrated into this study due to spatial and temporal overlap, ran for 91,33 (±22,85) days. An overview of the trap sets used can be found under Appendix 9.5 Map H.

In total, all camera traps ran for 2038 days (+9 excluded days from stations "E", "R" and "U"), which is reported to result in approximately 80% species detection rate (Rovero, et al., 2010), (Tobler, et al., 2008), (Srbek-Araujo & Garcia, 2005) (See →3.3).
If these 2038 days, the 19 functioning Cuddeback type camera traps recorded for 1038 days (54,63 days per trap) and the 16 functioning Bushnell type camera traps recorded for 1000 days (62,5 days per trap).

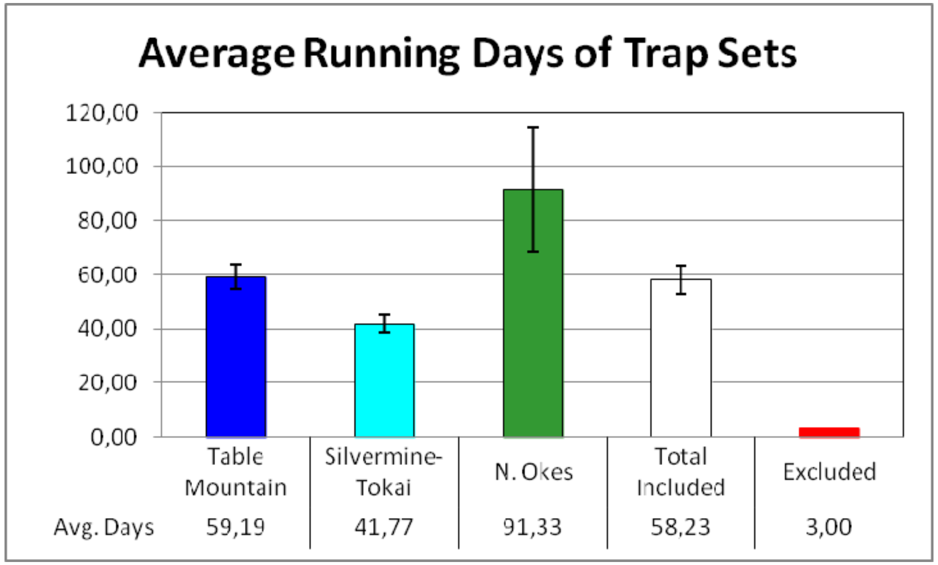


Figure 8 - Average Running Days of Trap Sets (± Standard Error)

3.1.2 Vandalism and Theft

Other studies showed, that regularly 20% to 30% of camera traps are lost due to vandalism and theft per survey (WWF-Global, 2006), (Kalita, 2012). Special precautions were carried out by a local professional sculptor who managed to adapt the camera's appearance in its specific environment so well, that none were prone to discovery in previously designated high-risk areas. These actions undertaken resulted in 0% non-technical equipment or data loss.

3.2 Identification Success

In total, a database of 12'285 triggering events, recorded on 35 camera stations (on average 323,3 triggering events per station), was generated.
From these 12'285 triggering events, 2'663 visits by individual metazoa could be extracted (21,7%; on average 76,1 visits per station). Triggering events not showing an individual visit consisted mainly of moving plants, sunlight aberrations, field researchers during equipment check-up and repetitive images of the same being during the same visit.
Of those 2'663 visits by individual beings, 1'795 visits were undertaken by humans, including 318 humans using vehicles (mainly bikes), but excluding the events triggered by study-related researchers and field workers.
Visits by 761 medium to large-sized mammals were captured, of which 351 could be attributed to house dogs and 2 to house cats. The remaining 405 visits are considered capturing events triggered by wild medium to large sized terrestrial mammals.
Visits by 87 excluded animals were captured, encompassing small rodents, birds, spiders and insects (→3.2.2).
Another 18 visits were evident but had to be excluded, because the identification of the visiting beings was considered impossible by all involved researchers. The estimated overall rate of identification success is 97,64% (→3.2.3).

Order	Taxon	English Name	Count	Percent
	Domestic Species		**2148**	**80,75**
Carnivores	*Canis lupus familiaris*	Domestic Dog	351	13,20
"	*Felis silvestris catus*	Domestic Cat	2	0,08
Primates	*Homo sapiens sapiens*	Modern Human	1795	67,41

Order	Taxon	English Name	Count	Percent
	Introduced Species		**48**	**1,81**
Rodents	*Sciurus carolinensis*	Grey Squirrel	42	1,58
Ungulates	*Hemitragus jemlahicus*	Himalayan Tahr	4	0,15
"	*Rusa unicolor*	Sambar Deer	2	0,08

Order	Taxon	English Name	Count	Percent
	Wild Species		**362**	**15,40**
Rodents	*Hystrix africaeaustralis*	Cape Porcupine	93	3,49
Ungulates	*Oreotragus oreotragus*	Klipspringer	4	0,15
"	*Raphicerus melanotis*	Cape Grysbok	7	0,26
Carnivores	*Caracal caracal*	Caracal	19	0,71
"	*Aonyx capensis*	Cape Clawless Otter	33	1,24
"	*Atilax paludinosus*	Watermongoose	106	3,98
"	*Galerella pulverulenta*	Cape Grey Mongoose	22	0,83
"	*Genetta tigrina*	Large-spotted Genet	68	2,55
Primates	*Papio ursinus*	Chacma Baboon	10	0,38
	Other Animals	**→3.2.2**	**87**	**3,27**
	Unidentified Events	**→3.2.3**	**18**	**0,68**
	TOTAL		**2663**	**100,00**

Table 7 - Count Data of all triggering events resulting in individual visits.

3.2.1 Identification Complications

As the study did not aim for the identification of individuals, determination of the species captured was the main operative challenge. Often, a captured animal showed only parts of an animal's body, making species identification more difficult. Interactive, as well as descriptive identification keys were used in such cases (Kingdon, 2013), (Stuart & Stuart, 2001).

Generally, larger diurnal animals could be identified more easily than smaller nocturnal ones. Diurnal activity resulted in colour imagery in both trap types used and resulted in reduced risk of under- or overexposure. Overexposure can whiten out parts of the image completely, leaving no possibility for post-processing image enhancement software, that makes the identification of specific traits possible. Overexposed imagery was encountered with both trap types used alike, mainly when animals triggered recordings during night time and in very low distance to the light source and the sensor system.

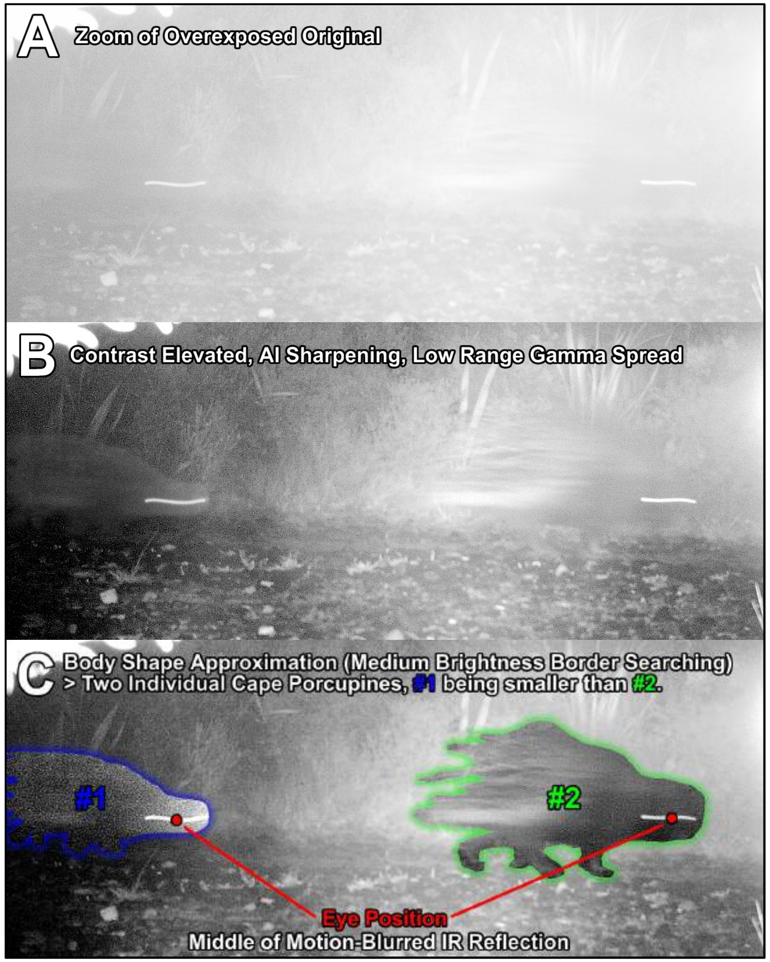


Figure 9 - Exemplary Capture of a Bushnell-Type Camera Trap (A), Image Enhancement (B) and Identification process (C) of two individual Cape Porcupines near the Silvermine Reservoir.

Underexposure only occurred on night-time shots and more often with the less intense infrared lighting of the Bushnell traps than with the visible flashlights of the Cuddeback traps. The Bushnell traps compensated for the lesser infrared image quality by taking a series of three captures at each triggering event. Underexposure often resulted in motion blur, especially for smaller species. Image enhancement (undertaken with specific software such as "Adobe Photoshop CS6", "Macromedia Fireworks 8", "Google Picasa 3.9") could provide more information from underexposed images than from overexposed images by spreading the brightness and gamma spectrum to enhance overall contrast levels, as well as by rescaling RGB channels and by automatic intelligent sharpening. Motion blur could be reduced by enhancing the contrast of an image specifically where the animal was assumed around a medium brightness level to determine body shape. Short white stripes signalized the moving position of the eye during exposure.

Once an animal was identified on a specific image, its order and family were obvious relatively immediately. For some animals, where more than one species was considered existent throughout the study area showing a very similar anatomy, identification turned out to be more difficult. Special attention had to be paid to members of the Genus *Genetta spp.*, aswell as to small ungulates of the genus *Raphicerus spp.*

3.2.1.1 Genets

In the vast majority of cases, on triggering events showing a member of the Genus *Genetta spp.*, the captured individual could be safely identified as "Cape Large Spotted Genet" (*Genetta tigrina*). In few cases, where only parts of the animal's body were captured, a slight risk remained, that the captured individual might also be a member of the species "Cape Small Spotted Genet" (*Genetta genetta*). The main traits, observable by camera traps, leading to this conclusion are (Dubus, et al., 2010):

- Tail Tip: *G. tigrina* has a black tip, *G. genetta* has a white tip.
- Hind legs: *G. tigrina* has completely black hind legs, *G. genetta* has black shins and calves with a white stripe and white paws.
- Spots: *G. tigrina* has four rows of very prominent black spots on each side, *G. genetta* has five rows of rather faded dark-brown spots.

Throughout all unclear events, *Genetta tigrina* was still considered the more likely species. All recorded *Genetta* triggerings were therefore treated as *G. tigrina*.

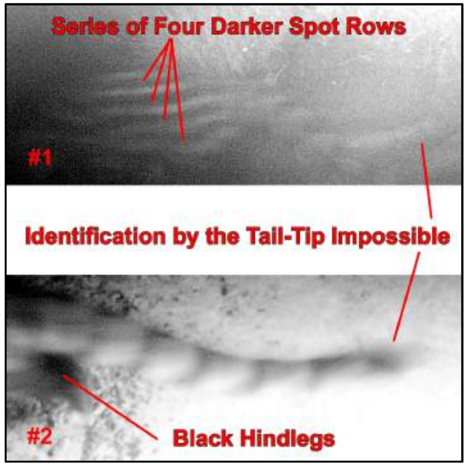


Figure 11 (left) - Exemplary Genetta spp. identified as "G. tigrina", according to the traits shown."G. genetta" is still possible due to motion blur.

Figure 10 (right) - Exemplary Raphicerus spp. identified as "R. melanotis" by the occurrence of false hooves despite its comparatively large size.

3.2.1.2 Small Ungulates

The "Grysbok" (*Raphicerus melanotis*) is the smallest and most common antelope found in the study area and was safely identified in most of the ungulate captures. Its body size alone is a clear hint for this species. In all colour images the Grysbok could be more easily identified by its highly specific fur pattern, showing few longer single white hairs in an otherwise very orange coat. As these criteria matched all captured images, confusion with the "Common Duiker" (*Sylvicapra grimmia*) is highly unlikely. Confusion with the "Steenbok" (*Raphicerus campestris*) on black and white images could not be excluded completely, as it only differs in a slightly larger body size, a slightly longer neck and a more prominent black stripe on the nose. The typical white under parts of *R. melanotis,* often could not be used for identification in the indistinct overexposed images. The pseudo-hooves on the hind legs are more typical for *R. melanotis.* In all unclear events, *R. melanotis* was still considered the more likely species and therefore recordings were treated as such.

3.2.2 Excluded Events

All non-mammalian triggering events were excluded from analysis. These events consisted repeatedly of the following taxa:
Arthropoda, namely Insects and Arachnids (Not further classified)
Aves, mainly Redwinged Starling (*Onychognathus morio*), Guinea Fowl (*Numinida meleagris*), Mallard (*Anas platyrhynchos*) and single others.

Following taxa were considered unobservable mammal species due to their non-terrestrial lifestyle: Bats, Seals, Whales and Dolphins.
No triggering event was recorded by any of these species.

Following taxa were considered not quantifiable due to their body size, although "accidental" recordings were expected to occur: Moles, Shrews, Elephant Shrews, Molerats, Dormice, Mice, Gerbils and Rats. Different approaches exist to estimate the population abundance of small mammals by using camera traps. They require a very different study setup, which usually does not allow for quantifiable information on medium- and large-sized mammals (McCleery, et al., 2014).
Out of these small excluded taxa, only occasional triggering events were recorded of the subfamily *Murinae spp.* (Rats and Mice): African Vlei Rat (*Otomys irroratus*) and Four-Striped Mouse (*Rhabdomys pumilio*). Both are considered fairly common prey species for members of the order Carnivora. Lastly, a single recording of African Pygmy Mouse (*Mus minutoides*) occurred as well.

3.2.3 Unidentifiable Events

18 triggering events could be clearly attributed to an animal of the target size, but did not provide enough information for identification. The most common reason for having to classify an event as unidentifiable, was 100%-white overexposure with unrecognizable shapes on large parts of the picture resulting from close proximity by the triggering individual to the camera system. Images, where no animal was captured, were not considered "unidentifiable" but rather false-positive "misfiring", usually triggered by abiotic factors.
Six unidentifiable events were recorded by Cuddeback camera traps (on average: One unidentifiable event every 173 trap days) and
12 unidentifiable events were recorded by Bushnell camera traps (on average: One unidentifiable event every 83 trap days).
Considering 2558 properly identified triggering events showing target-sized mammals and only 18 unidentifiable triggering events, the rate of identification success for target sized triggering events theoretically ranges at 99,30%. Because humans can be excluded as a cause for unidentified imagery in all 18 triggering events, this count should only be compared to the 763 properly identified triggering events showing target-sized mammals excluding humans, resulting in a rate of identification success of 97,64%.

3.3 Species Richness

In total, 9 native, wild, medium- to large-sized mammal species were safely identified within the study area. None of these are listed by the IUCN Red List into another conservation status than "Least Concern" (IUCN, 2014). Possible misidentification of *Raphicerus campestris* (Steenbok) as *Raphicerus melanotis* (Grysbok) and possible misidentification of *Genetta genetta* (Small-spotted Genet) as *Genetta tigrina* (Large-spotted Genet) could theoretically increase this number to 11 species.

Additionally, another 6 species are derived from human presence. Of these, one species (Himalayan Tahr) is listed by IUCN as "Near Threatened", because the species is believed to be in significant decline due to food hunting and habitat loss (Bhatnagar & Lovari, 2014). Another species (Sambar Deer) is listed as "Vulnerable" because of sustained declines due to food and trophy hunting (Timmins, et al., 2014).

Compared to the overall biodiversity of the Western Cape Province, 58 medium to large sized, terrestrial, wild mammals - theoretically detectable by a camera trap setup like this study - could occur within the province boundaries (Lloyd, 2000). Taxa excluded from this study (→3.2.2) were omitted to obtain this number.

In other words, (considering 9 detected native species,) 15,5% of all observable native wild species theoretically existent in the Western Cape province were found within the study area.

Order	Wild Species Taxon	English Name	IUCN Category
Rodents	*Hystrix africaeaustralis*	Cape Porcupine	Least Concern
Ungulates	*Oreotragus oreotragus*	Klipspringer	Least Concern
"	*Raphicerus melanotis*	Cape Grysbok	Least Concern
"	*(Raphicerus campestris)**	Steenbok	Least Concern
Carnivores	*Caracal caracal*	Caracal	Least Concern
"	*Aonyx capensis*	Cape Clawless Otter	Least Concern
"	*Atilax paludinosus*	Watermongoose	Least Concern
"	*Galerella pulverulenta*	Cape Grey Mongoose	Least Concern
"	*Genetta tigrina*	Large-spotted Genet	Least Concern
"	*(Genetta genetta)**	Small-spotted Genet	Least Concern
Primates	*Papio ursinus*	Chacma Baboon	Least Concern

Order	Introduced Species Taxon	English Name	IUCN Category
Rodents	*Sciurus carolinensis***	Grey Squirrel	Least Concern
Ungulates	*Hemitragus jemlahicus***	Himalayan Tahr	Near Threatened
"	*Rusa unicolor***	Sambar Deer	Vulnerable
Carnivores	*Canis lupus familiaris***	Domestic Dog	n/a
"	*Felis silvestris catus***	Domestic Cat	n/a
Primates	*Homo sapiens sapiens***	Modern Human	n/a

Table 8 - List of recorded species in the study area and their conservation status.
(x) = Species not recorded, but misidentification has to be considered possible due to incomplete or imprecise imagery.*

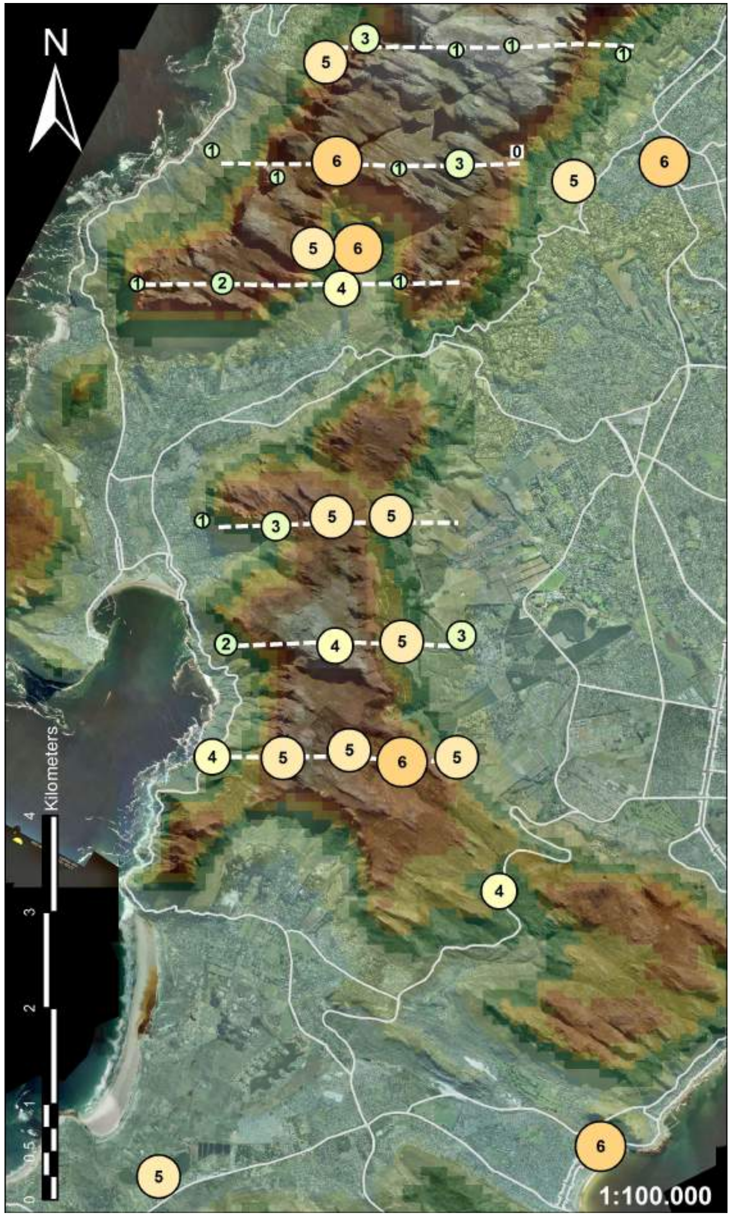
The Table Mountain National Park Management Board lists a total of 17 observable wild, native species within the boundaries of the study area (TMNP, 2014). Following species are claimed to exist within the study area, but their existence could not be confirmed (safely*) by trapping imagery:

Taxon	English Name	IUCN Category
Raphicerus campestris*	Steenbok	Least Concern
Sylvicapra grimmia	Common Duiker	Least Concern
Pelea capreolus	Grey Rhebok	Least Concern
Genetta genetta*	Small-spotted Genet	Least Concern
Procavia capensis	Rock Hyrax (Rock Dassie)	Least Concern
Ictonyx striatus	Striped Polecat	Least Concern
Vulpes chama	Cape Fox	Least Concern
Equus zebra zebra	Cape Mountain Zebra	Vulnerable

Table 9 - Potentially detectable wild native species based on TMNP public data. (x) = Species not recorded, but misidentification has to be considered possible due to incomplete or imprecise imagery.*

According to the data of the TMNP Management Board, 53% of all wild, native, medium to large sized, terrestrial, mammal species were detected throughout this study. Adding the 3 introduced, wild, non-domestic species from Table 1, in total 60% of all wild observable species were detected.

Never were all species detected at all sites. Species richness overall ranged from 1 to 6 (including humans and dogs). The average species richness excluding humans and dogs was 2,3.



Map 7 - Species richness at individual trapping locations. Circle size corresponds with allocated number.

3.4 Relative Abundance

Relative Abundance Indices (RAI) are a often recommended and intuitive tool to show interspecific population differences. They are considered to have the highest explanatory power, when species within a similar ecological niche are compared. RAI can be generated using mean event counts per trapping effort. They are considered a poor index for values (detection probabilities) under 1 and are often replaced by occupancy models in such cases (Gibbs, 2000). Occupancy models, as an often used surrogate to abundance analyses (Ahumada, et al., 2001), allow a higher amount of data fidelity, but require a study design with repeated presence/absence survey data (Rovero, et al., 2010). In the case of this biodiversity study a similar ecological niche (like trophic level or day range) cannot always be safely assumed. RAI therefore qualify in a more general way as occupancy modelling for statistical trend analysis (Sunarto, et al., 2013). As a mode of intuitive comparison, they can serve as an important information tool for decision makers, since baseline camera trap data is lacking for the study area (Jenks, et al., 2011). Special attention has to be paid to the fact, that RAI values are easily biased, when some species are likelier to be detected than others, for example because their larger home ranges result in higher capture rates (Sollmann, et al., 2013). Especially trail distance, but also other setup parameters of a camera station might additionally bias the capture rates towards certain species, when the stations are not well distributed (→2.8).

Comparing the relative abundance indices allowed the conclusion, that **Humans** were far more common in the study area than any other mammal. Their RAI is 108,48, suggesting that, on average, there was more than one human per camera trap per day recorded.

The second most common mammal in the study area was found to be the **Domestic Dog** with a RAI of 22,25. In other words, approximately every fifth human (20,5%) was

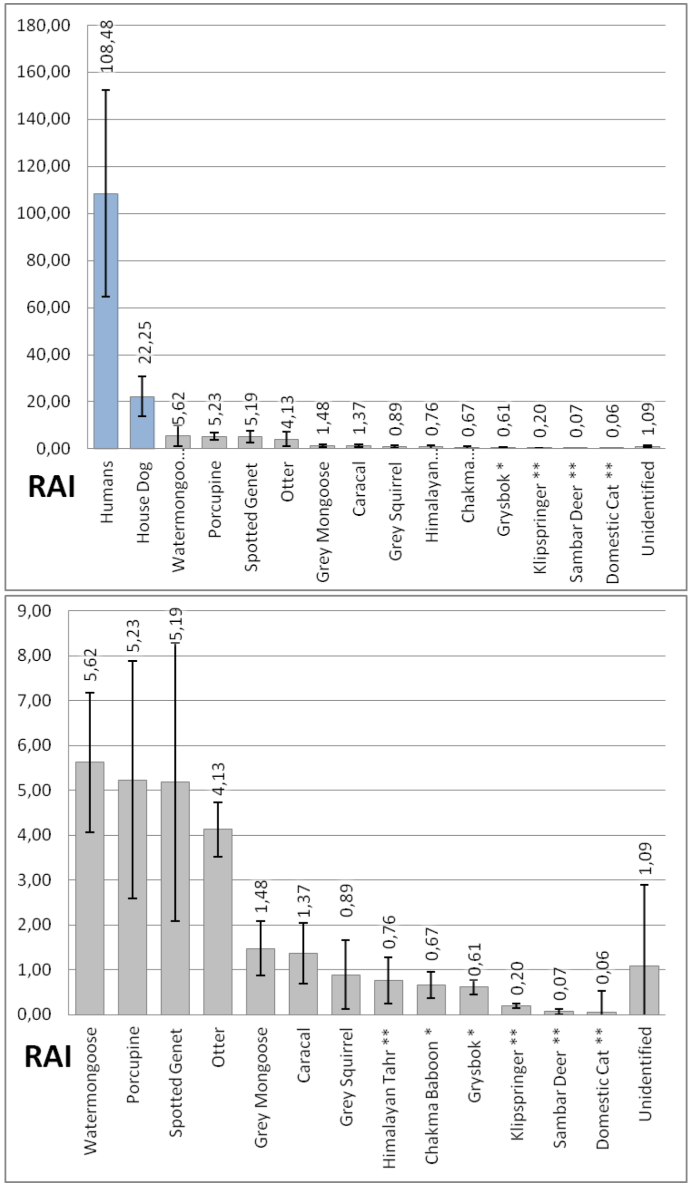


*Figure 12 - Relative Abundance Index (per 100 trap nights) for each analyzed species; error bars show Standard Error (±SE). Top Figure includes Humans and House Dogs (blue), figure below excludes both for easier comparison. (Low data reliability: * = Total event count <12. ** = Total event count <6.)*

accompanied by a dog. This finding is supported by the visitor survey of the national park management, where 18% of human visits were accompanied by a dog (SanParks/Setplan, 2001). None of the RAIs of any wild mammal reaches a higher value than 5,62. This demonstrates the overwhelmingly massive presence of human activity in the near-metropolitan environment.

Amongst wild mammals, quite substantial differences could be found in overall abundance. A group of four species was recorded most often in the study area: **Watermongoose** (RAI=5,62), **Porcupine** (RAI=5,23), **Large Spotted Genet** (RAI=5,19) and **Cape Clawless Otter** (RAI=4,13). These species are part of a similar trophic level and were all recorded in significantly larger numbers than any of the following animals.

Furthermore, significantly lower RAIs (but larger than 1,00) could be found for the **Grey Mongoose** (1,48) and the **Caracal** (1,37). Although the caracal usually travels substantially larger distances per day than any other recorded wild species, the obtained RAI seems to be a relatively realistic estimate. The spacing of camera stations with 2 km distances on a similar altitude level and 1 km distances across the mountain transect, makes the appearance of dependent caracal triggering events on multiple stations relatively unlikely. Additionally, the on- or off-trail diversity of camera stations reduces the risk of a predator home range bias (→2.8.9).

A diverse group of 7 species was found with low average RAI values of less than 1,00. Three of these species are introduced (squirrel, tahr, sambar deer), one is reintroduced (klipspringer), two are native to the study area (baboon and grysbok) and one is domestic (house cat). The least rare of these species was the **Grey Squirrel** (RAI=0,86). The true abundance of the Grey Squirrel might be underestimated by this value because of its arboreal lifestyle, which reduces the capture rate compared to ground-living animals.

The **Himalayan Tahr**'s low RAI of 0,76 (by 4 counts) still might be overestimated, because the specific camera station only ran for 12 days and a pair (male and female) of individuals was recorded twice at the same station. They are likely to be the same individuals (→4.2.11). Hence, their true abundance might only be half the calculated RAI.

Chacma Baboons were found to be spatially very limited to the Tokai pine plantation. While their occurrence throughout the whole 60 km^2 study area is very low (RAI=0,67), their total number in the plantation (habitat size is approximately 8,5 km^2) is currently counted at 218 individuals (Richardson/HWS, 2014), resulting in a strong presence throughout this small area.

The **Grysbok** was found on a relatively high number of traps (17%), but in low numbers (RAI=0,61). Due to its elusive behaviour (frequent hiding in the fynbos thicket and thereby avoidance of larger paths), the RAI might underestimate its true abundance.

The **Klipspringer** was one of the rarest sights in the study area (RAI=0,20). It was only counted four times, of which three animals occurred as a moving group on the peak of Table Mountain.

Two counts of (exclusively male) **Sambar Deers** result in an RAI of 0,07. Two counts of the same **House Cat** (recognized by fur pattern) make it the least abundant animal of the study area displaying an RAI of 0,06.

3.5 Covariate Statistics

The Kruskal-Wallis analysis of variance (by ranks) was chosen for statistical analysis, because it is a non-parametric method, which does not assume a normal distribution of residuals and is capable of comparing two or more independent samples that may have different sample sizes (Hollander & Wolfe, 1973). Therefore, it fits the "Relative Abundance Index" (RAI) values based on the data obtained from camera trap counts (Srbek-Araujo & Chiarello, 2013). To be able to see significant differences between covariate classes, a multiple comparison between standardized camera sets was performed, generating threshold differences for certain p-values (0,05; 0,10; 0,20 and others when necessary). The analysis was performed with "R" using the tool `"kruskalmc {pgirmess} #(between treatments)"` (Siegel & Castellan, 1988).

The camera traps were sorted manually into classes based on threshold values according to the distribution found within the covariate. If the covariate needed to be expressed in more than two classes, the analysis was repeated for each class individually versus the remaining ones. The relative abundance of each species at each camera station was used as input data. Camera stations "E", "R" and "U" were interpreted as <NA> values and therefore were omitted before processing. Factor levels were not reordered. Pairs of groups generate a y-value ("Observed Difference"), which is significant above a threshold difference for the designated p-values.

As Kruskal-Wallis tests analyze variances, the obtained results cannot show the direction of the observed difference. Only when comparing the directional differences of absolute values, the generated p-values can show the likelihood of the observed differences to be true.

(See →4.3 Covariate Profile analysis for the p-values integrated into directional information.)

		Number of Significant Results for a single observed species at:		
Covariate	Classes compared	**P<0,05**	**P<0,10**	**P<0,20**
Trap Type	2	2	3	5
Mountain Range	2	3	4	5
Altitude	6	4	6	11
Steepness of Slope	5	1	3	6
Mountain Aspect	4	2	4	7
Distance to Freshwater	5	5	6	9
Vegetation Type	5	4	7	15
Distance to Settlements	5	1	3	10
Distance to Hiking Trails	5	4	5	8

Table 10 - Overview of Significant Kruskal-Wallis Results

The individual results for all analyzed covariates can be found listed as graphs in →Appendix 9.5.

3.6 Occupancy Model

To calculate the proportion of area occupied (PAO) by a species of interest, the Open-Source Software "PRESENCE" (Version 6.1) was used. The naïve estimate of PAO ($\widehat{\Psi}$) is defined as:

$$\widehat{\Psi} = \frac{\textit{number of sites where a species was detected}}{\textit{total number of sites surveyed}}$$

The true PAO (Ψ), will therefore be underestimated, because a species might be present at a site, but not detected (MacKenzie, et al., 2002). Different models exist to enable an unbiased estimation of Ψ, depending on repetitions and assumptions made (MacKenzie, et al., 2003).

A single-season single-group and constant detection probability model was chosen to generate constant Psi-values (Ψ) for all different species. This model type allows for missing observations, like heterogeneous trap running durations and starting dates, and includes the following assumptions:

1. A species is as likely to be detected at a single site as at any other site. Unmodelled covariate parameters influencing detection probability will result in average Ψ values across the study range.
2. The occupancy state of the sites does not change for the duration of the surveying. Because the surveyed population can be considered closed in the study duration, this assumption is not violated.
3. Detection of a species is not connected to detecting it at another site. Min. spacing of surveyed traps was >500m (Bailey & Adams, 2005).

The data entered had to be transformed into a detection history matrix, which was set up with the resolution of one survey per day as columns and the data from the individual camera stations as rows. Single, as well as multiple detections, in a 24h circle, are registered in the detection history matrix as "1", no detection is registered as "0". The chance of detecting a species during the n-th survey ($p_{n=1}$) at a total number of sites ($i=35$), was calculated as an overall average probability of detecting a species in the first 24 hours after camera setup, given it is present at the site.

To compare the influence of covariates, the maximum likelihood of a chosen model (L) can be ranked and compared by calculating an Akaike Information Criterion $AIC = 2k - 2\ln(L)$ (Akaike, 1974). This maximum likelihood is defined as:

$$L(\Psi, p) = \prod_{i=1}^{i_{\text{total}}} \left(\Psi \cdot \prod_{n=1}^{n_{\text{total}}} (1 - p_n) + (1 - \Psi) \right)$$

(MacKenzie, et al., 2002)

Because the model $\Psi(.)$ constantly showed only very minimal differences in AIC values than other covariate models tested (Distance to Freshwater, Settlements or Trails; Steepness of Slope; Altitude; Mountain Range; Vegetation Environment), the model comparison is not shown here. Differences in covariate dependency therefore were investigated by non-parametrical statistical comparison of relative abundance indices. (→4.3)

Species sorted by $\widehat{\Psi}$ (high to low)	$\widehat{\Psi}$ Naïve Estimate	**Ψ(.) Occupancy** (± Standard Error)	Ψ 95% Confidence Interval	$\hat{p}$(.) Estimate of Detection Probability during First 24 Hours, if Species is Present at site
Human	0,66	**0,67** (±0,08)	0,50-0,81	0,16
Cape Porcupine	0,57	**0,62** (±0,09)	0,43-0,77	0,06
Domestic Dog	0,46	**0,47** (±0,09)	0,31-0,64	0,11
Large Spotted Genet	0,41	**0,47** (±0,10)	0,28-0,67	0,05
Caracal	0,23	**0,27** (±0,09)	0,14-0,46	0,04
Grey Mongoose	0,23	**0,27** (±0,09)	0,14-0,46	0,04
Watermongoose	0,20	**0,20** (±0,07)	0,10-0,37	0,11
Grysbok	0,17	**0,39** (±0,27)	0,06-0,85	0,01
Grey Squirrel	0,14	**0,16** (±0,07)	0,07-0,33	0,06
Cape Clawless Otter	0,06	**0,06** (±0,04)	0,01-0,20	0,36
Chacma Baboon	0,06	**0,08** (±0,07)	0,02-0,33	0,02
Himalayan Tahr	0,03	**0,03** (±0,03)	0,00-0,18	0,12
Klipspringer	0,06	-	0,00-1,00	-
Domestic Cat	0,06	-	0,00-1,00	-
Sambar Deer	0,03	-	0,00-1,00	-

Table 11 - Results for occupancy related variables for single season standard model. Klipspringer ($\widehat{\Psi}$=0,06), Domestic Cat ($\widehat{\Psi}$=0,03) and Sambar Deer ($\widehat{\Psi}$=0,06) produced no interpretable results, generating a confidence interval of 0,00-1,00 at Ψ(.)=1±0.

Each day, **Humans** occupied approximately ⅔ (67%) of the study area and can therefore be considered not only the most abundant mammal, but also the most widespread on a topographical level.

Porcupines showed a fairly close occupancy pattern (62%) and albeit their much lower abundance and density (resulting in a lower initial detection probability) they seem to spread over a large portion of the area available. Their detection probability ($\hat{p}$=0,06), on the other hand, is estimated to be much lower than for humans ($\hat{p}$=0,16) or domestic dogs ($\hat{p}$=0,11).

Domestic Dogs occupied less of an area each day than humans or porcupines (47%). Although dogs are highly abundant, their lower area usage can be explained by the fact, that large parts of the study area are restricted from dog walking and visitors seem to have preferential dog walking spots (→4.2.2). Both of these factors limit the range of domestic dogs.

Genets, although more than 4 times less abundant than dogs, showed an almost equal occupancy pattern (47%), but a lower detection probability estimate ($\hat{p}$=0,05). Of the group of four species showing the highest relative abundance in wild mammals, porcupines and genets occupied the largest proportion of area.

In occupancy analysis, the **Caracal** takes an even stronger position than estimated by relative abundance analysis, occupying 27% of the area. This suggests, that the relative abundance data is not biased towards more easily detectable species with larger home ranges (Sollmann, et al., 2013), but possibly even underestimates the role, this last remaining top level predator plays in the current ecosystem. This is supported by the comparatively low estimated detection probability of $\hat{p}$=0,04.

The **Grey Mongoose** occupies a similar proportion of area (27%) as the caracal and showed a similar estimated detection probability ($\hat{p}$=0,04). The presence of grey mongoose on higher altitudes is possibly substantially stronger (→4.3.2) than in other environments.

For a wild mammal, the **Watermongoose** was seen to be relatively easily detectable ($\hat{p}$=0,11), but fairly local in its overall presence (20%). Compared to its high RAI, the actual distribution seems to be limited, probably due to the necessity of direct availability of freshwater streams (→4.3.5).

The **Grysbok** showed a surprisingly high average occupancy of 39%, which is the most removed value from the naïve estimate of all analyzed species. The lowest detection probability estimate ($\hat{p}$=0,01) is an indicator for the grysbok's elusive nature, but the enormous confidence intervals question the reliability of the calculated result. Still, the obtained values suggest, that the overall presence of the grysbok is possibly underestimated by the low index found during relative abundance analysis.

The **Grey Squirrel** occupies a relatively small portion of the area (16%) and displayed a medium detection probability ($\hat{p}$=0,06) compared to other wild mammals. The small area of presence probably coincides with the availability of forest vegetation (→4.3.4).

The **Otter** is one of the least present mammals in the area (6%), but was found to need the least effort for detection ($\hat{p}$=0,36). Otters were only found on two camera stations overall, but when a camera was positioned in their habitat, they occurred often.

Baboons occupy a very small area (8%) which is the Tokai pine plantation. Over the whole study area, their detection probability therefore had to be very low ($\hat{p}$=0,02).

The lowest occupancy value measured, was found for the **Himalayan Tahr** (3%). Similarly to the otter, the occurrence on a very few traps (in this case only one station) results in a higher detection probability estimate ($\hat{p}$=0,12) than expected.

Klipspringer ($\hat{\Psi}$=0,06), **Domestic Cat** ($\hat{\Psi}$=0,03) and **Sambar Deer** ($\hat{\Psi}$=0,06) produced no interpretable results, generating a confidence interval of 0,00-1,00 at Ψ(.)=1±0. The most likely reason for these results is a lack of multiple recordings by more than just single traps.

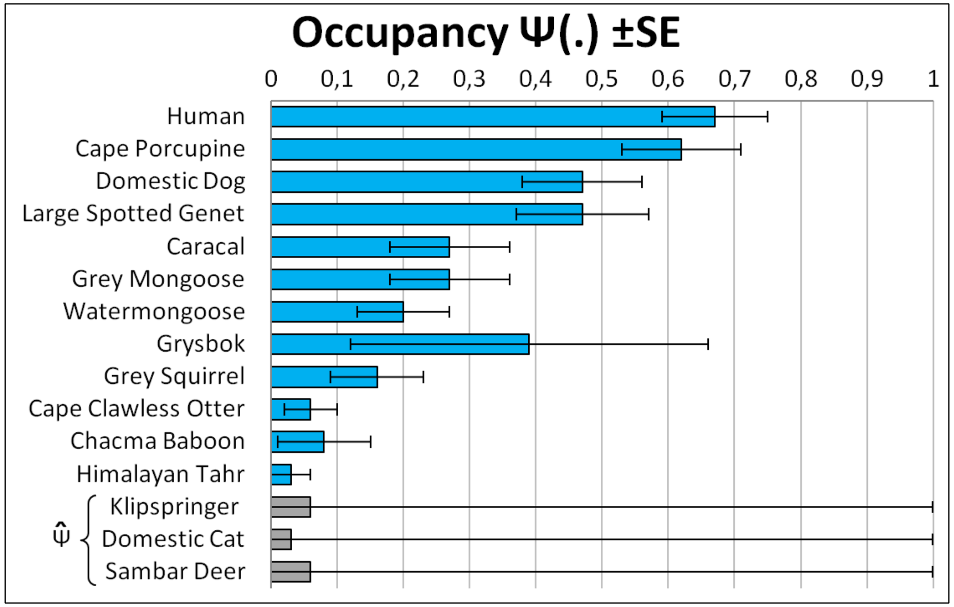


Figure 13 - Bar Plot of Ψ(.) Occupancy, ± Standard Error.
For Klipspringer, Domestic Cat and Sambar Deer, the Naïve Estimate $\hat{\Psi}$ is shown.

4 Analysis

4.1 Activity Patterns

Digital Camera Traps record the exact time of the day when an individual crosses the trapping location. This data allows for a cumulative analysis of the individual species' temporal roaming budget and circadian rhythm. Already in 1954, it was defined in behavioural ecology, that "an animal is active when it moves parts of its body or moves itself" (Aschoff, 1954). There are different approaches that can be implemented to analyse such data, but the most widespread approach is to calculate the species-specific data as a percentage of visits for a certain time interval (usually hourly) in a 24 hour period (Cheyne & Macdonald, 2011).
Furthermore, activity patterns are considered especially useful to compare multiple species captured in a biodiversity assay (Van Schaik & Griffiths, 1996) and can provide, connected with spatial information such as kernel density estimated (KDR) heat maps, a probability overview for the interaction between species in a study area (Ridout & Linkie, 2009).
The statistical likelihood of a species being active during a certain time period, was obtained by Principal Component Analysis (PCA, →4.1.12). The recorded data was distributed along two-dimensional vectors representing the summarized hourly activity categorization used throughout the analysis.

Statistical probability of two species being active at the same time (and therefore having the chance of interaction) was performed by an "Overlap Analysis" (→4.1.13). Multiple iterations and calculation methods were used to generate an average percentage of overlap, which was displayed as a distance matrix to visualize the overlaps between all species providing sufficient data.
Insufficient data for activity analysis was encountered for the tahr, klipspringer, domestic cat and sambar deer. To enhance data fidelity for baboon (→4.1.3) and grysbok (→4.1.10), additional data was integrated from literature sources.

The median setting times for the sun are (based on 22. April 2013):
Sunrise: 07:15. Solar Noon: 12:45. Sunset: 18:15.
Assuming this solar rhythm as constant over the study period, the following categorization was used:

Diurnal:	from	08:00	to	18:00	
Evening:	from	18:00	to	22:00	(Vespertine)
Nocturnal:	from	22:00	to	04:00	
Morning:	from	04:00	to	08:00	(Matutinal)

As this chapter deals with the most obvious behavioural information obtained during the study, anecdotal information on gender-specific or age-specific activity is included hereafter.

4.1.1 Humans

Humans *(Homo sapiens sapiens)* showed a very clear diurnal activity distribution. Almost all activity was observed between 07:00 and 19:00, including two daily maxima: A larger, global one between 08:00 and 13:00 and a smaller, local one between 15:00 and 17:00.

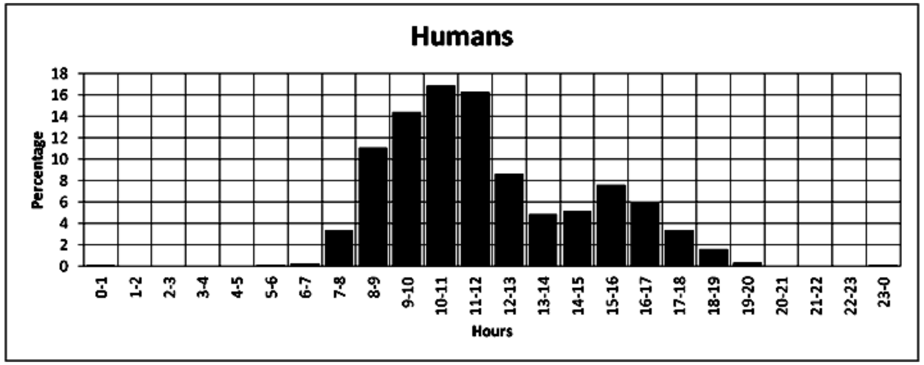


Figure 14 - Human activity pattern bar plot, hourly time of day (x-axis) vs. percentage of captured individuals (y-axis), n=1501.

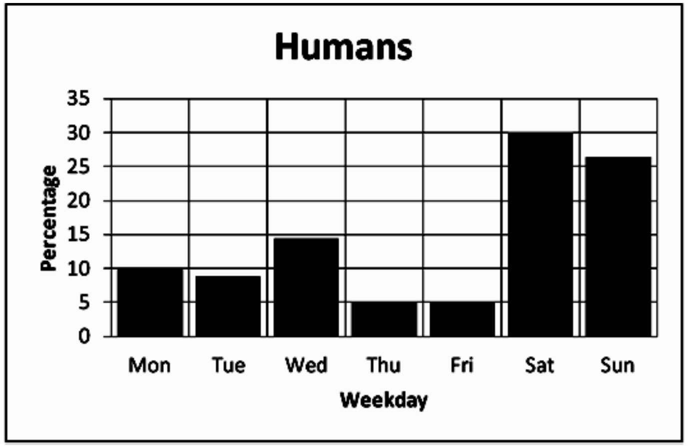


Figure 15 - Weekday bar plot of human activity, weekdays (x-axis) vs. activity percentage (y-axis), n=1501

The human activity - consisting mainly of recreational and touristic hiking or sport activity - has a local minimum between 13:00 and 15:00 explainable by avoidance of intense midday heat and general lunchtime habits. After sunset and before sunrise, no recreational activities were observed, following the anticipations of higher crime risk during night time on table mountain (George, 2010) and the prohibition of night-time national park visits.

Human activity was observed as being strongly influenced by the weekdays. With 56,34%, more than half of human camera triggering events were captured during the weekends (Saturday + Sunday), disclosing the question if diurnally active mammalian terrestrial wildlife is affected by the periodical reoccurrence of stronger human disturbance.

According to the most recent 2011 census of the City of Cape Town (SDI&GIS, 2012), 51% of inhabitants are female and 49% are male. Age was distributed as following: 25% were 14 years or younger, 18% between 15 and 24 years, and 57% were 25 years or older. Furthermore, ethnicity was distributed as 39% "Black African", 42% "Coloured", 16% "White" and 3% others.

No count data was analyzed during this study regarding human demographical parameters, but anecdotally, the following observations were made: Individuals recorded alone are more often male than female. Children were seen very rarely and if recorded, they were almost never unaccompanied by adults. The percentage of "white" visitors was found to be substantially larger than any other ethnicity.

4.1.2 Domestic Dog

Human activity correlates to the activity of domestic dogs *(Canis lupus familiaris)* which substantially differs from the patterns observed in wild or stray dogs. Reliable data on the amount of leash usage is impossible to be extrapolated from this dataset, because often only "leash-free" parts of the animal were captured.

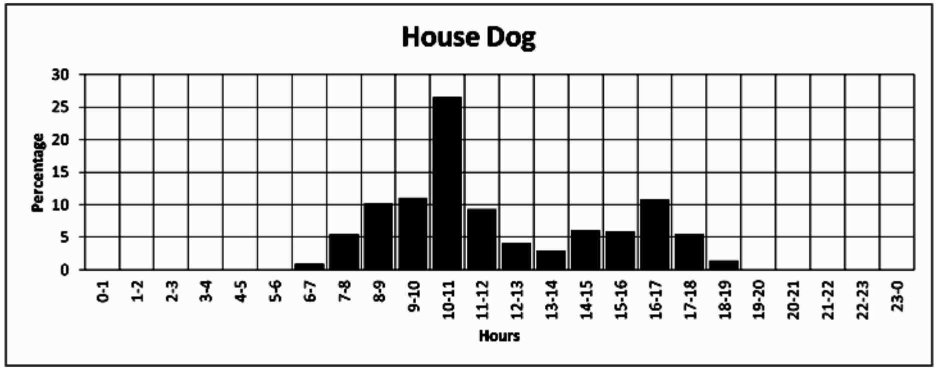


Figure 16 - Domestic dog activity pattern bar plot, hourly time of day (x-axis) vs. percentage of captured individuals (y-axis), n=344.

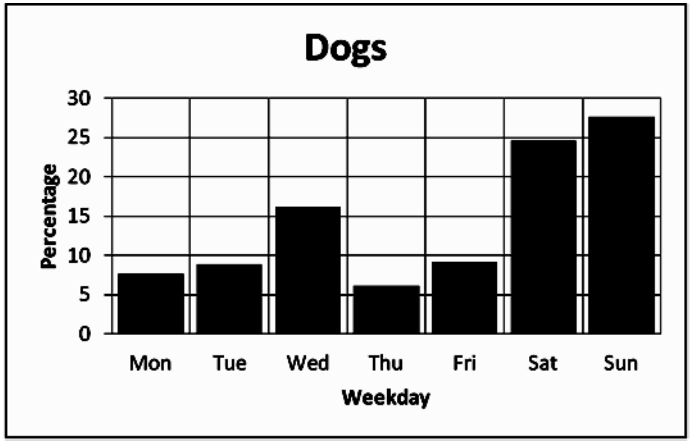


Figure 17 - Weekday bar plot of domestic dog activity, weekdays (x-axis) vs. activity percentage (y-axis), n=344

The domestic dog's diurnal activity ranges exclusively from 06:00 to 19:00, with a global maximum in the morning (08:00 to 12:00) and a lower local maximum in the afternoon (14:00 to 18:00).

Alan M. Beck analysed the activity patterns of near-metropolitan stray dogs and found a crepuscular/nocturnal activity pattern mix, with activity enduring all night and peaking between 03:00 and 06:00 in the morning, similar to the ancestral gray wolf (*Canis lupus*). The fact that no crepuscular or nocturnal activity was observed in the study area, suggests that there is few to none wild or stray dogs. If there are wild or stray dogs at all, they either play a generally diminishing role in the ecosystem or there is relic behaviour from domestication leaving them with the same activity they "used to have" in households. The latter is unlikely, as rearranging the circadian rhythm in stray dogs generally happens quickly (Beck, 1973). Additionally, pack formation would be expected for stray or wild dogs(Creel & Creel, 1995) and could not be observed. Therefore, the number of stray or wild dogs is likely to be very low and probably negligible.

Looking at weekdays, domestic dogs generally follow the human trend of triggering more than half of the events (52,28%) on the weekend days (Saturday and Sunday). This suggests, that probably due to the owner's working hours, dogs are mainly walked on the weekend. Therefore, diurnal terrestrial wild mammals have to be considered disturbed on weekends more drastically not only by humans, but also by domestic dogs.

4.1.3 Chacma Baboon

Papio ursinus is probably the wild mammal on the Cape Peninsula most used to human activity and presence, since their temporal activity distribution coincides with humans.

Baboon activity was documented between the hours of 08:00 and 16:00, with the highest activity between 12:00 and 16:00 in the afternoon. They were always found in troops. Due to the small number of individuals captured, literature data on the Cape Peninsula baboons was reviewed to draw a more accurate picture of activity:

Generally there is a strong effect of seasonality in baboons, shifting their maximum activity from mid-afternoon (15:00-16:00) in summer to late morning (10:00 to 11:00) in winter. An hourly breakdown shows constant activity in the whole troop from 08:00 to 18:00 encompassing feeding, socialising, resting and travelling; the night is usually spent collectively in tree tops resting (Van Doorn, et al., 2010).

The little data that was gathered in this study suggests that, because there were no triggering events in the late morning, the baboons captured on camera traps in May (autumn) are still in their summer activity habit.

No activity of baboons was recorded on weekends, but due to the small dataset, the assumption of human avoidance cannot be made.

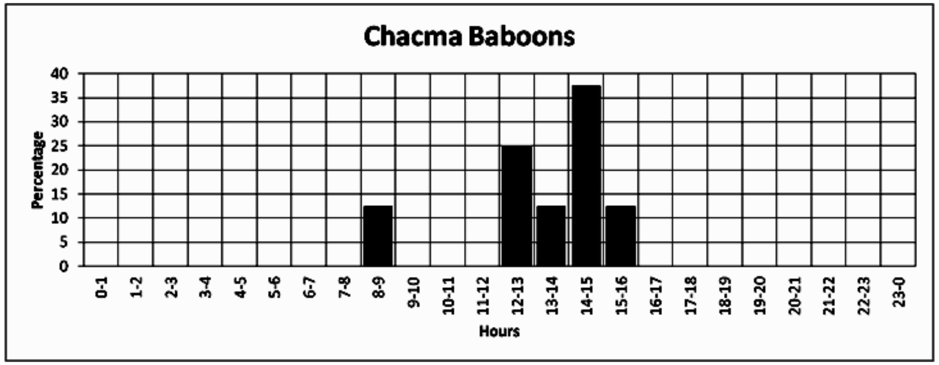


Figure 18 - Chacma Baboon activity pattern bar plot, hourly time of day (x-axis) vs. percentage of captured individuals (y-axis), n=8.

Figure 19 - Camera Evidence:
Diurnal Activity of a Troop of Chacma Baboons.

4.1.4 Grey Squirrel

Sciurus carolinensis is not native to the Cape Peninsula, but was introduced around 1900 by Cecil John Rhodes from North America. They kept their solitary lifestyle in the new environment, as well as their diurnal activity pattern. All recordings were triggered by solitary and adult individuals.

Their recorded activity ranges from 06:00 to 17:00 reaching a maximum in the later morning between 09:00 and 12:00. As an arboreal species, not all activity of squirrels can be recorded with ground-bound camera traps, although they do spend a substantial amount of time foraging on the ground. Possibly, they are even required to travel more distance on ground as they would in North America due to their inability to utilize fynbos as nutrition (Hamerton, 2014).

No weekday related preferences could be found within the dataset.

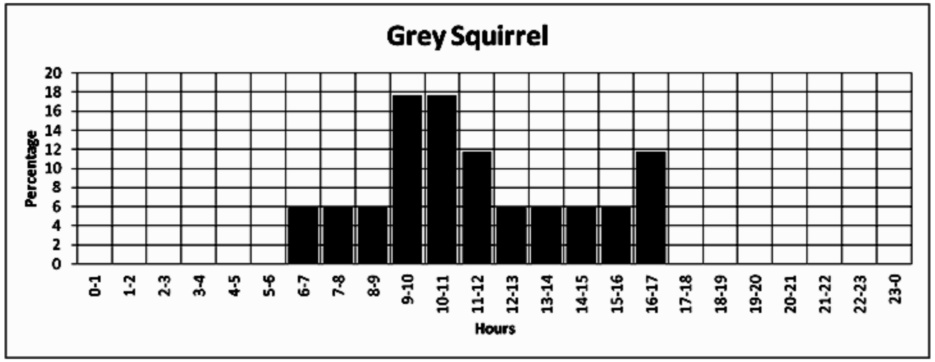


Figure 21 - Grey Squirrel activity pattern bar plot, hourly time of day (x-axis) vs. percentage of captured individuals (y-axis), n=17

4.1.5 Grey Mongoose

*Galerella pulverulenta (*formerly *Herpestes pulverulentus)* is exclusively diurnally active and was mainly captured solitary (90,5%) and rarely in pairs (9,5%).

No obviously juvenile individuals were found. The recorded activity ranges from 08:00 to 17:00, with a maximum around noon.

Literature describes the Cape Grey Mongoose as active from 06:00 to 20:45 in high summer (Cavallini, 1992), which is the breeding season. Juveniles stay in the burrow until April when they have gained around 85% of adult body mass. Throughout the year, 89% were sighted solitarily, 10% in pairs and 1% in groups of three. Groups are more likely to be found at sleeping sites. (Crawford, et al., 1983).

No weekday related preferences could be found within the dataset.

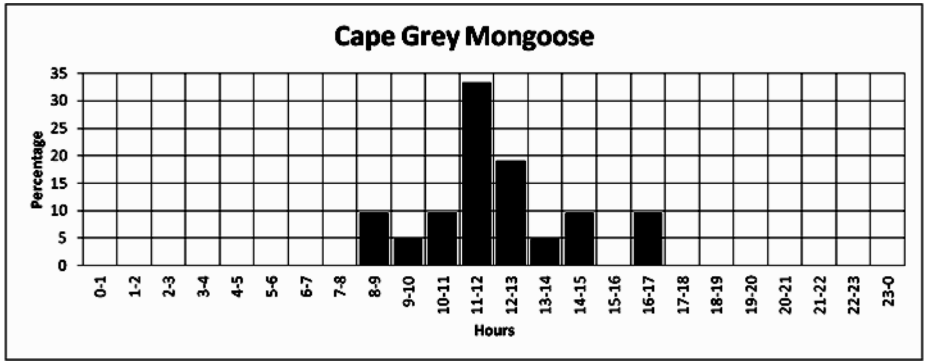


Figure 20 - Cape Grey Mongoose activity pattern bar plot, hourly time of day (x-axis) vs. percentage of captured individuals (y-axis), n=21

4.1.6 Watermongoose

Atilax paludinosus showed a completely different activity pattern than its relative, the Cape Grey Mongoose, with which it shares the subfamily Herpestinae.

Almost all activity (except for parental behaviour) was solitary and took place between 19:00 and 06:00 reaching a maximum between 20:00 and 21:00 and only a single individual record between 08:00 and 09:00. The pattern is neither clearly nocturnal, nor clearly crepuscular: The maximum activity shortly past sunset suggests a vespertine crepuscular activity, but the consistent activity during the whole night, as well as in the early morning hours can be considered more of an nocturnal nature. Indications for mainly solitary behaviour, as well as the mixed crepuscular and nocturnal activity, can also be found in literature. Activity in juveniles is supposed to be entirely crepuscular between 08:30 and 09:00 and between 17:00 and 19:00 and only shifts to nocturnal behaviour in adults (Baker, 1992). Interestingly, during this study, juvenile activity was found to happen between 20:00 and 01:00 (total juvenile individual triggering events: n=5).

As the watermongoose is considered an highly adaptable species, this behavioural change could be an suppressing effect of human evening activity (overlap only 4,6% →4.1.13.2) in the proximity of the watermongoose habitat during the standard juvenile activity hours mentioned by Baker, resulting in an behavioural shift of juvenile activity towards later hours of the night.

A comparatively low overlap of 49,1% with the otter (→4.1.13), considering that they closely share their ecological niche, might also include concurrence and therefore a temporal avoidance of otter activity as a reason for the observed behavioural shift.

No weekday related preference could be found within the dataset.

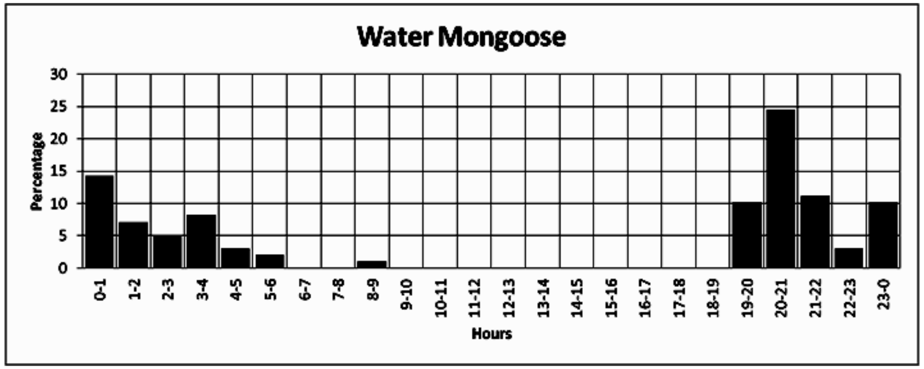


Figure 22 - Watermongoose activity bar pattern plot, hourly time of day (x-axis) vs. percentage of captured individuals (y-axis), n=98

Figure 23 - Accompanied juvenile activity of Atilax paludinosus at 00:13 (left) and 20:27 (right).

4.1.7 Large-Spotted Genet

The coastal species, *Genetta tigrina,* was the only *Genetta spp.* species found, although the presence of the "Common Small-Spotted Genet" *(Genetta genetta)* seemed possible considering habitat and distribution. Literature reports both species to have very similar activity patterns (Larivière & Calzada, 2001). Genets were always recorded solitary and of approximately adult size. Their activity can be considered crepuscular, with a vespertine maximum after sunset from 20:00 to 22:00 and a matutinal maximum before sunrise between 05:00 and 06:00. Genets were more likely to be recorded between Tuesday and Thursday (60% cumul.) than between Saturday and Monday (25% cumul.), suggesting a strong avoidance of human interaction. Additionally, no diurnally active Genet was recorded on the weekends, but the sample size of day-time recordings (n=10) is too small, to conclude this effect. Uniquely the Genet spends, although it is primarily active during the darker hours (82,8%), a substantial part of its activity in daylight (17,2%). Literature notes, that adult male Genets are more likely to be strictly nocturnal than younger female ones, stating that nocturnality is gender dependent and becomes predominant as the animal matures. Young females are listed as diurnally active between 19% and 28% (Palomares & Delibes, 1994). From the images obtained, it was impossible to completely determine age or gender of the Genets recorded during daytime. Subjectively, Genets appeared smaller and with shorter tails on the daytime images than on night time images, but as the sexual dimorphism in Genets is comparatively minor (Rodrigues-Refojos, et al., 2011), this anecdotal observation remains speculative.

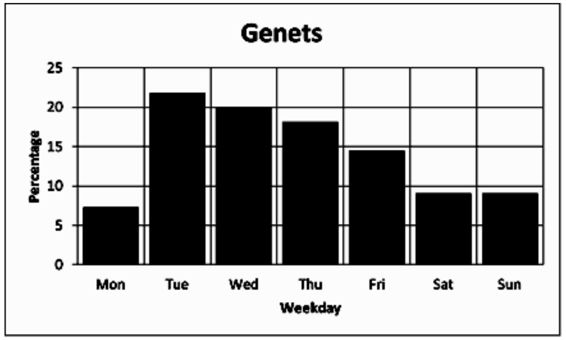


Figure 24 - Weekday bar plot of Genet activity, weekdays (x-axis) vs. presence percentage (y-axis), n=55

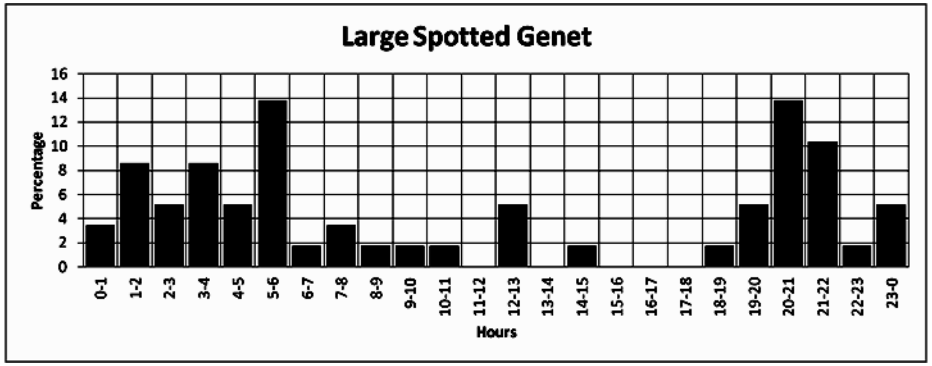


Figure 26 - Large Spotted Genet activity bar pattern plot, hourly time of day (x-axis) vs. percentage of captured individuals (y-axis), n=58

Figure 25 - Size comparison of exemplary nocturnally active Genetta tigrina (left) at 23:18 and diurnally active Genetta tigrina (right) at 10:56. Note the height of the body at the hind legs in relation to the surrounding vegetation and the ear to body length ratio, which is smaller in the diurnally active individual, suggesting that it is younger and/or female.

4.1.8 Otter

Aonyx capensis shows primarily nocturnal activity with an crepuscular matutinal maximum and occasional diurnal activity.

Otters were frequently found active in social groups of two or three. About 67% were found solitary, 13% in pairs and 20% in a group of three. Literature reports, that 69,4% of sightings were solitary otters, 21% were of two otters and 10,5% were of a group of three (Somers, 2000). Coastal populations - like those in the study area - were found being even more solitary: Sightings were reported as 78% single, 12% pair, 9% group of three, 1% group of four. Furthermore, they show a more distinct crepuscular behaviour (Larivière, 2001). Specifically in the Western Cape Province though, Otters are documented to show predominantly nocturnal habits, most sightings involving pairs or small family groups with occasional daylight sightings in specific areas (Stuart, 1981). Although the Otters share their ecological niche specifically with the Watermongoose regarding their diet (Somers & Purves, 1996) and semi-aquatic lifestyle, there seems to be a temporal avoidance in activity: While the Otter's crepuscular maximum is matutinal between 04:00 and 07:00, the watermongoose's crepuscular maximum is vespertine between 19:00 and 01:00.

Hints for a possible avoidance of the weekend can be seen in the dataset.

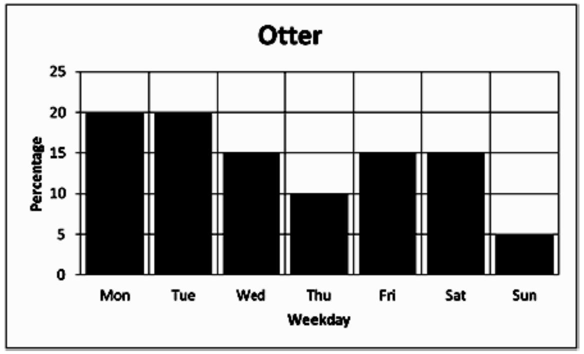


Figure 28 - Weekday bar plot of Otter activity, weekdays (x-axis) vs. presence percentage (y-axis), n=20

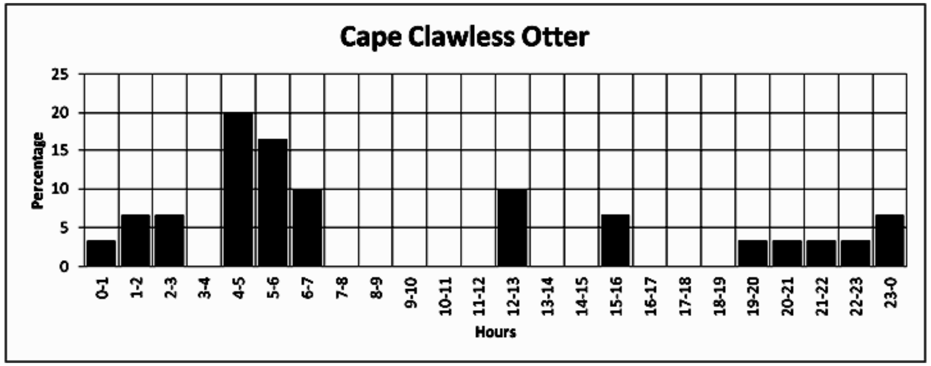


Figure 27 - Cape Clawless Otter activity bar pattern plot, hourly time of day (x-axis) vs. percentage of captured individuals (y-axis), n=30

4.1.9 Porcupine

Hystrix africaeaustralis showed an exclusively nocturnal activity. Being recorded mostly solitary, groups of two or three also occurred. Juveniles were never recorded solitarily. The global activity maximum was between 20:00 and 00:00 and a smaller local maximum between 02:00 and 05:00. Strictly crepuscular activity was rarely recorded.

In 82% of sightings, single porcupines were recorded individually, 15% were recorded in pairs and 3% in groups of three. They are described foraging mostly as single individuals, but living in a den or burrow as family groups based upon monogamous adult pairs (Corbet, 1996). Corbet also suggests, that the occurrence of family groups is largely dependent on the opportunities available for mature offspring to disperse from their natal group. Litter size is recorded to be mostly one, but up to four. They remain in the burrow for the first nine weeks and reach adult size within 20 weeks. Offspring can remain with the family group for extended periods and females that remain with the family group will not reproduce until they disperse into a new area (Van Aarde, 1987). Although this behaviour is mentioned in literature, bigger family groups than two (an adult pair of individuals likely to be mates) or three (an adult animal with two juveniles) could not be found in the study area. Possibly the absence of very large natural predators (like leopard, hyeana or lion) decreases pressure on the porcupine population and therefore allows a quick dispersal of mature offspring.

No preference for specific weekdays could be found in the dataset.

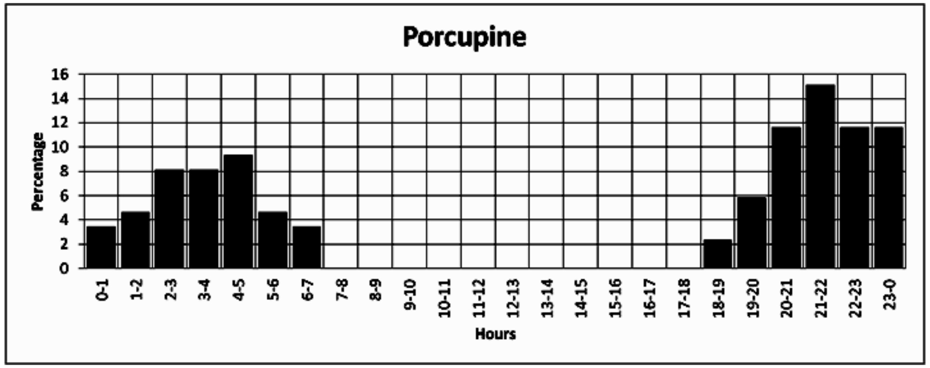


Figure 29 - Porcupine activity bar pattern plot, hourly time of day (x-axis) vs. percentage of captured individuals (y-axis), n=86

Figure 30 - Adult porcupine in company of two juveniles. Estimating the juvenile's body sizes, they are considered to be just several weeks old, possibly recently reaching the age of nine weeks to leave the burrow. Juveniles like these still have softer quills, which makes them less protected.

4.1.10 Grysbok

Raphicerus melanotis was sighted exclusively as single individuals, mostly from 05:00 to 07:00 and from 19:00 to 21:00.

83% of activity was found during the night.

Described as being primarily nocturnal in summer and crepuscular in winter, the activity pattern of the grysbok showed a relatively crepuscular behaviour in the dataset. Due to the small sample size, a figure from previous telemetry work in the Fynbos biome (which is the mandatory habitat) in Western Cape was included (Novellie, et al., 1984). They found an average activity of 70% during the night and 74% inactivity during the day, whereas 22% of females were active during the day and 29% of males. Those observed animals spent exactly 50% of the day active and 50% inactive.

Although the sample size of n=6 does not allow for an analysis as precise as the data of Novellie et al., the peak activity of the grysbok in both studies coincides with a maximum in the evening (19:00 to 21:00), activity during the middle of the night, a second maximum in the early morning around 05:00 and occasional diurnal activity. Overall, a picture of the Grysbok's mainly, but not strictly crepuscular activity can be drawn. No information on weekday preference can be concluded from the dataset.

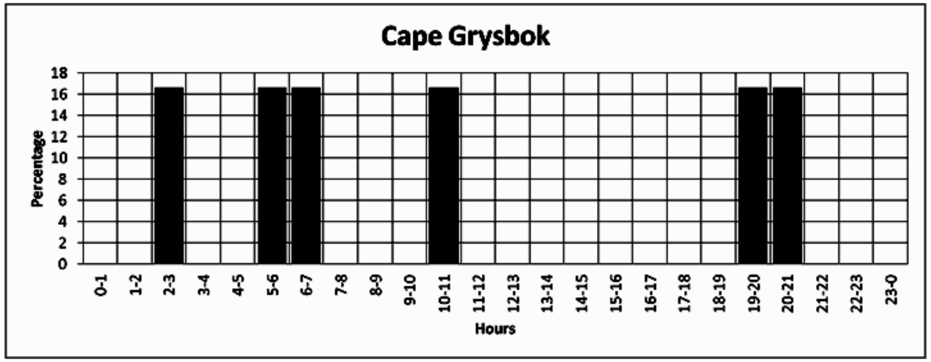


Figure 31 - Cape Grysbok activity pattern bar plot, hourly time of day (x-axis) vs. percentage of captured individuals (y-axis), n=6

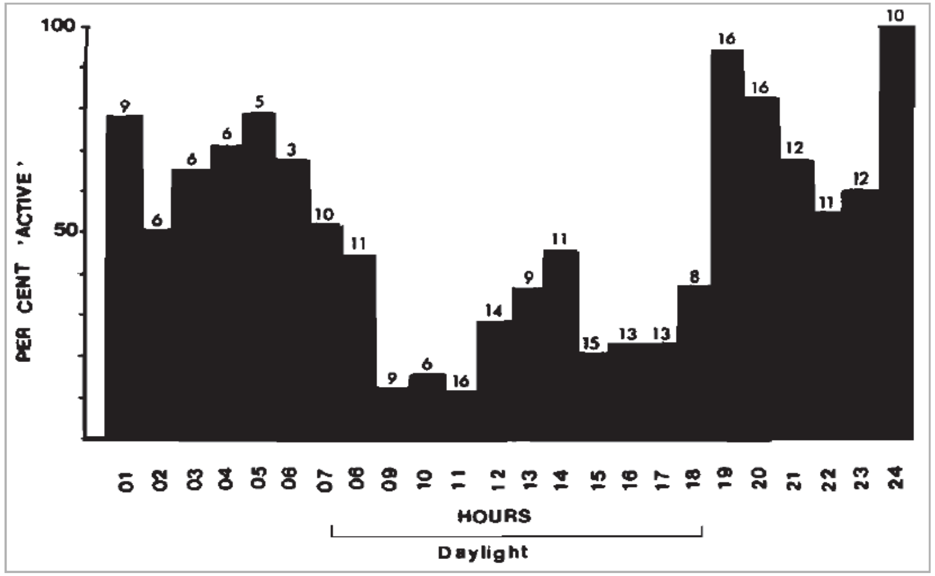


Figure 32 - Daily variation in the percentage of radio telemetric signals recorded as "active" for three Cape Grysbok observed in the Jonkershoek Valley (40 km to Cape Town) between 17 June and 15 August 1973. The sample sizes (number of signals) are shown above each bar of the histogram. A transmitter signal from a moving animals could be distinguished from one from a stationary animal. The graph is shown to increase the understanding of the Grysbok's activity.(Novellie, et al., 1984)

4.1.11 Caracal

Special attention comes to the activity pattern of *Caracal caracal* as the largest carnivore and predator remaining on the Cape Peninsula, showing possible predator-prey relationships.

All caracals were recorded solitary and never in pairs, which is listed as entirely possible in literature (Stuart, 1981). Sightings were observed as exclusively nocturnal from 19:00 to 08:00, with a maximum in the early morning hours between 04:00 and 06:00. This finding greatly differs from activity patterns found in Caracal populations that are unrelated to metropolitan areas. In Turkish pine forests, maximum activity was observed around 08:00 and from 14:00 to 22:00, showing strong afternoon activity (İlemin & Gürkan, 2010).

In the Western Cape the caracal is considered more predominantly nocturnal, being able to adjust its activity to the prey behaviour. Still, several sightings throughout the Cape list the caracal as being also active diurnally in the morning and late afternoon, often just sunbathing around the den, but also hunting (Stuart, 1981). Anthropogenic avoidance effects are likely to explain the lack of diurnal Caracal sightings on the Peninsula. This avoidance is not only dependent on a direct link between the human's and the caracal's activity, but might even be a result of the severe decrease in diurnally active prey such as the rock hyrax. Additionally, touristic and recreational human activity (including dog walking) lowers the chance of an effective hunt for the caracal on potential prey species that do occur diurnally in the study area such as Grey Mongoose, Baboon, or partially Genet and Grysbok. (For potential prey species see →4.1.13 Temporal Overlap Analysis)

The often violent reactions of settlers and farmers towards caracals can also be considered a possible historical long-term adaptation of the diurnal avoidance shift in the local caracal activity.

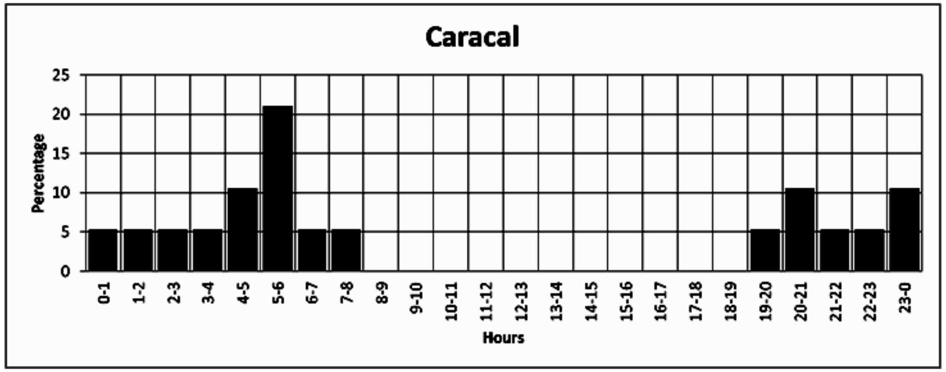


Figure 34 - Caracal activity pattern bar plot, hourly time of day (x-axis) vs. percentage of captured individuals (y-axis), n=19

Figure 33 - Solitary, nocturnally active Caracal caracal in Disa Gorge.

4.1.12 Principal Component Analysis

PCA was conducted using R: "`princomp({},cor=T)`". As input data, average relative abundance indices (RAI) were distributed over the same classes as for previously stated:

Diurnal:	from	08:00	to	18:00	
Evening:	from	18:00	to	22:00	(Vespertine)
Nocturnal:	from	22:00	to	04:00	
Morning:	from	04:00	to	08:00	(Matutinal)

Using arithmetic mean RAIs ensures comparable values for analysis in widespread datasets. Additionally, input datasets were scaled around zero to unify large variances.

On the biplot graph, crepuscular and nocturnal activity patterns were seen more transitional. They show closer vectors to each other and the species, described by their direction, are spread widely over this transition. The diurnal vector is very strictly opposed and was plotted in close proximity to all strictly diurnal species.

PC1 could be correlated with sunlight and the thereby induced daytime temperature as the environmental key element of dividing diurnal activity from crepuscular and nocturnal activity. PC2 was connected with fog condensation being the strongest in the morning, occurring through day and night likewise and being the weakest in the evening.

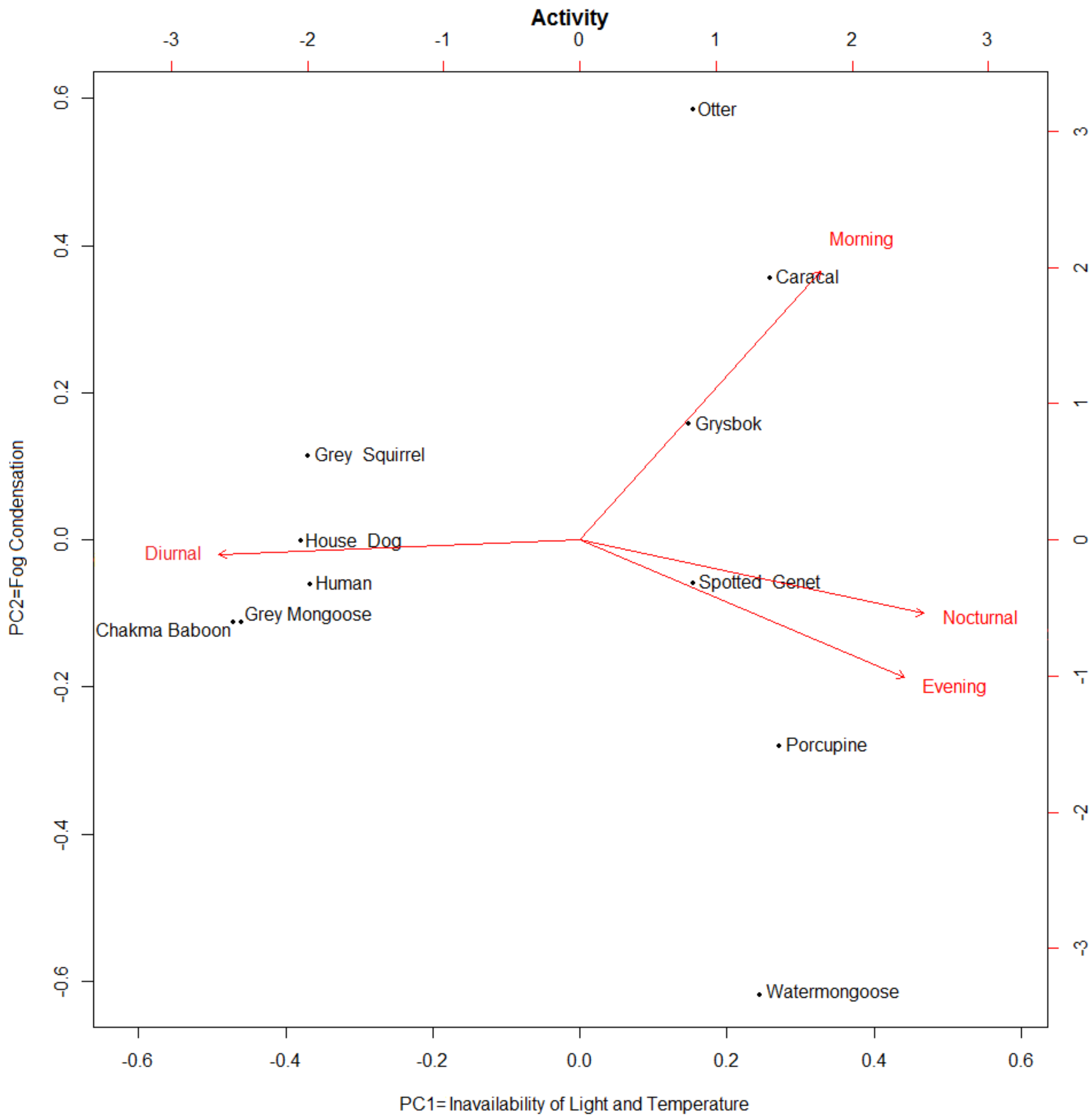


Figure 35 - PCA Biplot. Graph: Positioning of Species Data Points and Activity Pattern Vectors. PC1 explains 76,96% of variance, PC2 explains 19,15% (96,11% cumulative) of variance. Standard Deviation of PC1 = 1,755. Standard Deviation of PC2 = 0,875.

4.1.13 Activity Overlap Analysis

Overlapping temporal patterns is a common method in the analysis of resource competition or predator-prey relationships, to discover potential interaction possibilities between multiple species (Linkie & Ridout, 2011).

The "Coefficient of Overlapping", commonly referred to as Δ (Delta) in literature ranges from 0 to 1 (0%="no common activity" to 100%="complete overlap"). The proportion of activity differing between two species at any time of the day is referred to as being less than 1-Δ (Ridout & Linkie, 2009). The input data (species specific picture's time stamps) is statistically considered "circular". Δ is obtained by two distinct methods: "Kernel Density Estimation" or by "fitting a flexible parametric family of circular distributions, called trigonometric sum distributions" (Fernandez-Duran, 2004). The analysis was run using the R-Package "`overlap`" using the estimator ($\hat{\Delta}$) iterations $\hat{\Delta}1$; $\hat{\Delta}4$ and $\hat{\Delta}5$ (selected, because $\hat{\Delta}2$ is equivalent to $\hat{\Delta}1$; and $\hat{\Delta}3$ produces NA-values with circular data) (Ridout, 2011). An arithmetic mean was calculated over all $\hat{\Delta}$-iterations generated by both methods resulting in a distance matrix showing the overlap between all species where sufficient data could produce meaningful results. Datasets from literature were used to enhance data fidelity for the Chacma Baboon (Cape Peninsula) (Van Doorn, et al., 2010) and the Cape Grysbok (Jonkershoek Valley, 40 km to Cape Town) (Novellie, et al., 1984).

Visualization Legend: Colour Ramp

100	90	80	70	60	50	40	30	20	10	0

	Humans	House Dog	Porcupine	Spotted Genet	Watermongoose	Grey Mongoose	Grey Squirrel	Chakma Baboon	Grysbok	Caracal	Otter
Humans		0,881	0,046	0,191	0,046	0,776	0,891	0,615	0,275	0,109	0,213
House Dog	88		0,054	0,197	0,046	0,661	0,851	0,582	0,287	0,119	0,224
Porcupine	5	5		0,795	0,821	0,020	0,070	0,031	0,714	0,768	0,595
Spotted Genet	19	20	80		0,689	0,150	0,229	0,181	0,845	0,842	0,769
Watermongoose	5	5	82	69		0,024	0,049	0,030	0,634	0,675	0,491
Grey Mongoose	78	66	2	15	2		0,784	0,648	0,220	0,060	0,194
Grey Squirrel	89	85	7	23	5	78		0,651	0,299	0,163	0,267
Chakma Baboon	62	58	3	18	3	65	65		0,250	0,107	0,222
Grysbok	28	29	71	85	63	22	30	25		0,753	0,711
Caracal	11	12	77	84	68	6	16	11	75		0,764
Otter	21	22	60	77	49	19	27	22	71	76	

Figure 36 - Activity Distance Matrix of Mean Delta ($\bar{\Delta}$ and $\bar{\Delta}$ in %) for Overlapped Species. The two halves of the table differ in the number of digits shown and the usage of a colour ramp for an easier overview of the information displayed. The upper halve contains the direct $\bar{\Delta}$ values, the lower halve contains colour ramped $\bar{\Delta}$ percentages.

4.1.13.1 Caracal-Prey Relationship

The **Caracal** has to be considered the only species in the study area which is likely to prey on other studied species, as it is the only member of *Carnivora* growing to a reasonable body size. It is reported to prey upon a variety of species, dominated by mammals. The most common prey are rodents (>70%), but the following species found in this study were also documented by scat analysis from the Southern Cape: Cape Grysbok, Domestic Cat, Grey Mongoose, Large Spotted Genet and Baboons (Braczkowski, et al., 2012). The highest relative occurrence frequency (mean=63,0%) in the caracal's diet was attributed to the Vlei rat (*Otomys irroratusm*) which did occur on the camera traps in this study, but was considered to small in body size to be studied analytically. Also the Striped mouse (*Rhabdomys pumilio*) (attributed with a mean relative occurrence frequency of 3,8% by Braczowski) occurred during this study but was considered too small for further analysis (see →3.3.1). House cats (*Felis catus*) are known to be part of the caracal's diet and appeared on camera traps, but their number was too small to conclude an activity pattern for overlap.

Considering the activity overlap, the following species are possible local prey to the Caracal (sorted from highest to lowest probability):

The Large Spotted **Genet** ($\bar{\Delta}$=84,2%) shares the most activity with the caracal of all studied species. Its body size, connected with the temporal overlap makes it a likely prey species. The relative scat occurrence frequency found in the Southern Cape Study was 1,8%.

The second most strong overlap was found with the **Porcupine** ($\bar{\Delta}$=76,8%). Although being a rodent, its vicious character, when provoked, and the unique defence-adapted body shape (quills) make them an unlikely target. The few reports of successful predation on porcupines by lions and leopards include turning them upside down for the kill. This strategy seems possible for the caracal as well, at least for juvenile porcupines. Occasional reports exist of even larger *Felidae spp.* being seriously/fatally wounded while attempting to kill a porcupine, prove the porcupine to be a less likely potential prey species(Mori, et al., 2013). No scat analysis undertaken in South Africa found porcupine remains in caracal droppings (Melville, et al., 2004).

An overlap of $\bar{\Delta}$=76,4% was found with the **Otter**. The aquatic lifestyle and spatial avoidance (see →4.3 Covariate Profiling), as well as the potentially life-threatening harm a defending otter can cause to a caracal, make it an highly unlikely prey species.

A very large overlap was found with the **Grysbok** ($\bar{\Delta}$=75,3%). The Caracal is often reported, to be able prey on species larger in body mass than itself and even stores its prey in trees as seen in leopards. The Grysbok was found being preyed upon by the caracal with an relative scat occurrence frequency of 1,8% in the Southern Cape. Throughout the study area it might serve -relatively seen- as a more important source of prey, because other ungulate species seem to be extremely rare.

An overlap of $\bar{\Delta}$=67,5% was found with the **Watermongoose**. Similarly to the Otter, its aquatic lifestyle as well as (for a viverid) large body size make it an unlikely prey species. The low spatial interaction profile reduces the probability of a predator-prey relationship. As other species

of the family Viverridae (such as Genet, Yellow Mongoose and Grey Mongoose) are found to be relatively likely prey species, at least occasional opportunistic attempts by the caracal to prey on a (possibly weak or juvenile) watermongoose can still be considered possible.
Only little overlap was found with the **Chacma Baboon** ($\bar{\Delta}$=10,7%). Caracals were found to enter at least the outer areas of the Tokai pine plantation regularly, thereby creating a spatial overlap. As baboons were found to be part of the caracal's diet in the Southern Cape (1% relative scat occurrence frequency), thereby an occasional preying could be possible throughout the Tokai plantation on the one hand. On the other hand, the shift in the caracal's behaviour to less daytime activity in the study range limits the interaction possibility.
The comparatively minute overlap with the **Grey Mongoose** ($\bar{\Delta}$=6,0%) is a result of the exclusively diurnal activity. Although it was found to be preyed upon by the caracal in the Southern Cape (Relative Scat Occurrence Frequency up to 12,5%), the activity shift in the caracal makes an predation interaction less likely.
No overlap could be calculated for the **Klipspringer**, but two deaths of collared animals are recorded, after the reintroduction of the klipspringer to the Table Mountain section. The caracal is suspected to be the most likely cause for those mortalities (Zimmermann, 2006).

4.1.13.2 Human Activity Interaction

Humans and **House Dogs** showed one of the highest activity overlaps of the study (88,1%). This supports the assumption that the vast majority of house dogs in the study area are domestic pets walked rather than stray dogs or wild dogs (→4.1.2).
Other high overlaps with human activity were found for **Grey Mongoose** (77,6%), **Grey Squirrel** (89,1%) and **Chacma Baboon** (62%). Especially the baboon (MLA, 2009), but also the other two species (Mills & Hes, 1997)(Palmer, et al., 2007), are known for a strong habituation towards human activity.
Low overlaps were found for **Grysbok** (27,5%), **Otter** (21,3%) and **Genet** (19,1%). These species are known for partially diurnal activity. The Grysbok was found in other regions of the Western Cape to spend 50% of its activity diurnally. The lower recorded overlap with human activity might be a result of an avoidance behaviour, but due to the small dataset this finding cannot be concluded. The avoidance strategy of Otter and Genet might rather be of a spatial nature (→4.3).
Very low overlap was found for the **Caracal** (10,9%). As it is reported to be more diurnally active in less metropolitan settings, this finding might indicate a behavioural adaptation to avoid human contact. Possibly, human disturbance also lowers the Caracal's hunting success (→4.1.11).
The lowest activity overlaps were found with **Porcupine** (4,6%) and **Watermongoose** (4,6%). Both show consistent nocturnal activity unrelated to human disturbance.

4.2 Density Distribution

Kernel Density Estimation is a non-parametrical statistical method to plot a population-specific probability density function, based on a finite data sample. In the case of this study the plotted variable is the occurrence of a species per 100 trap nights at the specific trapping locations. The "Kernel Density Tool" of the "ESRI ArcGIS 10 Spatial Analyst" extension was used, to calculate a raster surface ("Heat Map") estimating the population densities in proximity to the trapping locations. The grid cell containing the highest surface value is typically the cell of the trapping location, displaying the maximum likelihood of species occurrence. With increasing distance to the proven occurrence the surface value decreases, reaching zero at the "Search Radius Distance" (SRD) from the trapping location (ESRI, 1995-2012). To obtain a SRD, the estimated maximum individual day range of a certain species was used, reaching per definition 1 animal per 100 trap nights (RAI) at the display threshold. If a neighbouring trapping location shows a similar value of occurrence, the surface values between and in close proximity to both trapping locations will be connected by higher surface density values resulting in a larger likelihood of potential species density. The mathematical kernel function is a quadratic kernel function described by Silverman (Silverman, 1986).

The scale legend of the grid cell colour starts with bright yellow at an RAI=1 and ramps over orange, red, magenta, violet and blue at RAI_{MAX}. Each of the colours resembles ⅙ (16,67%) quantile of the occurrence likelihood. Therefore, the red-magenta border shows the geographical distinction of the 50% quantiles.

No 3D-Parameters like the altitude profile and fences are included in the model, as the grid function is not based on topographical information, but only on the camera rates and the 2D-Coordinates of the trapping stations. The density surface was calculated, but not displayed beyond the coast line, as the studied mammals are not expected to swim substantially far out into the ocean. Physical barriers (cliffs, fences, main roads) might intersect a real population on the actual mapped terrain, which would be considered connected by the kernel function in an ideal open flatland setting.

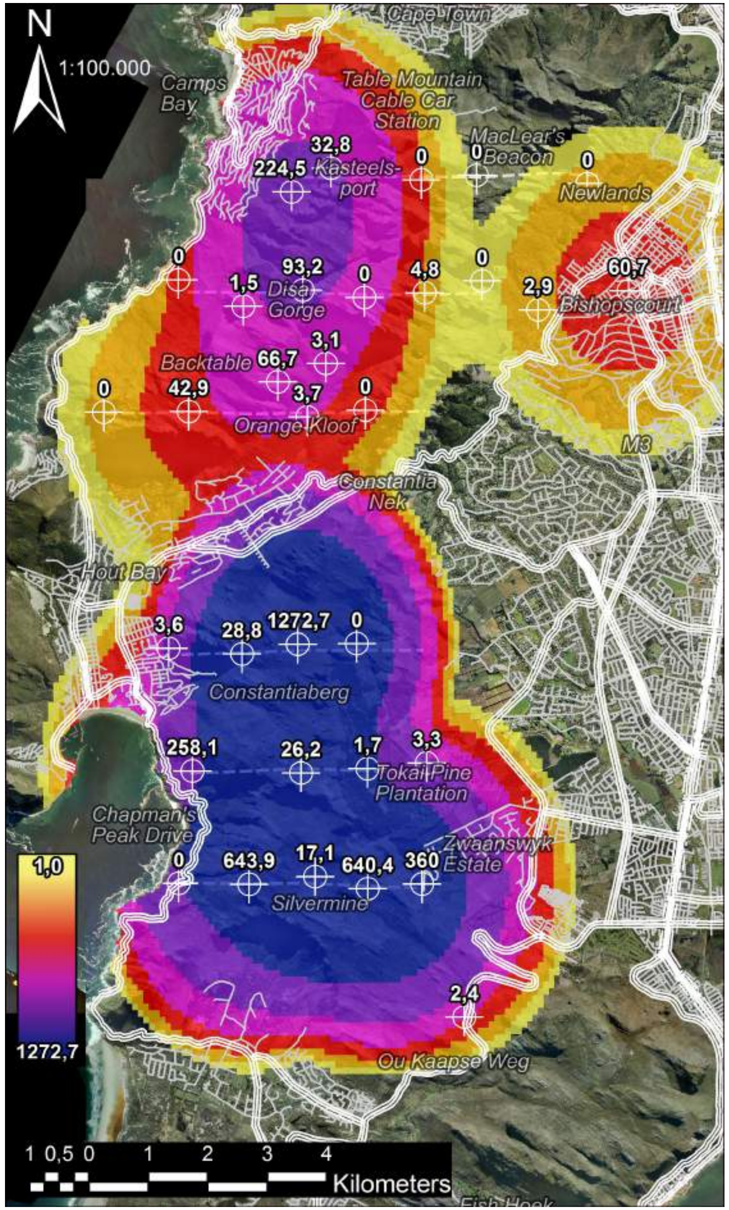
The density maps can only provide information for the sampled area and no information can be withdrawn for areas in further distance to the sampling stations than the estimated day range. A recording of "0" at a camera location, as well as the border of the search radius distance, do not directly imply the absence of a certain species. Sometimes stations recording no events, are still shown within an plotted area of higher density likelihood. In these cases, a strongly visited neighbouring station makes the complete absence of the species at the station showing "0" less likely. Therefore, the neighbouring station's probability function "overpowers" the one of the unvisited station.

4.2.1 Humans

To obtain an estimate for human day range, the following assumptions were made: From data surveyed by TMNP, the average time spent on Table Mountain by cable car visitors is approximately two hours (Cable Car Management, 2013). Using a low hiking speed estimate of 3 $^{km}/_{h}$, an average hike would result in a distance of 6km daily. Because of the steep topography and the fact, that humans often use round routes or return otherwise to their starting point, this value was halved, forming a (rather underestimated) maximum plotted search radius distance of 3 km for the heat map plot.

Although rather underestimated, the density plot suggests, that no patches in the study area are totally independent from hikers. The highest RAIs (up to 1272,7), as well as the complete highest ⅙-quantile, were found on the higher mountain surface of Constantiaberg/Silvermine-Tokai. A second hotspot on Table Mountain ranged from Camps Bay (224,5) over Kasteelspoort (32,8) below the cliffs of the cable car station, up to Disa Gorge (93,2) including the "Backtable" (42,9) and the ring road of Orange Kloof (66,7). Measured densities of humans on Table Mountain were expected to be lower than on Constantiaberg, because less exposed trapping locations had to be selected to prevent discovery.

Without doubt, the stations "C" (Cable Car) and "D" (Maclear's Beacon) were in absolute closest proximity to the cable car mass tourism with its 3000 visitors per day. The RAI values of "0" for both stations result from the decision to put the traps up at locations, which were inaccessible to humans. The camera trap positioned in the popular Newlands forest had to be similarly hidden.

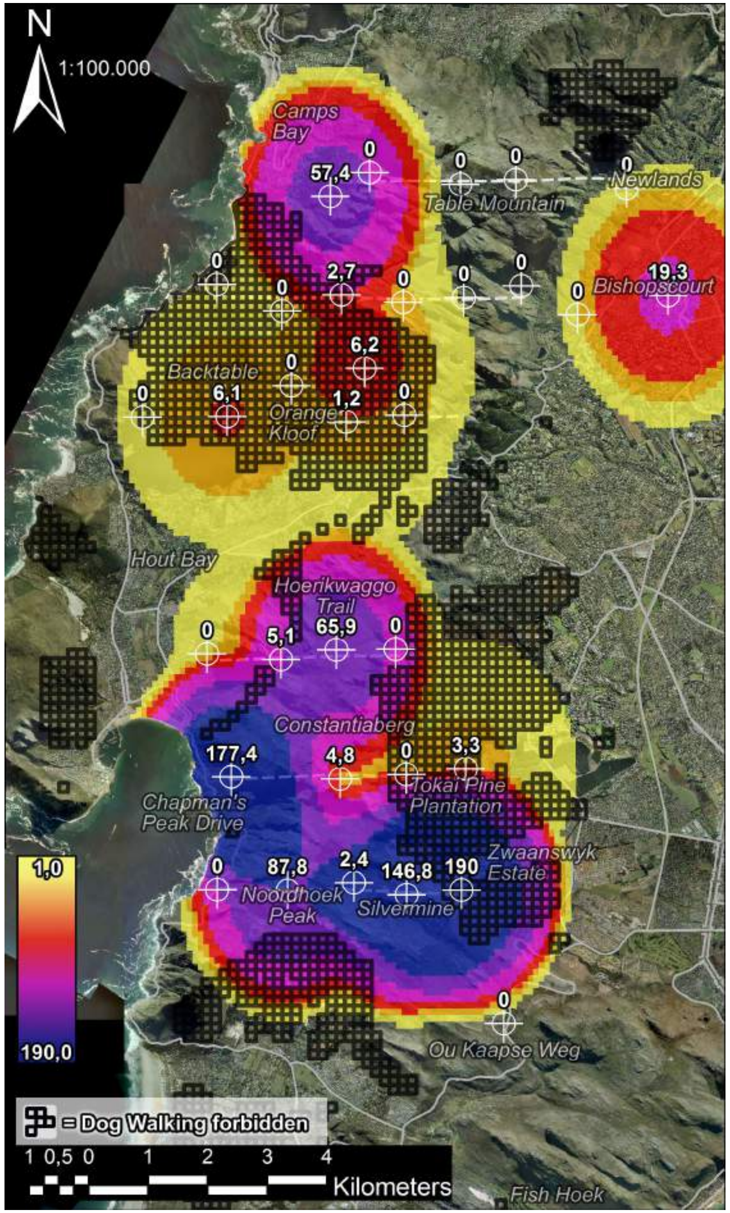


Map 9 - Kernel Density Heat Map Plot for "Humans". Label units are individual relative abundance indices (RAI) in visits per 100 days. Max. Plotted Radius Distance is 3 km at a threshold of RAI=1/100d.

4.2.2 House Dogs

Because "humans walking their dog" (very short distances) and "humans walking with their dog" (rather extensive hikes) could not be differentiated by the study, arriving at a meaningful average day range was rather difficult. British literature reports, that 91,5% of dog walks last less than two hours and 34,5% of dog walks last less than one hour (Forestry Commission New Forest, 2005). Hiking speed accompanied by dogs is slightly higher and return to the point of departure can be assumed. With a radius distance of 2 km, a conservative estimate was used.

The highest ⅙-quantile of dog walking, as well as the highest absolute values were found in a "crescent-shaped" area around the peak of Constantiaberg, starting from the paved road intersecting Hoerikwaggo Trail (65,9), continuing down to the northern toll booth of Chapman's Peak Drive (177,4), over Noordhoek Peak (87,8), the Silvermine Reservoir parking lot (146,8) and down to the southern end of Tokai plantation (190) at Zwaanswyk Estate. In most sections of this high-activitiy zone dog walking is allowed, although a permit might be required. Another hotspot was found near Camps Bay (57,4). Almost no dogs were found on the plateau of Table Mountain, partially because the cable car does not allow dogs. Few dogs were walked in the designated forbidden zones of Orange Kloof (6,2) and the western "Backtable" (6,1). The highest amount of walked dogs was listed in literature for Newlands: 60% of hikers were accompanied by dogs in the Newlands area (SanParks/Setplan, 2001), which compares to an average accompaniment rate of 18% throughout the study area. The camera station placed in Newlands recorded no dog events, because it had to be placed far from trails to prevent accidental discovery.



Map 10 - Kernel Density Heat Map Plot for "Domestic Dogs". Label units are individual relative abundance indices (RAI) in visits per 100 days. Max. Plotted Radius Distance is 2 km at a threshold of RAI=1/100d.

4.2.3 Wild Mammals (Overview)

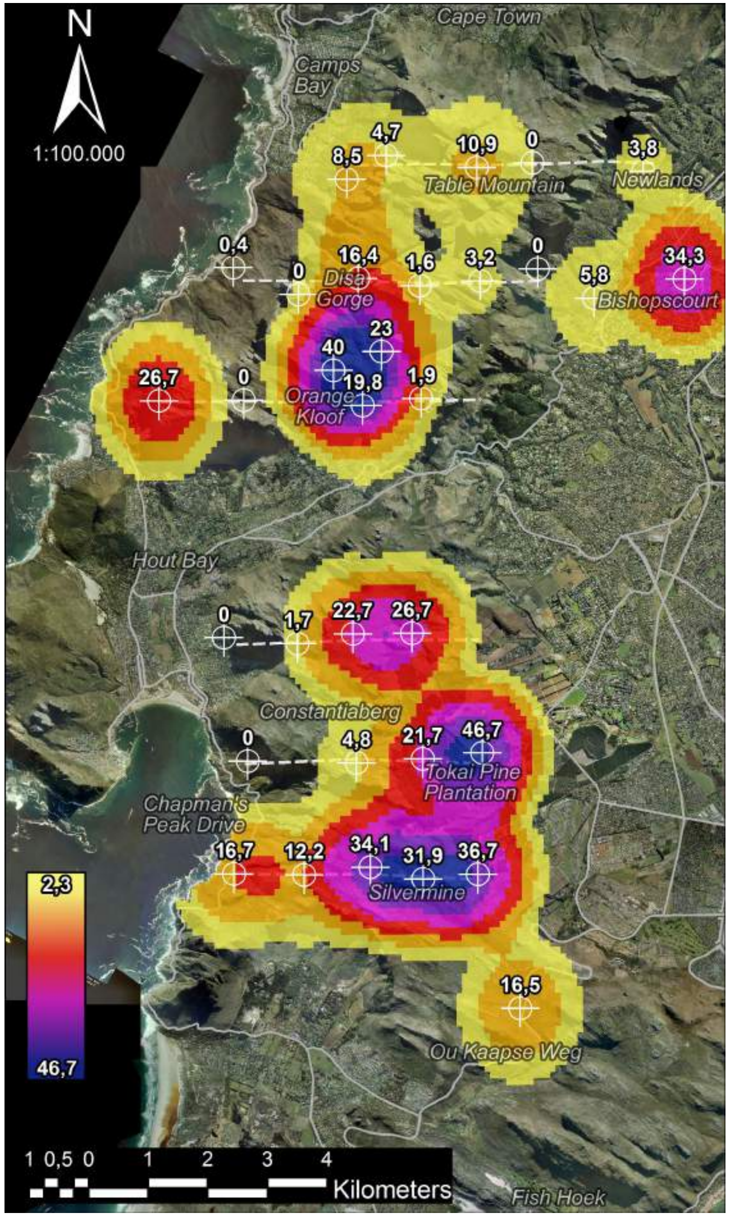
Summing up the RAIs of all observed wild species as a basis for the density heat map plot, allows the identification of density hotspots in the study area. These hotspots do not only show the highest activity, but also coincide with the highest biodiversity of medium- to large-sized mammals (→3.3).

Densities of the highest ⅙-quantile were reached in the protected area of **Orange Kloof** (RAI=[40|23|19,8|16,4]), in the **Silvermine Nature Reserve** (RAI=[34,1|31,9]) in close proximity to the freshwater reservoir, as well as in the **Tokai forest pine plantation** (RAI=[46,7|36,7|26,7|21,7]). All of these hotspots show a dense and relatively high growing vegetation, offer an easy permanent availability of open freshwater, have specialized administrative regulations for human access and have no direct motorized traffic.

While the pine plantation seems to be a special case being a highly transformed environment, Orange Kloof and the surroundings of the Silvermine reservoir show topographical similarities: They are largely untransformed valleys without settlements, immersed in the surrounding mountain plateau; a situation, which protects both from very strong winds and increases direct precipitation.

Cliffs and steep slopes show lower densities than flat or plateau areas, whereas peak areas display lower densities than medium or low altitudes.

With a radius distance of 1,8km a rather conservative, lower medium day range was assumed. As the RAIs of multiple species are summed up for the heat map plot, a display threshold of RAI=1,0 would overestimate the distribution, extending the heat map too far. To arrive at a more meaningful threshold, the average wild species richness of 2,3 was used as a the factor, which the threshold value was multiplied by.

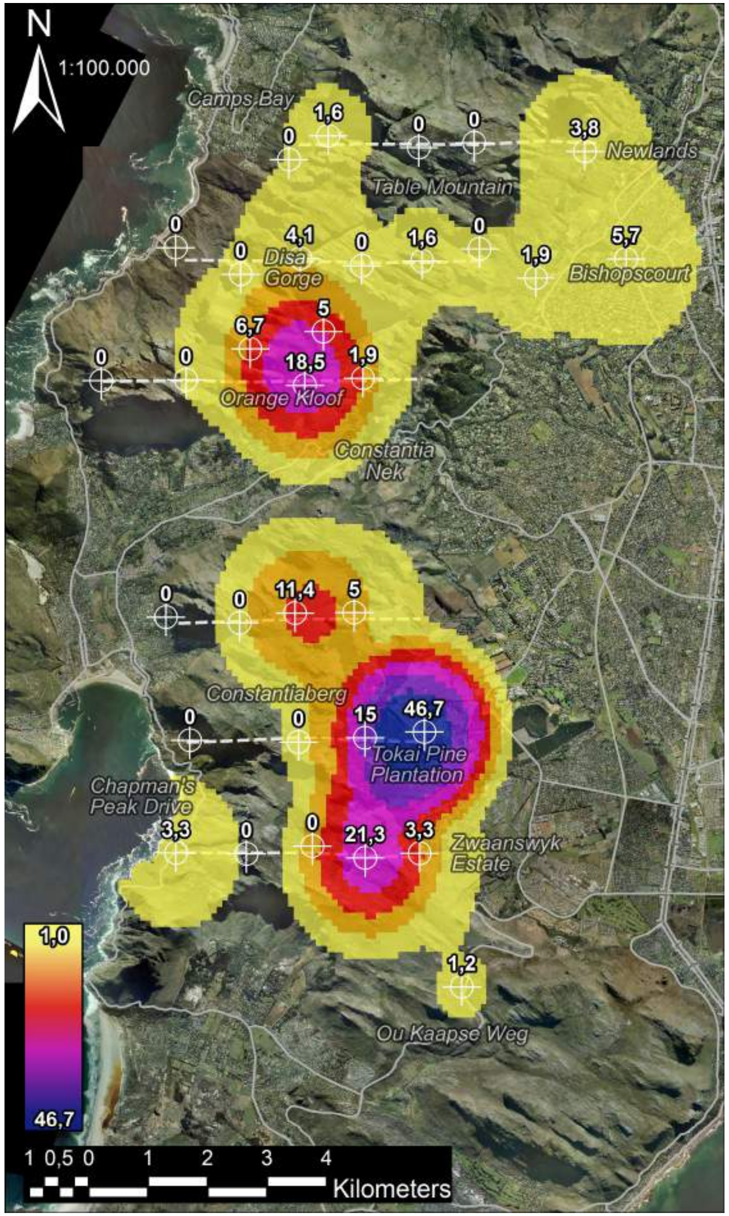


Map 11 - Kernel Density Heat Map Plot for "Wild Mammals". Label units are individual relative abundance indices (RAI) in visits per 100 days. Max. Plotted Radius Distance is 1,8km at a threshold of RAI=2,3/100., RAI threshold factor equals the average wild species richness.

4.2.4 Porcupine

Porcupines showed the most dense abundance pattern of all wild mammals found within the study area. The extension of the porcupine's areas of highest densities, coincides largely with the availability of forested areas on both mountain ranges. The highest densities were reached on the lowest slopes of the Tokai pine forest plantation (up to 46,7 porcupines per 100 trap nights), but they were detected throughout the plantation. They were also found appearing in quite substantial numbers on the plateau slopes of the Constantiaberg mountain range (11,4 and 21,3). They also ventured as low as Zwaanswyk Estate (3,3) and did not avoid proximity to major roads such as Chapman's Peak Drive (3,3) and Ou Kaapse Weg (1,2). No recordings were found on the highest peaks of Constantiaberg. A second hotspot for porcupine activity was the bottom of the Orange Kloof valley (trap recorded 18,5 porcupines per 100 trap nights) which is largely covered in indigenous forest and granite fynbos thicket. The steeper slopes of Orange Kloof are also inhabited by porcupines (6,7; 5; 1,9), as well as Disa Gorge (4,1). The population is still existent on the main plateau of Table Mountain (1,6) and extends into the suburban areas reaching a comparatively high number of 5,7 at the Liesbeek river in Bishopscourt. Porcupines were the only wild mammal found in the Newlands recreational and dog walking area (3,8). Only few individuals were detected on the steep slopes of Table Mountain near Camps Bay (1,6). Migratory effects between the two mountain ranges at Constantia Nek cannot be excluded.

The porcupine's territorial requirements are relatively small, ranging around $2km^2$ per couple with approximately $1km^2$ overlap (De Villiers, et al., 1994). This data led to the assumption of 1,5km at RAI=1,0 as a realistic maximum plotted radius distance.

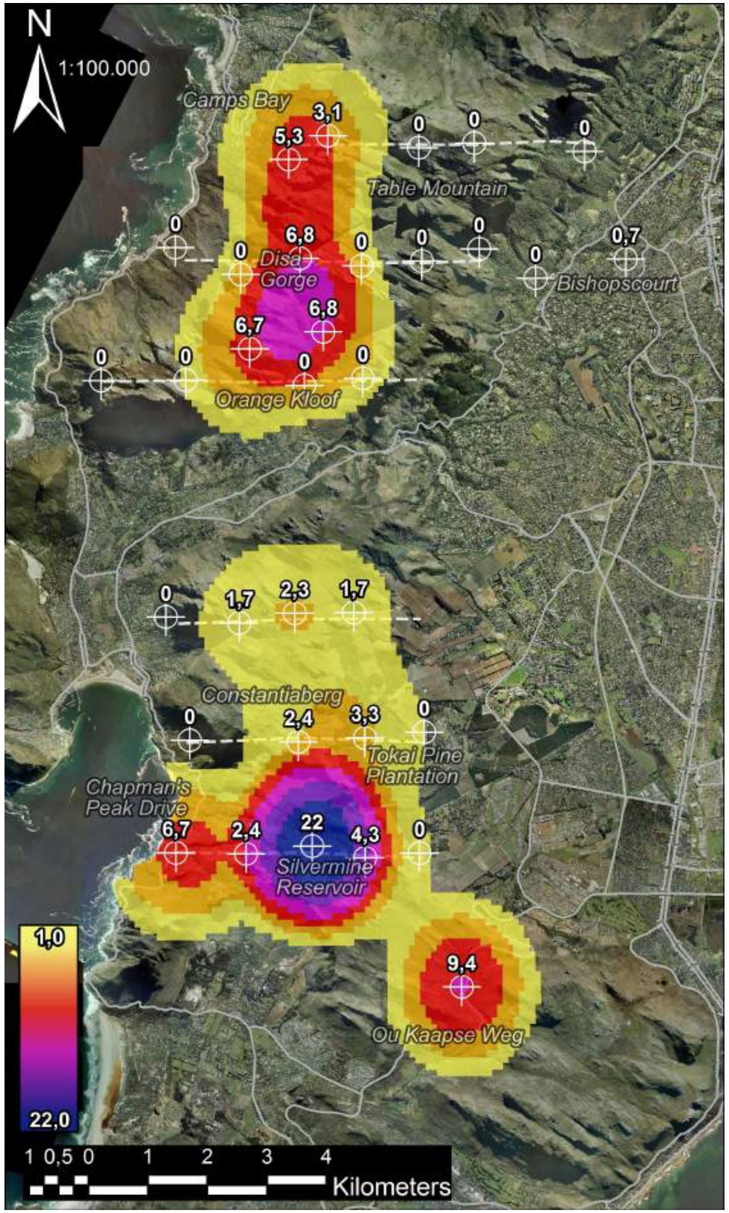


Map 12 - Kernel Density Heat Map Plot for "Porcupine". Label units are individual relative abundance indices (RAI) in visits per 100 days. Max. Plotted Radius Distance is 1,5km at a threshold of RAI=1,0/100d.

4.2.5 Large-Spotted Genet

The habitat of the Genet is distributed over both mountain ranges. Generally, the direct urban edge seems to be avoided, but occasional proximity to settlements occurred. The overall highest density was reached at the Silvermine Reservoir with 22 Genets per 100 trap nights. They appeared throughout the higher altitudes of the Silvermine-Tokai-Area, while they were more common in the south of Constantiaberg (2,4 - 22) than North of it (1,7 - 2,3). The Genet was the most common wild mammal in the study to appear next to the main roads of Chapman's Peak Drive (6,7) and Ou Kaapse Weg (9,4) suggesting that it could adapt well to the presence of motorized traffic. In the Tokai Plantation it occurred (1,7; 3,3), but was recorded in locations further away from settlements. The highest density in the Table Mountain Section was found on the steeper slopes of Orange Kloof up to Disa Gorge (6,7 - 6.8). No Genets could be found on the plateau of Table Mountain. This suggests, that the Genet's preferred habitat coincides with taller growing fynbos or forests. Furthermore, Genets occurred close to Camps Bay and on the north-western TBM slope (3,1; 5,3). The map suggests a connected population between Orange Kloof and Camps Bay, but the steep cliffy terrain might serve as a physical obstacle. Only very rarely, were genets found to penetrate the metropolitan suburb area near Bishopscourt (0,7).

Genets showed a large variation in habitat usage ranging from 0,7km^2 (Ikeda, et al., 1983) to 7,8km^2 (Palomares & Delibes, 1994). On average, between 0,33 and 0,67 individuals per km^2 were calculated, which lead to the estimation of 1,8km as max. plotted radius distance.



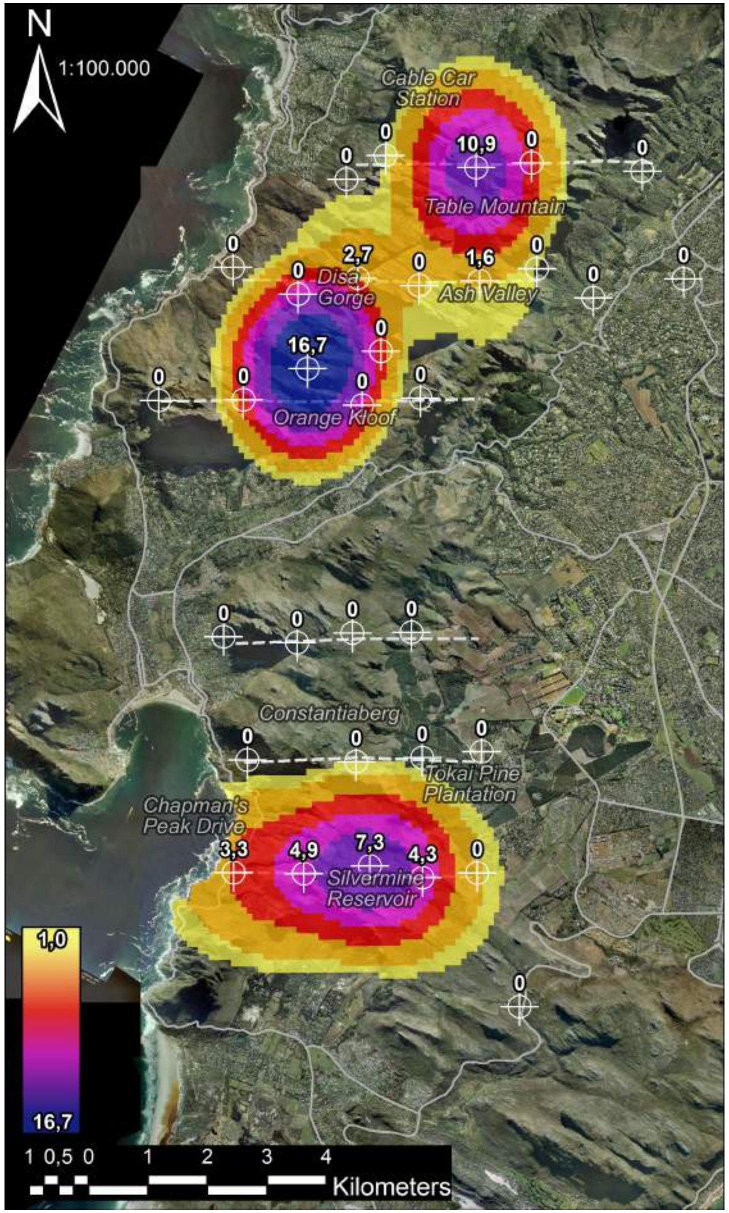
Map 13 - Kernel Density Heat Map Plot for "Genet". Label units are individual relative abundance indices (RAI) in visits per 100 days. Max. Plotted Radius Distance is 1,8km at a threshold of RAI=1,0/100d.

4.2.6 Grey Mongoose

The highest absolute number of Grey Mongoose was found on the steep eastern slope of Orange Kloof (16,7) in high-grown afrotemperate forest. They consistently appeared on the highest slopes of the mountain ranges. The second highest density (10,9) was recorded at the summit of Table Mountain in close proximity to the top station of the cable car. Considering the Grey Mongoose's diurnal activity, the low growing vegetation and the extreme tourist numbers (records of the cable car), severe behavioural habituation of the TBM population can be assumed. The two described hotspots on TBM seem to be part of the same population, showing a connection through the Reservoirs/Ash Valley (1,6) and Disa Gorge (2,7).

No grey mongooses were detected in the pine plantations or in the northern parts of Constantiaberg area. The third highest density was reached near the Silvermine Reservoir (7,3), gradually declining in western direction over the Noordhoek Peak cliffs (4,9) to Chapman's Peak Drive (3,3) and declining in eastern direction to the Silvermine Nature Reserve parking lot (4,3).

As they were only found in the southern part of Constantiaberg and no records were found on the lower traps of Orange Kloof it can be considered likely, that the TBM subpopulation is regularly isolated from the Constantiaberg subpopulation.



Map 14 - Kernel Density Heat Map Plot for "Grey Mongoose". Label units are individual relative abundance indices (RAI) in visits per 100 days. Max. Plotted Radius Distance is 1,8km at a threshold of RAI=1,0/100d.

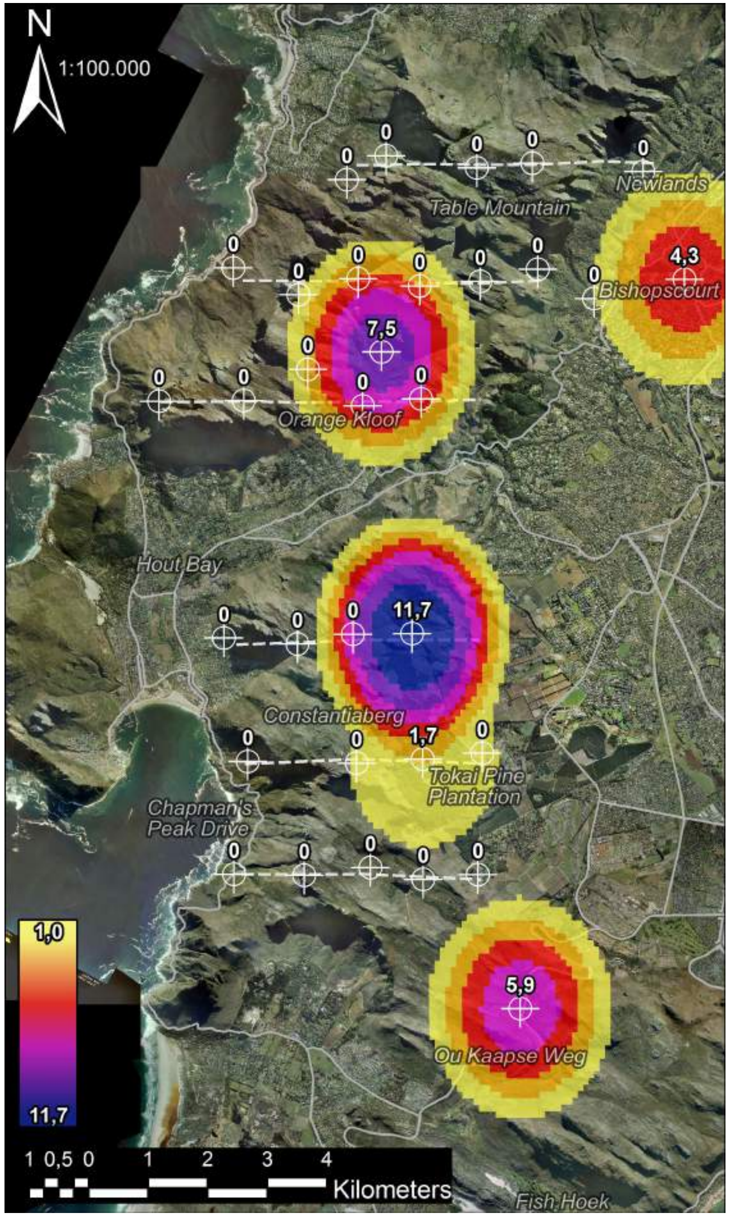
4.2.7 Watermongoose

Literature reports overlapping home ranges of Watermongooses of approximately 2km^2, which led to the assumption of 2 km search radius distance (Mitchell, 2000).

The highest absolute density of watermongoose was found in the northernmost section of the Tokai pine plantation (11,7) close to a small stream. Rarely were they seen to spread into the central plantation (1,7). The single other location they were found on Constantiaberg was close to Silvermine river (5,9), near Ou-Kaapse-Weg. A dramatic shift in density was seen at the ocean river mouth of the Silvermine river, in the town of Fish Hoek (157,5). Because the location was considered too far from other sites to produce meaningful results for the density maps, it is not included in the graphics. In this water-rich environment surrounded by civilization, the Watermongoose actually seems to thrive substantially better than at any other station of the study. The opportunistic usage of human resources might be a possible explanation for the more than tenfold increase of recordings compared to other stations.

On Table Mountain area, they only occurred under the thick canopy of the Orange Kloof afrotemperate forest, on the upstream riverbeds of the Houtbaai river (7,5). Additionally, they were one of the more common animals being found to venture into suburban spaces (4,3) at Bishopscourt.

Their occurrence in dry fynbos areas and high altitudes seems to be relatively unlikely.



Map 15 - Kernel Density Heat Map Plot for "Watermongoose". Label units are individual relative abundance indices (RAI) in visits per 100 days.
Max. Plotted Radius Distance is 2,0km at a threshold of RAI=1,0/100d.

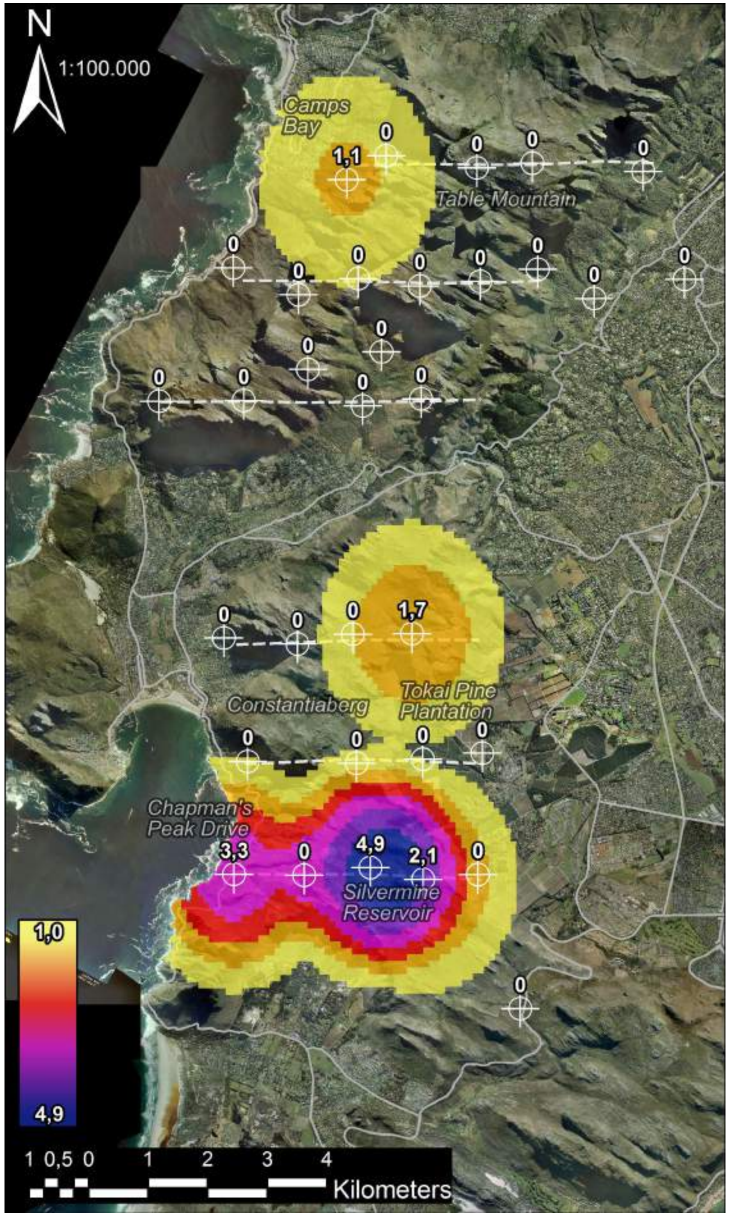
4.2.8 Grysbok

Habitat requirements for the grysbok range between 0,06 and 4,56km^2 per animal (Kerley, et al., 2003), which led to the assumption of a medium 2 km search radius distance similar to the Watermongoose.

The Grysbok was found to be a rare sight in general, occurring the most often close to the Silvermine reservoir with only 4,9 recordings per hundred trap nights. Single individuals were found close to the Silvermine parking lot (2,1) and on the low western slopes of Constantiaberg at Chapman's Peak Drive (3,3). Together with rare recordings in the northernmost parts of Tokai plantation (1,7), the Silvermine area forms the main connected habitat of the elusive ungulate.

On Table Mountain plateau, no occurrences were apparent, only very few recordings (1,1) were found on the lowest western slopes near Camps Bay. A maintained connection of the Camps Bay individuals with the Silvermine subpopulation cannot be assumed.

No grysbok was recorded to roam through afrotemperate forest or strongly urbanized spaces.



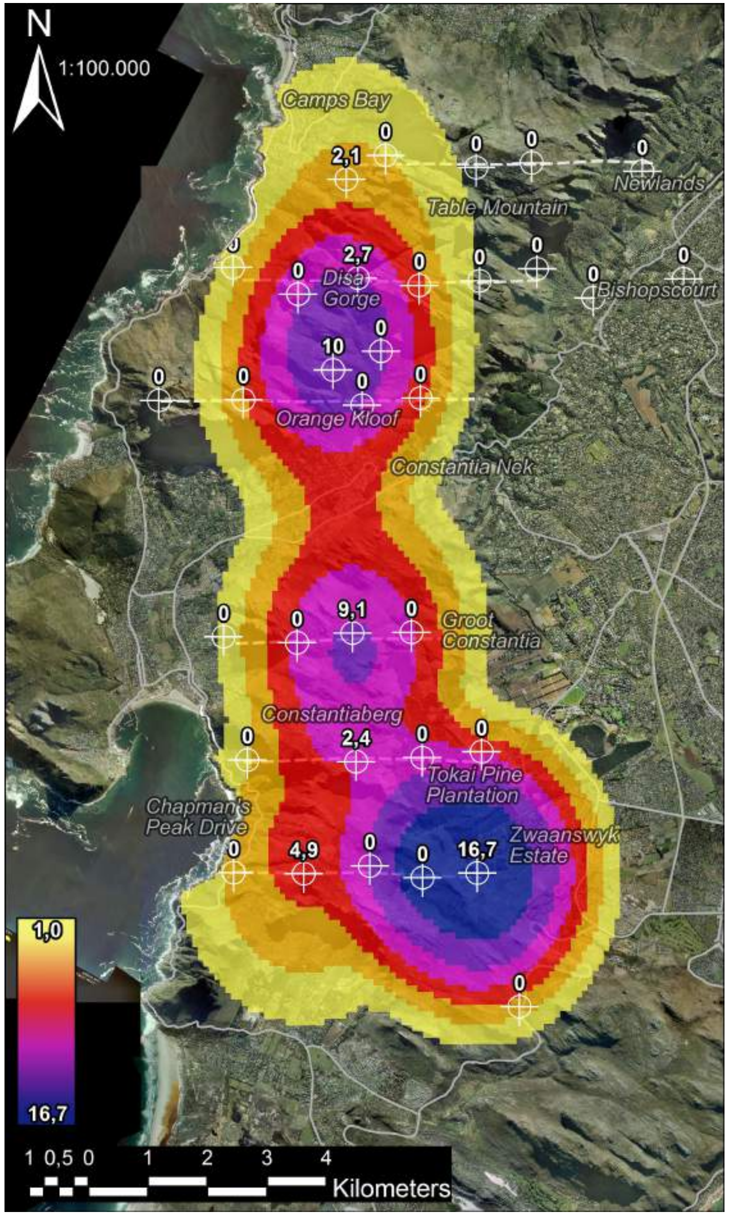
Map 16 - Kernel Density Heat Map Plot for "Grysbok". Label units are individual relative abundance indices (RAI) in visits per 100 days. Max. Plotted Radius Distance is 2,0km at a threshold of RAI=1,0/100d.

4.2.9 Caracal

The caracal is the largest species of *Carnivora spp*., that managed to survive in the study area. Although literature reports average daily travelling distances of at least 6,6 km (Weisbein & Mendelssohn, 1990), the closed natural habitat space of the study area makes very large direct travelling distances unlikely(Avenant & Nel, 2002). Therefore, for density estimation, half of this value = 3,3km was assumed as a conservative estimate. Even assuming this very low day range, the strong presence of the caracal throughout the spatially limited study area is remarkably high. Most caracals were found in closest proximity to the fenced off urban edge of Zwaanswyk Estate in the southernmost Tokai pine plantation (16,7). Surprisingly, no other plantation stations recorded a caracal (except for one unidentifiable recording possibly showing a larger mammal of a caracal's size near the Groot Constantia Vineyards). Instead, the highest slopes of Constantiaberg (9,1 in the North; 2,4 at the peak; 4,9 at the southern cliffs) seemed to be the larger, connected roaming area of caracals. A possible explanation could be the regular descent of individuals to the urban edge for hunting purposes.

The hotspot of caracal activity on Table Mountain, is the afrotemperate forest on the steep western slope of Orange Kloof (10,0). The population stretches over Disa Gorge (2,7) down to the lowest western slopes of TBM at Camps Bay (2,1). A migration of individuals across Constantia-Nek between the subpopulations of Table Mountain and Constantiaberg cannot be excluded. No caracals were found in the urban areas themselves.

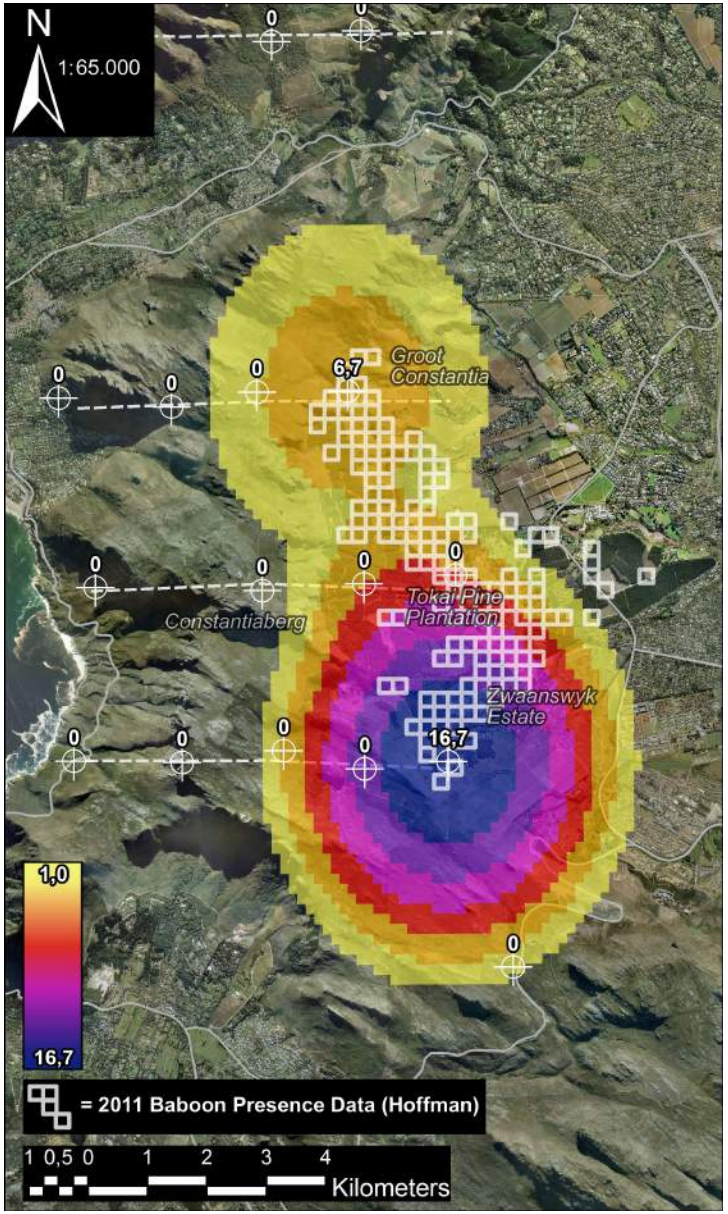
Genet, grysbok and grey mongoose show an overlapping density pattern to caracals. This spatial distribution therefore might coincide with a predator-prey relationship (→4.1.13.1).



Map 17 - Kernel Density Heat Map Plot for "Caracal". Label units are individual relative abundance indices (RAI) in visits per 100 days. Max. Plotted Radius Distance is 3,3km at a threshold of RAI=1,0/100d.

4.2.10 Chacma Baboon

Historically reported to be highly abundant throughout the study area, baboon populations nowadays are significantly reduced to two to four troops ranging in the Tokai forest plantation (Hoffman, 2011), where only two camera stations captured their presence. The highest RAI measured (16,7), was found at the southern-most area of the plantation bordering urbanization at the "Zwaanswyk Estate". Repeated "raiding attacks" by members of two Tokai baboon troops on private property led to the construction of high-voltage close mesh fencing systems around the estate, in an attempt to reduce disturbances. While conducting field work, the fencing system anecdotally proved unable to keep out all baboons from the estate, requiring specialised "baboon monitors", field workers who track and remove the animals (ZAPO, 2011). An abundance of RAI=6,7 was found at the northern end of the Tokai plantation, where the area usage of baboons is restricted by similar fencing systems to prevent "raiding attacks" on the vineyards of "Groot Constantia". These fencing systems, as well as 2011 GPS collar data showing that baboons do not climb the cliffs to reach the higher altitudes of Constantiaberg, allow the conclusion, that the density map plot overestimates the area usage of baboons. The availability of human-derived food might be an additional reason to limit the baboons' actual day range in the study area compared to populations observed in less transformed environments (Hoffman & O'Riain, 2012).



Map 18 - Kernel Density Heat Map Plot for "Caracal". Label units are individual relative abundance indices (RAI) in visits per 100 days. Max. Plotted Radius Distance is 2,2km at a threshold of RAI=1,0/100d. Overlay grid data by Hoffman (2011) includes higher resolution.

4.2.11 Others

All other mammals found during the study, appeared in too few numbers or on too few trap stations to produce meaningful results for kernel density estimation heat map plots. Therefore, absolute count numbers are graphically displayed in Map 19, where the triggering events took place.

Grey squirrels (RAI=0,89) were found on the eastern side of the mountain chains (1 in Tokai "V1", 34 on the Liesbeek River: 1 at "L12", 33 at "L10") and in Orange Kloof (6 at "H8" and 1 at "P"). None were found outside of forests.

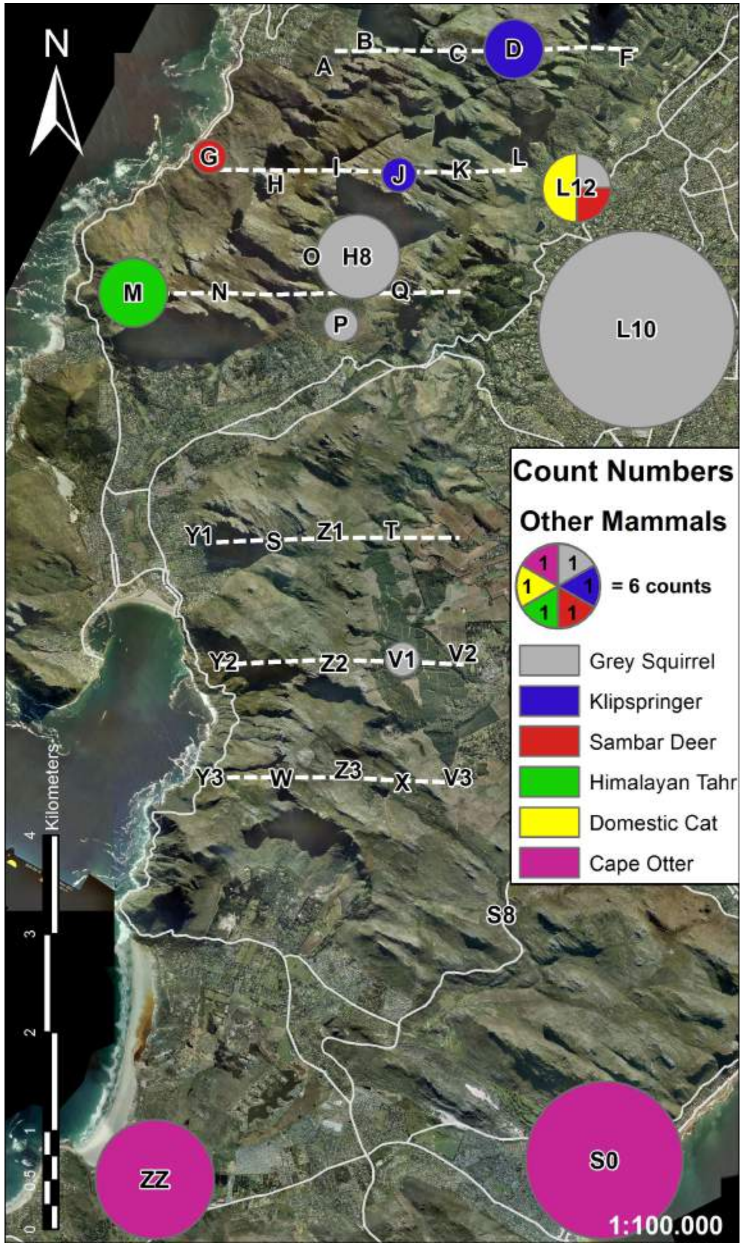
Klipspringers (RAI=0,20) were only found on the plateau of Table Mountain: 3 near MacLear's Beacon ("D") and 1 close to Victoria Reservoir ("J").

The **Sambar Deer (RAI=0,07)** was recorded twice on the lower slopes of Table Mountain. Once in Oudekraal Nature Reserve close to Camps Bay ("G") and once at the Liesbeek river near Kirstenbosch ("L12"). Both pictures clearly showed a male individual.

A pair (one male and one female) of **Himalayan Tahrs (RAI=0,76)** was recorded twice on the westernmost cliffy slopes of the "Backtable" (4 at "M").

Only one individual **Domestic Cat (RAI=0,06)** was recorded twice at the Liesbeek River near Kirstenbosch (2 counts at "L12"). The typically strong fencing systems of private gardens, in proximity to the mountain ranges, as well as small territorial habits seem to keep domestic cats largely out of the nature reserves(Meek, 2003).

Cape Clawless Otters (RAI=4,13) were recorded 33 times in Fish Hoek valley south of Silvermine, in closest proximity to freshwater and urban spaces (12 in Kommetjie at "ZZ" and 21 in Fish Hoek at "S0").



Map 19 - Count Number plot for those mammals studied, where no meaningful results could be obtained by a density heat map plot.

4.3 Covariate Profiles

The detected relative abundance frequencies of one covariate class were arithmetically averaged forming a "mean occurrence" for a single species in this class. Camera stations "E", "R" and "U" were treated as <NA> and omitted before processing. The sum the calculated averages of all classes formed 100% for each species. Normalized frequency distribution bar graphs were plotted for each covariate, to compare the individual species' covariate profiles. Covariate influences can be shown by this method independently from the overall population density of a surveyed species (Srbek-Araujo & Chiarello, 2013).

Nevertheless low population densities, resulting in low individual event counts, affect the accuracy of the RAI triggering frequencies. Species counted more than 12 times were considered usable for covariate profile analysis, whereas event counts between 6 and 12 times (*, orange in Table 12) were considered usable, but contained a limited risk of improbability. Event counts with values below 6 (**, red in Table 12) are still shown in the analysis, but the profile data can show no more but a slight tendency. The asterisk symbols (* and **) are used throughout the covariate profile analysis to indicate reliability of the species' profile.

P-Values listed are obtained by Kruskal-Wallis Multiple Comparison and are included as described in →3.6 Covariate Statistics and can be found in →Appendix 9.5.

This profile overview allows to determine the direction of the observed statistical difference.

Species	Individual Events
Humans	1795
House Dog	351
Watermongoose	106
Porcupine	93
Spotted Genet	67
Grey Squirrel	42
Otter	33
Grey Mongoose	22
Caracal	20
Chacma Baboon *	9
Grysbok *	7
Himalayan Tahr **	4
Klipspringer **	4
Sambar Deer **	2
Domestic Cat **	2

Table 12 - Individual event counts for each species included in the covariate profile analysis. Orange (*) = reliable data, but limited risk of improbability for covariate dependence; Red (**) = data included showing single captured individuals, but the profiles cannot show more but a tendency.

4.3.1 Mountain Range

Sambar Deer** and **Himalayan Tahr**** were solely introduced to the Table Mountain section specifically by humans. Due to the isolated character of the two sections and no findings of triggering events in the Southern Section a migration of these species' individuals between the sections has to be considered unlikely (100% TMS, p>0,2).

Klipspringers** once were native to the whole peninsula, but were - after their extermination by humans - specifically reintroduced to the Table Mountain section. The data (100% TMS, p>0,2) for this species indicates, that migratory effects between the sections are unlikely.

Domestic Cats** were seen exclusively in the Table Mountain Section (100%, p>0,2). The higher urbanisation density around the northern section probably coincides with a higher density of pets in general.

Grey Squirrel, as an introduced species, originally needs Northern American type mixed forest as it is unable to ingest the abundant fynbos material. Larger suitable connected forest patches, as well as usable suburban garden areas, are found to be more prevalent in the Table Mountain Section (over 90%, p>0,2) (here especially the low eastern slopes and Orange Kloof), whereas in the Silvermine-Tokai section only the pine plantation area of Tokai is a suitable habitat.

Grey Mongooses show no clear preference for one specific section of the national park (55% TMS, p>0,2).

Genets appeared in both sections, but significantly preferred the Silvermine-Tokai section. (70%, p<0,05).

Caracal and **Porcupine** appear in both sections, but seem to prefer the Silvermine-Tokai section (70%-80%, p>0,2).

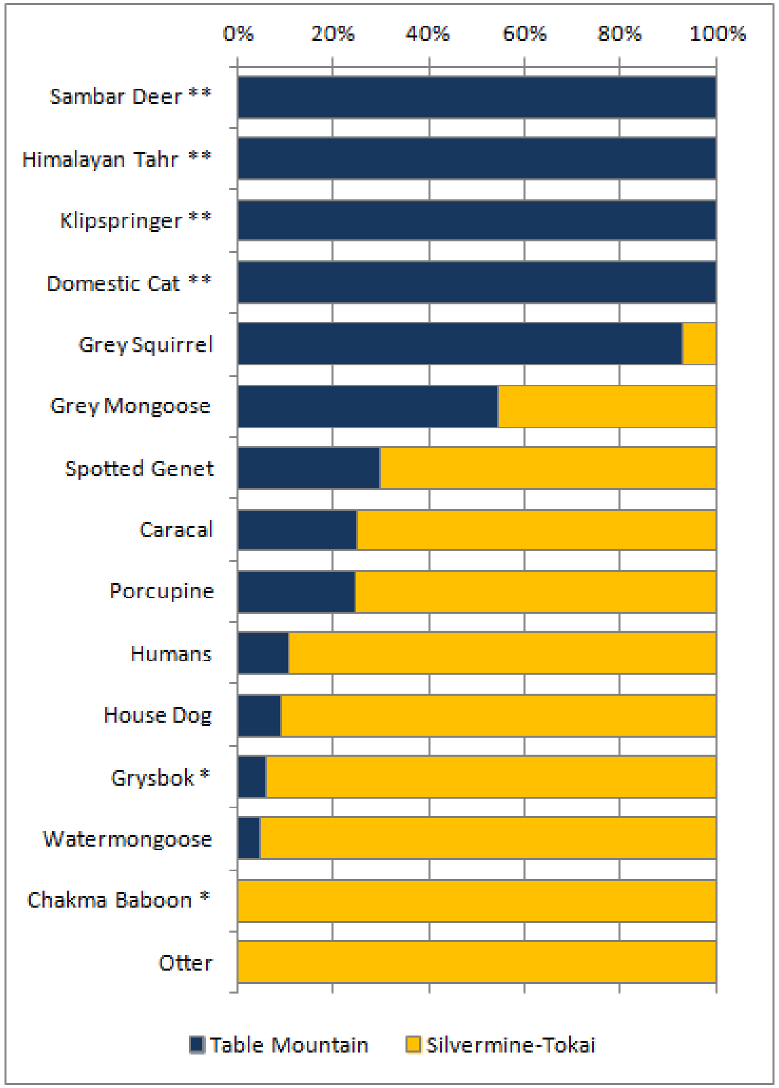


Figure 37 - Mean occurrence profiles of animal species in the northern section (Table Mountain, TMS) and the southern section (Silvermine-Tokai, STS).

Humans (90% STS, p<0,2) and **House Dogs** (92% STS, p<0,1) were captured more often on the Silvermine-Tokai cameras. This effect superficially seems antithetic to the expected mass tourism in the Table Mountain Section. Possibly this is explained by the higher need to place camera traps in discrete locations away from paths throughout Table Mountain Section, so they would not be discovered by tourists. More remote camera trapping locations in Silvermine-Tokai are less easily reachable by the general public and an entry fee has to be paid. These factors - together with slightly smaller measures of the Bushnell camera trap housings - allowed for a more open positioning of the traps in the Silvermine-Tokai Section on hiking and dog-walking paths. Therefore, a higher number of humans and house dogs were captured in this section.

Grysbok* (95% STS, p<0,2) and **Watermongoose** (96%, p>0,2) were captured almost exclusively in the Silvermine-Tokai Section.

Otters were found exclusively south of Silvermine in Kommetjie and Fish Hoek. Those locations were counted as part of the Silvermine-Tokai section (100% STS, p>0,2).

Baboons* were observed exclusively in the Tokai Pine Plantation, which is part of the Silvermine-Tokai Section (100% STS, p>0,2).

4.3.2 Altitude

Otters (100% below 150m, p>0,2) stayed on lowest altitudes. The reason for this behaviour could be their attachment to freshwater rivers as the preferred hunting and habitat biotope. The lower altitudes of the rivers provide deeper water and more shallow banks, making altitudes below 150m the most likely for Otters.

Domestic Cats** (100% below 150m, p>0,2) preferably roam in a small radius around their owner's house (Meek, 2003) and were therefore seen exclusively around the human settlements which are all built on the lowest altitudes.

The **Sambar Deer**** (100% below 150m, p>0,2) originated from the human zoos on the lower altitudes. Higher altitudes seem to be too difficult to reach for the non-mountainous Sambar Deer.

The **Watermongoose** (100% below 300m, p<0,05) was captured significantly more often on lower altitudes. Similarly to the Otter, the watermongoose prefers the shallow lower freshwater rivers.

Grey Squirrels (100% below 300m, p<0,2) keep close to human settlements on low altitudes. Suburban gardens and the forest patches along the rivers possibly resemble their original living space.

Genets (96% below 600m, p<0,1) were observed on all altitudes, but more than 50% were documented under 150m (p>0,2). They seem to be able to climb altitudes of 600m and above, but do so rarely (4%).

Also the **Grysbok*** occurred on a wider range of altitudes but was never seen venturing above 600m (p>0,2). 42% occurred between 450m and 600m, 48% below 150m (p>0,2), suggesting an additional preference for these two zones (90%: 0-150m and 450-600m, p<0,2).

The **Porcupine** occurred significantly more often on lower altitudes, but they were recorded throughout the study range. 43% occurred below 150m (p<0,05), 65% occurred below 300m (p<0,05), 70% occurred below 450m (p<0,2), 98% occurred below 600m (p<0,05) and 98% occurred below 750m (p<0,2).
The profiles of Genet, Grysbok and Porcupine coincide with relatively flat fynbos or forest thicket as the preferred habitat. The higher amount of triggerings in the 451-600m class can be explained by the plateau mountain fynbos availability in this range.

The **Grey Mongoose** was observed throughout the range of altitudes, but showed an extraordinary preference for high to highest altitudes: 30% above 750m (p>0,2), 68% above 450m (p<0,1) and 96% above 300m (p<0,2). Its grey fur colouring makes it more adapted to the rocky terrain on the highest slopes, its small body size also allows to hide in the low growing mountain vegetation on higher altitudes.

Humans preferred higher, but not highest altitudes (80% over 450m, p<0,2; and under 750m, p>0,2). This effect might be artificial, because the cameras close to the upper cable car station (over 1000m) should have recorded substantial mass tourism, but those camera stations had to be hidden so well that no humans discovered the traps nor were

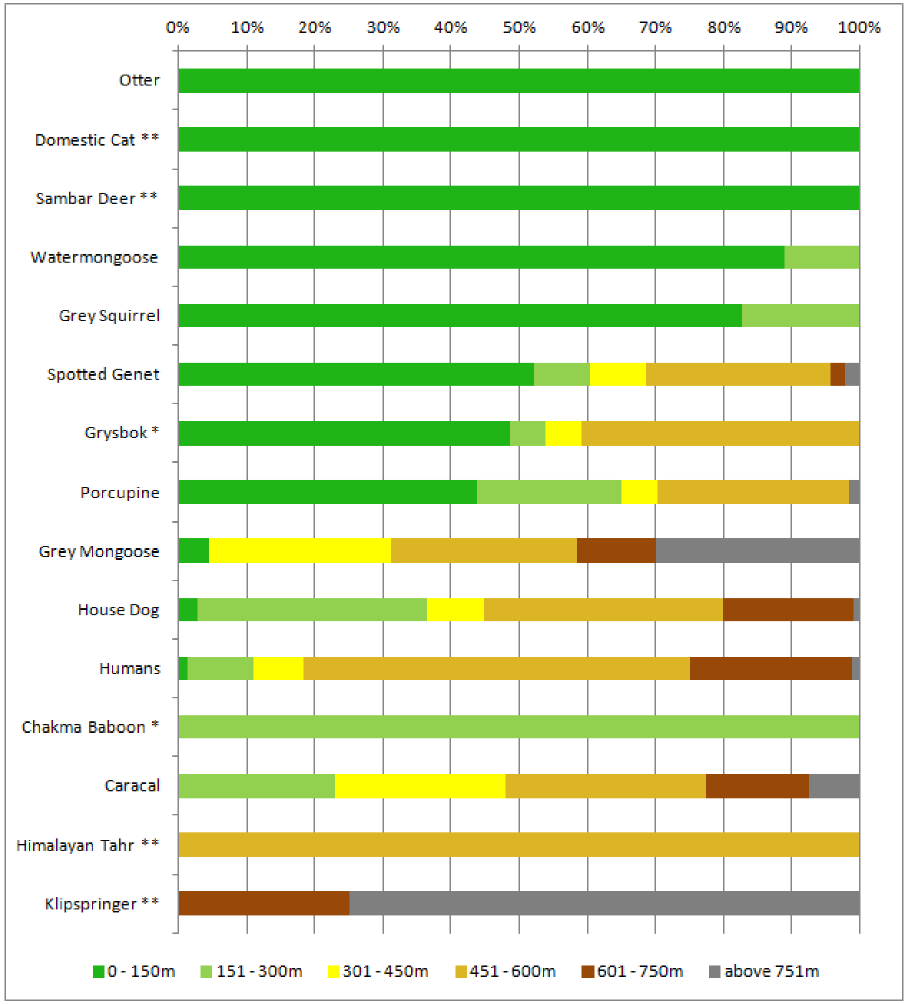


Figure 38 - Mean occurrence of animal species in the different altitudes of TMNP. Colour classes are changed every 150m. An altitude overview on the study area is given on Appendix 9.4, Map A.

humans recorded. Also, on the lower altitudes special hiding of the traps resulted in less triggering events of humans although they have to be assumed to be ubiquitous. **House Dogs** match the profile of humans, but seem to occur more often on lower altitudes (37% below 300m, p>0,2) than humans (11% below 300m, p>0,2). This indicates, that hikers without dogs are seen more often on higher slopes than dog walkers.

Chacma Baboons* exclusively occurred in a range between 151 and 300m (p>0,2) which corresponds with the altitude levels studied in the Tokai Plantation.

The **Caracal's** altitude range was found to be very distributed from as low as 151m up to the highest altitudes, while it is more likely to be encountered on higher rather than lower altitudes. 77% occurred above 300m (p<0,2). By doing that, it shares its topographical predation range mainly with Genet, Grysbok, Porcupine, Grey Mongoose, Baboon and Tahr. Klipspringers, Watermongoose and Squirrel only share parts of their range with the preferred range of the caracal. A large topographical overlap between humans/dogs and the caracal also has to be assumed, but encounters are very unlikely due to the nocturnal nature of the caracal's behaviour in the study area.

The **Himalayan Tahr**** was recorded exclusively between 451m and 600m (p>0,2), but the single recording location lies on the plateau of the western "Backtable" of the southern Table Mountain section, where no higher altitudes can be reached. Due to its mountainous origin, even higher altitudes seem likely as a suitable habitat for the Tahr, but could not be confirmed in this study.

The **Klipspringer**** was recorded exclusively on very high altitudes in mountainous plateau terrain, most of them even in peak areas (75% over 750m, p>0,2). They seem to be the only larger mammal in the study area present so strongly on the highest altitudes. According to the National Park Management they share their ecological niche with the Tahr and are in concurrence for resources. The findings suggest though, that tahrs are more common on the "Backtable" south-western end and klipspringers more common on the northern tabletop of the Table Mountain section. Spatially they possibly interfere less with each other than expected.

4.3.3 Terrain Slope and Aspect

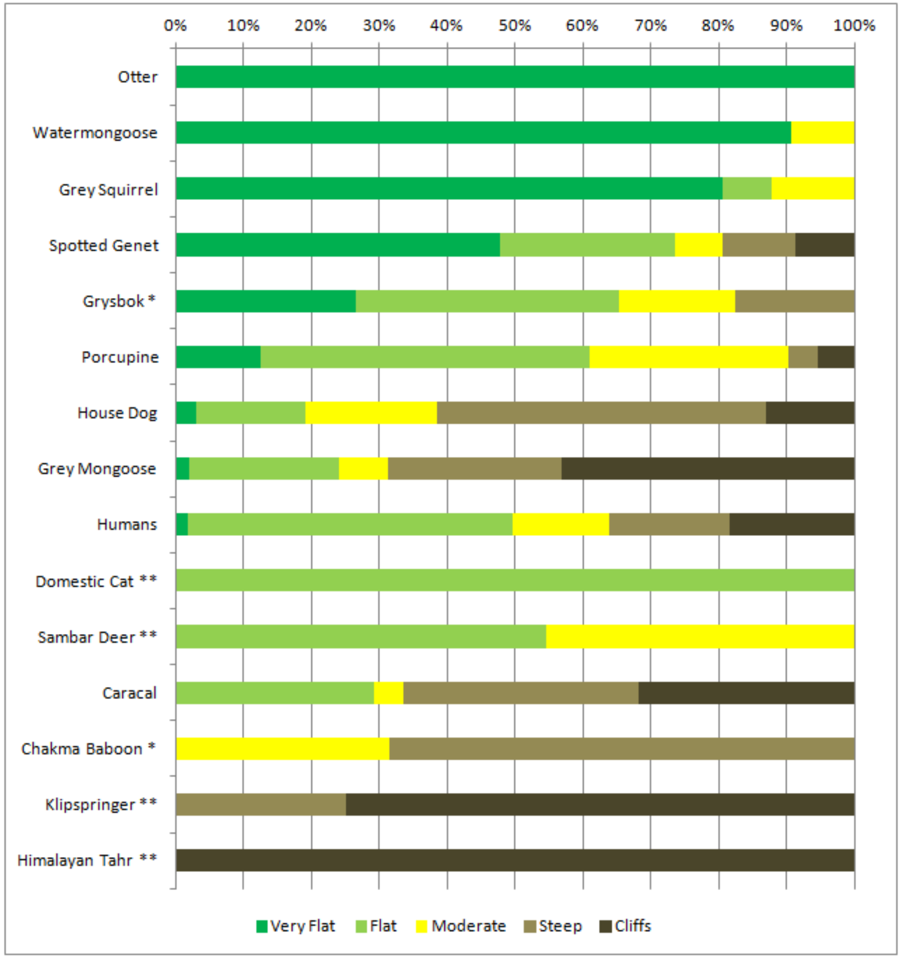


Figure 39 - Mean occurrence of animal species in different levels of steepness of slope on the TMNP terrain. Colours and classes coincide with Appendix 9.4, Map B.

Otters were found exclusively on very flat slopes (100% below 4° steepness, p>0,2 and 100% flatland, p<0,2), which only occur in the flatlands. They seem to avoid the upper river systems and stay on the foot of the mountain.

The **Watermongoose** shows a very similar profile, being adapted to flatland (91% below 4° steepness, p<0,05 and 92% flatland, p<0,1). In contrast to the Otter, some individuals were captured on moderate slopes, indicating that the watermongoose can move a bit further from the streams up the eastern mountain slope.

Grey Squirrels mainly remained in the flatland (81% below 4°, p>0,2 and 87% flatland, p>0,2). If found on the mountain, they ventured on the often densely forested eastern slope which is more suitable for them than the western slope considering the indigestible fynbos.

The **Grysbok*** appeared on all slopes except for cliffs, which were avoided completely (p>0,2). In fact, it mainly occurred on flat or very flat slopes (65% below 10° steepness, p>0,2) and preferred the flatland terrain (57%, p>0,2) to the mountain plateau (17%). It was recorded slightly more often on western (18%) than eastern (7%) slopes (p>0,2). This topographical movement profile might represent a behavioural avoidance strategy towards its only predator, the caracal.

The **Caracal** shows a strong preference for the eastern slopes (>65%, p>0,2) and was never found in the flatland: Except for the very flat slopes (100% steeper than 4°, p=0,2) it occurs on all levels of steepness, especially steep terrain and cliffs (66% steeper than 16°, p<0,2).

Tahr** and **Klipspringer**** both favoured the mountain plateau (100%, p>0,2). They both occurred only on steepest slopes (75% cliffs for the klipspringer, 100% cliffs for the tahr, p>0,2) and prefer the cliffs of the mountain plateau.

The **Grey Mongoose** was recorded mainly on steep or cliffy slopes (68% steeper than 16°, p>0,2). Although it shows a preference for the mountain slopes, no preference for the western or eastern slopes was found (both ~40%, p>0,2). Its topographical distribution shows similarities to the caracal.

The **Genet** is very present in the flat to very flat slopes (73%, p>0,2) and very connected to flatland terrain (69%, p>0,2). No preference for one side of the mountain could be found.

Like the Genet, the **Porcupine** could be found on all levels of steepness, although it prefers light slopes (61% less steep than 16°, p<0,1) to steeper terrain. Unlike the Genet, the Porcupine shows a preference for the eastern slope (25%, p<0,2) compared to the western slope (9%, p<0,1), but overall favours the flatland (58%, p<0,05).

Domestic Cats** were only found in the flatland around urban spaces, exploring flat terrain in close vicinity (100% flatland, p>0,2; 100% less steep than 10°; p>0,2).

The **Sambar Deer**** was found on flat and moderate slopes (p>0,2), in the flatland and on western slopes (p>0,2). No evidence was found for occurrence on the mountain plateau or the steeper eastern slopes. While initially escaped on the eastern side of the mountain, the presence of a male individual on the western side is now evident.

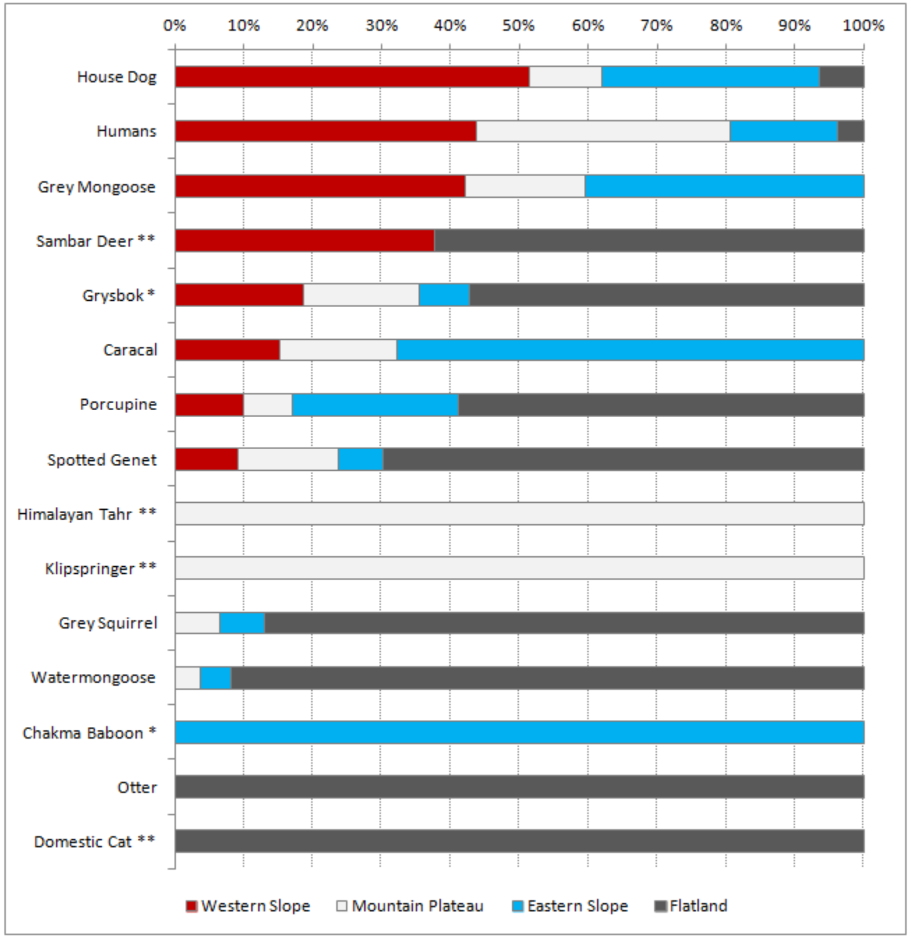


Figure 40 - Mean occurrence of animal species in the topographical aspect classes of the mountain slope. Colours and classes coincide with Map Appendix 9.4, Map B.

The **Chacma Baboon*** is restricted to the eastern slope of the Tokai pine plantation on moderate (32%, p>0,2) to steep slopes (68%, p>0,2). From direct observations, the Tokai baboon's presence in flat terrain is also evident. Their climbing abilities would theoretically allow them to inhabit the cliffs of the higher altitudes, but their presence was not recorded there. The tall pine trees serve the protective function, steep cliffs usually provide for other baboon populations (Yihune, 2006).

Human and **House Dog**, although they both settle on the lowest most flat slopes, are not recorded in these areas. This is due to the already stated need of hiding the trapping cameras especially well in the locations that are easily accessible. Lower discoverability therefore results in lower trapping counts of human activity. Humans were especially abundant on the mountain plateau (38%, p>0,2), whereas house dogs were only rarely taken to the plateau (11%, p>0,2). In general, humans and dogs triggered the cameras slightly more often on the western than on the eastern slopes, although this effect could also be based on the need for disguise in proximity to settlements. Dogs were walked more often on steep slopes (49%, p>0,2) in comparison to hiking humans without dogs (18%, p>0,2). Humans without dogs (47%, p>0,2) preferred flat terrain to dog walkers (16%, p>0,2).

4.3.4 Habitat and Vegetation Type

Some animals adapted very well to the human presence in the metropolitan area, namely the **Otter** (100% at the urban edge, p<0,06) and the **Watermongoose** (over 90% at the urban edge, p<0,01). Both of them need the shallow lowland streams which are located close to settlements, thus opportunistically gaining access to human food resources. The watermongoose seems to rarely take occasional overland trips into different habitat types, whereas no otters were found outside their distinct habitat.

Grey Squirrels mainly stick to the urban space (84%, p>0,2), where they were introduced. If they are found outside of this environment, they seem to prefer forested areas (afrotemperate or plantation) to the fynbos.

Domestic Cats** mainly stay in the urban space (78%, p>0,2) and only occasionally leave into the bordering lowland fynbos (22%, p>0,2) of the Table Mountain section, but never travel as far as the forested areas or the montane fynbos. Their small body size makes them well adapted for fast movement in the dense granite fynbos thicket, where the mobility of larger mammals might be more limited.

Porcupines are only rarely found close to urban spaces (14%, p<0,05), but they prefer transformed environments (68%, p<0,002). They thrive in the open plantation areas (53%, p<0,05) compared to natural spaces. They seem to especially avoid the mountain sandstone fynbos (8%, p<0,05), possibly because of its high altitude. Considering all natural spaces, they prefer the original afrotemperate forest (20%, p<0,2) over all types of fynbos.

Genets prefer natural landscapes (75%, p>0,2) to transformed ones (25%, p>0,2). Where they appear in transformed spaces, they show no preference for plantations (12%, p>0,2) or the urban edge (13%, p<0,2). Throughout natural spaces they are as likely to be found in the afrotemperate forest (29%, p>0,2) as in the montane fynbos (28%, p>0,2), but slightly less likely to be found in the lowland fynbos (18%, p>0,2). In terms of vegetation, Genets seem to show a generalist behaviour, being able to inhabit all studied environments. Whenever they were recorded in transformed spaces, they showed nocturnal activity, suggesting a behavioural avoidance towards humans (→4.2.5).

Humans and **House Dogs** were both found showing very little numbers of recordings (6% and 5%, p>0,2) in the Urban space. This is partially, because the cameras close to urban spaces had be placed further away from human paths, but also indicates that humans try to find a more natural environment for recreational activity than spaces on the urban edge. Walked dogs were recorded considerably more often in the plantation area (42%, p>0,2) than humans without dogs (23%, p>0,2), suggesting that at least the permitted outer areas are a preferred dog-walking location. Humans were recorded the most often in the montane fynbos (48%, p>0,2), which seems to be the preferred vegetation type for recreational activity. Dogs were more often taken to lowland fynbos (30%, p>0,2) than to montane fynbos (20%, p>0,2), probably because the lowland fynbos belt is closer to settlements and shows a less cliffy terrain. Humans alone were found more often in the afrotemperate forest (7%, p>0,2) than dogs (<2%, p>0,2). This finding might be caused by the prohibition of dog walking in the afrotemperate forest of the

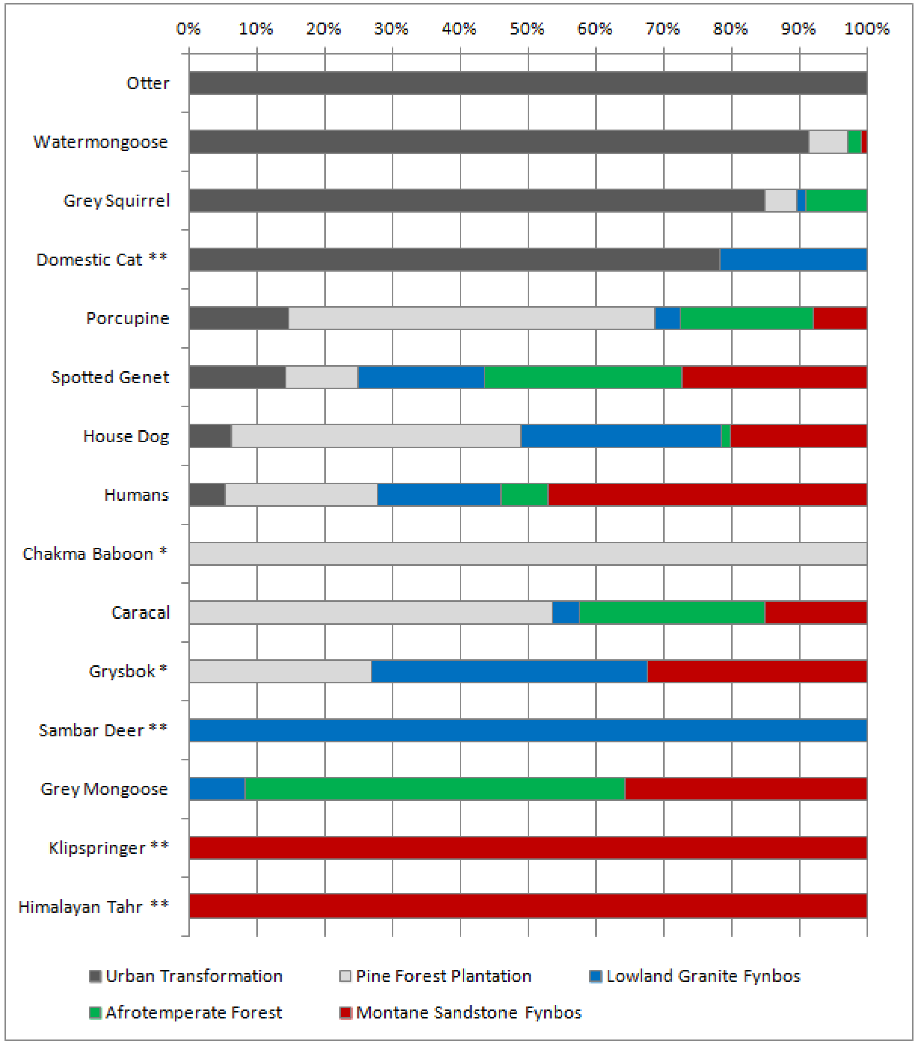


Figure 41 - Mean occurrence of animal species in the different vegetation areas of the National Park. Colours and classes coincide with Appendix 9.4, Map G. The class "Sand Fynbos" was excluded due to insufficient repetitions.

Orange Kloof area at the southern "Backtable" of the Table Mountain section and by the avoidance of dog owners to walk their pets on the steep and inaccessible eastern slopes of the Table Mountain section, where all other remnant patches of afrotemperate forest are found.

Chacma Baboons* occurred exclusively in the pine forest plantation (p<0,15) and the surroundings of the Tokai area. No individual was recorded to penetrate a different habitat. Direct observations could show recurring attempts of baboons penetrating nearby garden and settlement areas. Specific "Baboon monitors", equipped with pellet guns, are employed by the municipality to ensure that the baboons remain in their designated space. In all other spaces of the study area historically suitable for baboons, culling measures close to urbanisation explain their absence in others and binding to this single location. Baboons are extremely well adapted to human presence and the invasion of urban habitats. They gain access to human derived food resources, thus their need to forage in the remnant fynbos patches of the Tokai area was often diminished in the past (Richardson/HWS, 2014). Although baboons are known to damage pine plantations by bark stripping (Katsvanga, et al., 2009), their presence is tolerated, as the economical damage is considered higher in completely urbanized spaces. They can hide from predators like the **Caracal** in the treetops of pines, which baboons climb far easier than the caracal. The constant presence of baboons might be a reason for the caracal to show an extraordinary preference for the pine plantation and the Tokai area (53%, p>0,2), although predation on baboons in other settings is considered rather rare (→4.1.13.1). The open ground could offer the best hunting environment, especially compared to the granite lowland fynbos thicket, that the caracal tries to avoid (4%, p>0,2). The plantation also offers resemblance to the afrotemperate forest environment which the caracal prefers (27%, p>0,2) to both, the lowland and the montane fynbos (16%, p>0,2).

More so than the baboons, the **Grysbok*** seems to be the most probable prey for the caracal. Its overlapping nocturnal activity, inability to climb the pines and documented presence in the plantation (27%, p>0,2), make it a likely target. It could not be documented in the afrotemperate forest, but showed a strong preference for fynbos (73%, p>0,2), whereas lowland granite fynbos was documented slightly more often (41%, p>0,2) than montane fynbos (32%, p>0,2). The grysbok's den is generally found protected in the thicket of high grown lowland fynbos, but foraging is possibly easier in less overgrown vegetation. All recordings of the grysbok in the pine plantation showed nocturnal behaviour, also suggesting a spatial avoidance of human activity.

Of the two recordings of **Sambar Deer**,** one was triggered in close proximity to afrotemperate forest, suggesting that it could also occur in this vegetation type. Still, it possibly prefers the dense thicket to low grown vegetation and is able to survive in the fynbos environment despite its alien origin (Cowan, 2013). The sambar deer is very unlikely to be preyed upon by any wild animal on the peninsula due to their large body size. Human extermination pressure might keep the few remaining individuals distant to human presence.

The **Grey Mongoose** shows an exclusive presence in non-transformed spaces. It is frequently reported to search proximity to humans and feed on human resources, but on the peninsula its diurnal activity seems to require the grey mongoose to spatially avoid human activity. Its preferred retreat is the aftrotemperate forest (56%, p>0,2), followed by the less dense montane fynbos (36%, p>0,2). Very little activity was documented in the lowland fynbos (8%, p>0,2).

Klipspringers* were found exclusively in the montane sandstone fynbos being diurnally active, which is part of their long-term ecological niche. Furthermore, montane fynbos is the only vegetation type found in the study area, which lies in the preferred altitude levels for the klipspringer.

The alien **Himalayan Tahr*** was also found exclusively in the montane sandstone fynbos. This vegetation type probably resembles their original habitat in the Himalaya the most out of all possible environments on the peninsula.

4.3.5 Permanent Freshwater

As freshwater is the predominant habitat for the **Otter**, its exclusive occurrence (100%, p>0,2) on those camera traps placed closer than 25m to streams, was no surprise.

The **Watermongoose** also - almost exclusively - travelled no further than 25m from a freshwater stream (98%, p<0,05). As their lifestyle is, like the Otter's, very dependent on the constant availability of freshwater. The findings suggest that, if both travel bigger distances, they do so staying in proximity to streams, river mouths or lakes.

Grey Squirrels are mainly bound to alien forest vegetation to feed. Alien vegetation is especially connected to higher water demands than the arid fynbos vegetation in South Africa. Although rivers are not directly necessary for the squirrel's lifestyle, their preferred habitat only exists in closest proximity (94% under 25m, p<0,1) to freshwater resources.

The **Genet** was found to spend 73% (under 25%, p<0,1) of its occurrence in closest proximity to streams, but occasionally travels up to 300m away. Its preference for rivers might be connected to a spatial avoidance of its last remaining predator, the caracal. Additionally, the denser thicket of the riverbanks might give the genet a more protected environment for its den.

The **Grysbok*** showed a high affinity to riverbanks and other freshwater spaces (68% under 25m, p>0,2), which might also be related to the spatial evasion of the caracal as its only predator. As a selective browser, it prefers to feed on highly nutritious fynbos or alien vegetation (Kigozi, et al., 2008). Although the grysbok is reported to have only low demands for direct freshwater supply (because its water requirements are satisfied by the intake of high water content vegetation) and highly nutritious vegetation is more easily found close to freshwater in the study area, making the surroundings a likely browsing area.

The **Sambar Deer**** showed a preference for spaces in close proximity to freshwater (100% closer than 75m, 41% closer than 25m, p>0,2), which corresponds with their adapted affinity to lowland fynbos. The Sambar Deer is reported to thrive best in well watered habitats and is only very rarely found far away from freshwater (Timmins, et al., 2008).

House Cats** were also found, being closely related to freshwater spaces (100% closer than 75m, p>0,2; 75% between 25m and 75m, p<0,1), although this finding might be an artefact of the positioning of camera traps. No camera traps were set up in the drier parts of urban flatland areas, where domestic cats are probably as likely to be held as pets as in the urban areas closer to streams.

The **Porcupine** showed no specific preference for spaces in proximity (70% further than 25m, p<0,05) or distance (100% closer than 300m, p<0,1) to freshwater sources. Its spatially distributed occurrence in respect to moderate freshwater distances coincides with its generalist diet. It is present from arid savannahs to tropical rainforests, but is hardly ever found in extreme conditions such as wetlands or the driest deserts (Van Aarde, 1987).

For **Baboons***, freshwater is generally considered a critical resource (100% closer than 300m, p>0,2). Surprisingly, they were often found distant to freshwater (77% further than 150m, p>0,2). As with the grysbok, high water content of vegetation might explain the results.

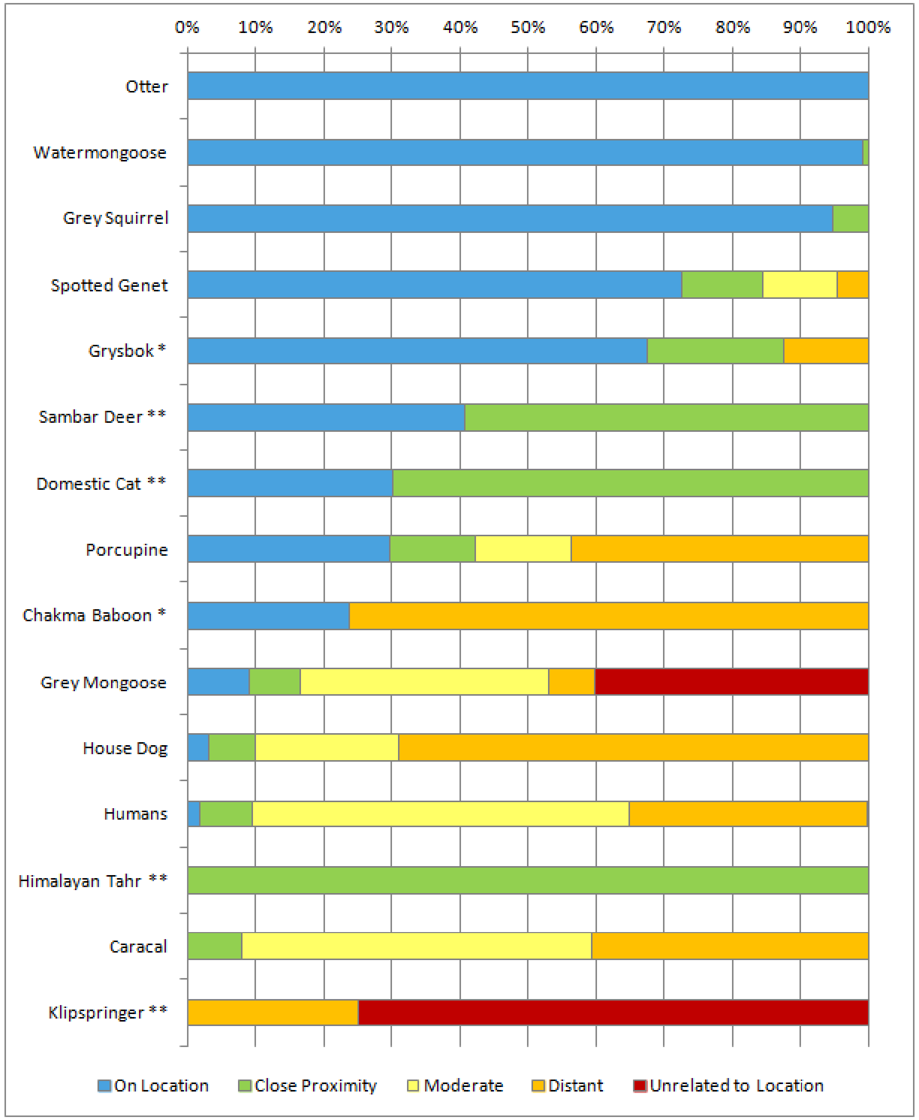


Figure 42 - Mean occurrence of animal species in different distances to permanent surface freshwater sources. Colour code correlates to Appendix 9.4, Map C.

Significantly higher probability of local baboons occurring far from permanent surface water was found in recent literature (Hoffman, 2011). The **Grey Mongoose** was recorded in all distances, but showed an outstanding preference for spaces particularly remote from freshwater sources (40% further than 300m, p>0,2; 83% further than 75m, p>0,2). This finding correlates with the grey mongoose's habitat in the dry montane sandstone fynbos. In its preferred habitat, the afrotemperate forest (showing a comparatively high amount of surface water), the grey mongoose mainly moves in a moderate distance to freshwater (51% between 25m and 300m, p>0,2) and only rarely visits the immediate surroundings of rivers (9% closer than 25m, p>0,2).

As **Humans** and (non straying) **House Dogs** are not directly dependent on surface water for their water supply, both their profiles show a preference for locations rather distant from water sources. Both, humans (91%, p<0,2) and dogs (90%, p>0,2) were mainly found further than 75m from freshwater. Dogs were walked even further away from rivers (69% further than 150m, p>0,2) than humans without dogs were recorded (35% further than 150m, p>0,2). The most human activity was recorded in moderate proximity to freshwater (55% between 75m and 150m, p<0,2). Both, humans and dogs, show a very similar spatial freshwater profile to the caracal.

The **Himalayan Tahr**** was only found in close proximity to freshwater (between 25m and 75m, p>0,2). It is known to use its mobility potential on the steepest slopes to ensure resource stability in respect to freshwater (Watson, 2007). On the Cape Peninsula water access therefore does not limit the tahr's success.

The **Caracal** showed an occurrence avoiding direct presence in proximity to water by being found exclusively in the moderate range from 25 to 300m distance (100%, p<0,2), and very often (92%, p<0,2) between 75m and 150m. It was never evident on a camera that was placed inside a 25m buffer zone around a river. The water demand is sufficiently supplied by the intake of the prey's body liquids (Wozencraft, 2005). The avoidance of freshwater spaces suggests, that the caracal prefers the plain, open terrain for hunting, whereas potential prey on the river banks could escape easily through the water or dense thicket on the riverbanks.

As an indigenous antelope the **Klipspringer**** is well equipped to cope with extensive droughts in rocky mountain areas and therefore never needs direct access to freshwater, but rather satisfies its water supply by consuming succulent vegetation containing high amounts of water. This is supported by the finding that 75% of Klipspringers occurrence was found more than 300m away from freshwater (p>0,2), whereas the remaining 25% never got closer than 150m to surface water (p>0,2). By staying in this extreme terrain, the klipspringer cam reduce the spatial overlap with the caracal as a potential predator.

4.3.6 Settlement Proximity

Domestic Cats** occurred exclusively on the urban edge (100%, p>0,2). Their behavioural adaptation as a domestic pet in combination with their small home ranges (Meek, 2003) make it seem unlikely, that they appear anywhere else.

The **Grey Squirrel**, as an alien species, unable to ingest the fynbos, needs the proximity to human settlements (87% Urban Edge, p>0,2), where they can feed of and live in the many alien plant species brought into the study area by humans.

The **Watermongoose** shows a clear preference for the urban edge (86%, p>0,2) and closely related spaces (97% closer than 300m, p<0,2). Throughout the study area, the combination of preference for low altitudes and necessity for freshwater leaves it no choice, but to live in close proximity to human settlements.

Chacma Baboons* occurred exclusively in areas very close to human settlements (72% Urban Edge, p>0,2; 100% closer than 300m, p>0,2). As they were only found in the Tokai pine plantation, which is situated right next to the Cape Town suburb "Tokai", their frequent interaction with humans and settlements is commonly considered inevitable. By using terms like "kleptomaniacs", "raiding", "plundering", etc. to describe their behaviour in the mass media (Mouland, 2013), the baboon's urban presence is perceived very emotionally.

Caracals were recorded in the most remote locations, as well as on the fences of estate settlements. Their main presence in spaces closer than 1200m to settlements (66%, p<0,1) and relatively high frequency on the direct urban edge (48%, p>0,2) suggests a comparatively strong

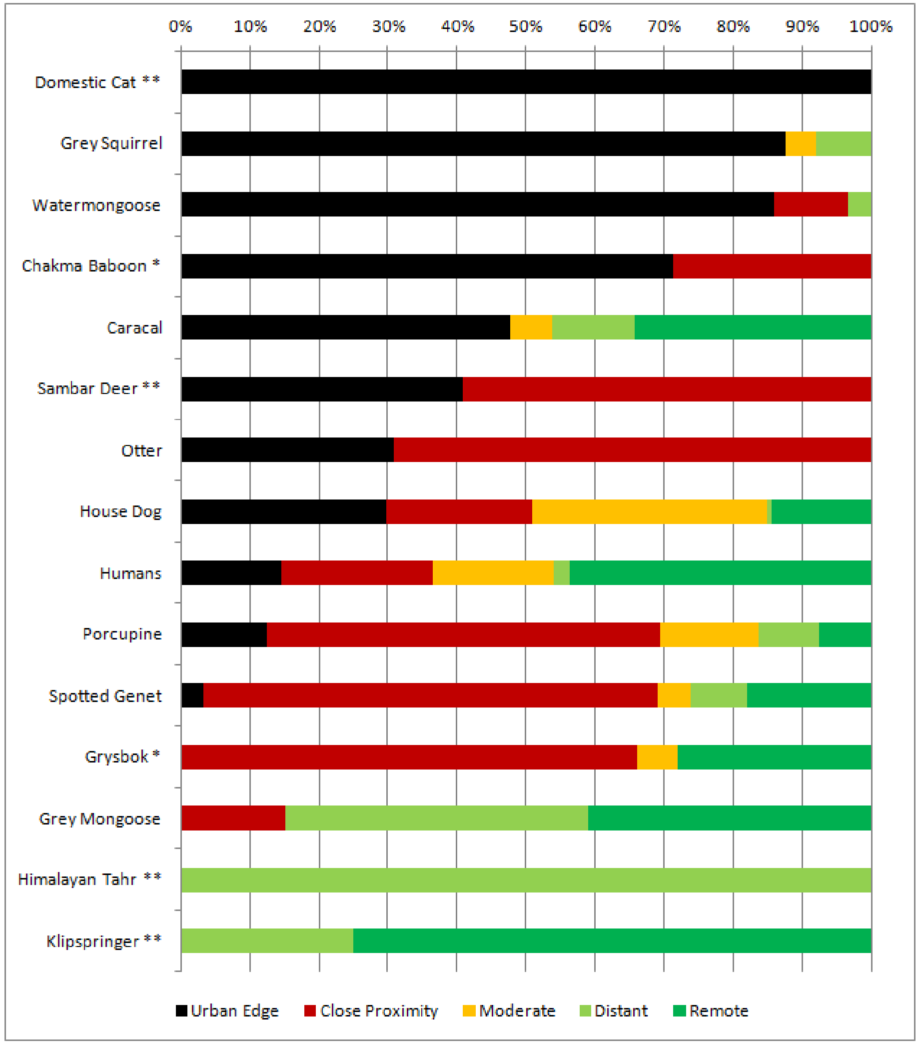


Figure 43 - Mean occurrence of animal species in different distances to permanent settlements. Colour code correlates to Appendix 9.4, Map D.

adaptation to the presence of settlements, but not to the direct presence of humans.

The **Sambar Deer**** was found exclusively in spaces closer than 300m to settlements (100%, $p>0,2$). Their affinity to low altitudes and their reported preference for well-watered habitats requires proximity to settlements in the study area.

Similarly, **Otters** were found exclusively in spaces closer than 300m to settlements (100%, $p>0,2$). Their strictly freshwater-related habitat in low altitudes gives them no option but to be closer than 300m. Compared to the Watermongoose, their presence in the urban edge zone was considerably lower (32%, $p>0,2$).

Humans, as well as **House Dogs** occurred throughout all settlement distance classes. Humans, by themselves, actually showed a trend, not to occur close to settlements but rather in "open nature" (14% closer than 50m, $p<0,2$; 43% further than 1200m , $p>0,2$), which probably relates to the fact, that the majority of captured humans were following a recreational activity where "natural" areas are preferred to suburbs. A perception of comfort and personal safety might explain the observation, that house dogs (being walked) were recorded more often in the zones closer to settlements (30% closer than 50m, $p>0,2$; only 14% further than 1200m, $p<0,2$) than humans by themselves.

Porcupines generally avoided the presence on the direct urban edge (88% further than 50m, $p<0,2$), but kept staying in a closer range (69% closer than 300m, $p<0,05$). They were recorded up to the most remote locations, making them seem quite ubiquitous. Their preferred range is between 50m and 300m distance (57%, $p<0,2$) which could be connected to their flatland affinity combined with an avoidance behaviour towards human activity.

A very similar distribution was found for the **Genet**, being able to occur throughout all studied settlement distance classes, but preferring the close proximity zone (50m-300m: 66%, $p>0,2$). They were found to enter the urban edge zone only very rarely (closer than 50m: 3%, $p>0,2$).

The **Grysbok*** was never recorded on the urban edge, but occurred most often relatively close proximity to settlements (150m-300m: 66%, $p>0,2$). It was also found comparatively often in the most remote locations (28% further than 1200m, $p>0,2$). Areas of close proximity often coincide with the availability of high-grown vegetation, which suits the elusive nature of small antelopes.

Grey Mongooses showed a very clear preference for habitat spaces far away from settlements (85% further than 700m, $p<0,2$; 41% further than 1200m, $p<0,1$). This finding coincides with their preference for the highest altitudes and montane fynbos vegetation.

The **Himalayan Tahr**** was found exclusively in distant locations (100% between 700m and 1200m, $p>0,2$), suggesting an avoidance of settlements.

Klipspringer** was the species observed to be the most distant from settlements overall (75% further than 1200m, $p>0,2$; 100% further than 700m, $p>0,2$), suggesting a strong avoidance of settlements as well.

4.3.7 Distance to Hiking Trails

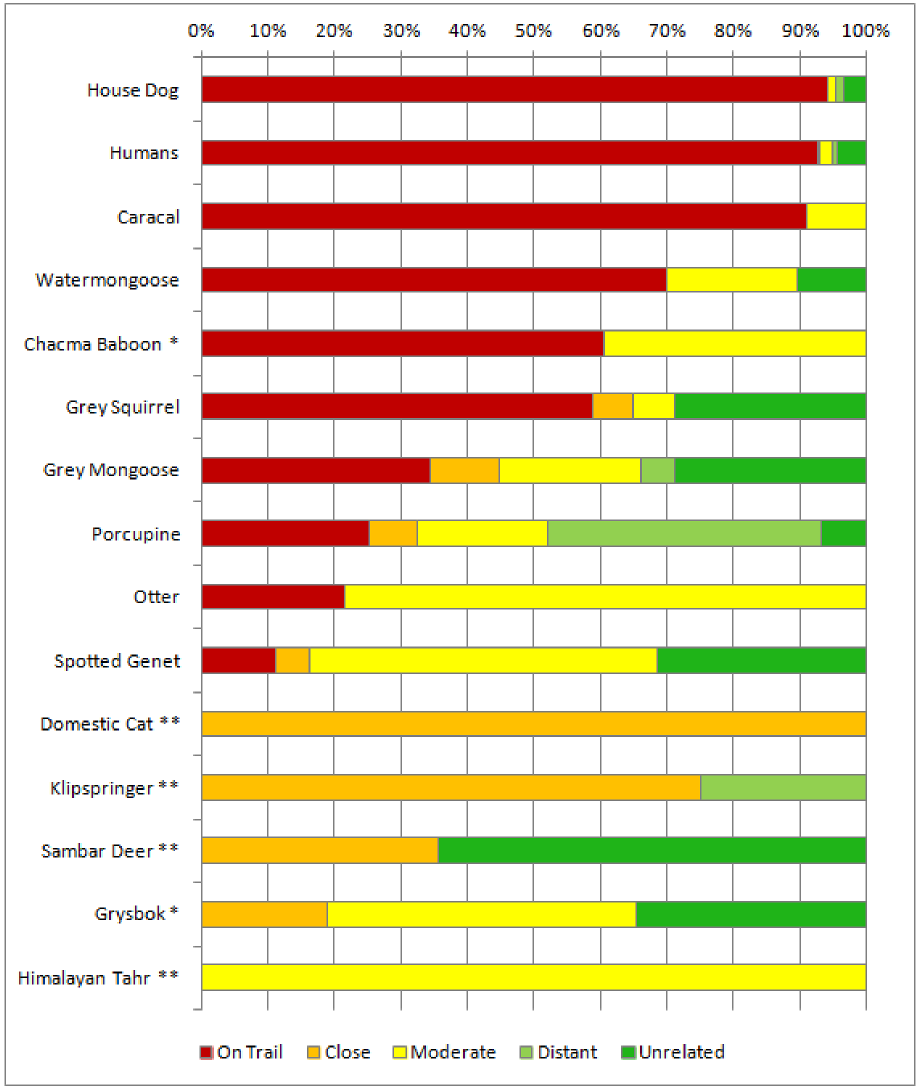


Figure 44 - Mean occurrence of animal species in different distances to publicly accessible hiking trails. Colour code correlates to Appendix 9.4, Map F.

Humans and **House Dogs** were found to be the most intense users of hiking trails. 94% of house dog occurrence and 92% of human occurrence was captured closer than 15m to trails (p<0,001 for both). As visitors and dog walkers are regularly reminded by signs and different media to not venture into off-trail spaces (SANParks, 2009), the regulations seem to be widely accepted.

The second most intense trail user was found to be the **Caracal** (91% closer than 15m, p<0,05). While it is widely known, that larger predatory felidae are more likely to be found on trails and roads (Lisek, 2013), the percentage of trail usage in the local caracal population is still surprisingly high. Possibly trails ease the caracal's hunting efforts.

The **Watermongoose** occurred with 70% trail usage (p>0,2), but was occasionally observed to venture far into off-trail areas (11% further than 120m, p>0,02). As the trail network is more dense in proximity to flat freshwater spaces next to urbanisation, where the Watermongoose was mostly recorded, this tendency might be explained by other covariates.

As **Chacma Baboons** were only recorded in the Tokai pine plantation (and considering their extraordinary amount of habituation towards humans), their trail usage of 60% (p>0,02) is not surprising.

The **Grey Squirrel** was recorded at all distances to trails. Considering its mainly arboreal lifestyle it is probably largely independent from trail usage and can be found where the vegetation is suitable.

Also for the **Grey Mongoose**, a wide range of trail distances could be found. It was recorded with 56% occurrence further away than 80m (p>0,2) suggesting a slight preference for off-trail spaces.

Porcupines were found at all distances to trails, but a preference for off-trail spaces (68% further than 80m, p>0,2) cannot be excluded. The strongest occurrence was found in the "distant" class (41% between 80 and 120m, p>0,2).

The **Otter** was only found with 22% trail usage (p>0,2). As it shares its habitat with the watermongoose, a more similar profile in trail usage would be expected. The much lower trail usage of the otter compared to the watermongoose might be a result of an avoidance behaviour towards human activity.

Genets occurred preferentially in off-trail areas (88% further than 15m, p<0,2; 83% further than 40m, p>0,2). Their avoidance of trail usage might be a behavioural adaptation to the strong presence of caracals in the trail space. Additionally, their small body size allows for better movement in off-trail areas than by larger animals. Human avoidance effects cannot be excluded as a possible reason.

Domestic Cats were only recorded in close proximity to trails (100% between 15m and 40m, p>0,2). The only recordings of cats were found in close proximity to suburban areas, which usually provide a more dense trail network.

Klipspringers were never found on trails, but in close and distant locations. As they roam the peak areas of Table Mountain, a habituation to mass tourism (75% "close", p>0,2) can be assumed. Although claimed to be a rare sight, even guided tourist tours are offered to find them (Gorrie, 2012).

The **Sambar Deer** was never recorded on trails, which is surprising due to its large body size making roaming in strongly vegetated areas fairly difficult. It was recorded as the animal with the highest usage of areas completely unrelated to trails (75%, p>0,2). An elusive, behavioural nature might be the reason for strict avoidance of human contact.

The **Grysbok** was never found on trails (100% further than 15m, p<0,2) and seems to prefer rather distant spaces (82% further than 40m, p>0,2) and showed the second highest occurrence in areas completely unrelated to trails (35%, p>0,2). Like with genets, the avoidance of trails might be a behavioural adaptation to the strong presence of caracals in that space.

The **Himalayan Tahr** was only found on cliffy parts relatively distant to hiking trails (100% Moderate, p>0,2). As the mountain sandstone cliffs represent the conditions of its geographic origins most, its preference for off-trail spaces could stem from different reasons than in other mammals.

5 Discussion

5.1 Mammalian Biodiversity

Many previous studies described the effects, metropolitan urbanization can have on the abundance and richness of wild mammals. Several variables determine if increasing or decreasing tendencies – for overall species richness or individual species' demographic parameters – are observed (McKinney, 2008). It is often reported, that urbanization is a major cause of native species extinction (Czech & Krausmann, 2000) and that "urbanization is increasingly homogenizing the biota", especially in less developed countries (Pauchard, et al., 2005). Both these negative impact interrelationships were found present in the city of Cape Town and only very recently modern "holistic" conservation measurements were enacted (2010) to increase the sustainability of the metropolitan growth in respect to biodiversity (Rebelo, et al., 2011). Today, around 90% of the untransformed natural remnant areas, representing 35,1% of the total city area, are considered areas with (future) active conservation measurements (Holmes, et al., 2012).

5.1.1 Current Situation

The conservational position of Table Mountain and Constantiaberg, regarding medium and large sized mammals, is considerably weak compared to other nature reserves in the Republic of South Africa: Only 9 native wild species were observed, which equals 15,5% of all observable species native to the Western Cape Province (58, see →3.3), (Lloyd, 2000). Another 3 introduced species, as well as 2 species of pets plus *Homo sapiens* affect the local ecosystem in a largely unpredictable manner. The 9 native species plus the above mentioned 6, sums up to a total of 15 species.

Typically, camera trap studies with a similar and comparable trapping effort, are able to capture approximately 80% of the present species (→3.3). Assuming this case, a predicted overall richness of around 19 species (100%) could exist; 4 species would have remained undetected. One of these species is definitely the Rock Hyrax (*Procavia capensis*), which is still occasionally photographed by tourists at the upper cable car station (→5.1.2.5). Overall, this estimate leaves few space for the 8 (!) undetected remaining native species, claimed by SANParks to exist within the boundaries of the study area (→3.3). These species (along with others) are more likely to be found in the southern section of the national park, but reintroductorial migration from this section into the northern section currently has to be considered highly unlikely. Even in its fullest extent, the most recent Biodiversity Network Conservation Plan (City of Cape Town Municipality, 2012) cannot ensure an uninterrupted surface corridor between the two sections in Fish Hoek Valley, as well as an uninterrupted surface corridor between the Silvermine-Tokai section and the Table Mountain section at Constantia Nek. Because of the critical function of these corridor areas in a future connected conservation plan, the insufficient corridors were mapped as a momentary biodiversity threat and increasing the connectivity of the conservation area has received a higher prioritisation (Benn, 2008).

Hereafter, short profiles of the observed species are given to illustrate the registered biodiversity (for RAI see →3.4; for Ψ & $\hat{p}$ see →3.6):

The **Cape Porcupine** (*Hystrix africaeaustralis*; RAI=5,2; Ψ=0,67; $\hat{p}$=0,06) was the most abundant wild mammal found in the study. Its activity is entirely nocturnal and its preferred habitat spaces are Orange Kloof, Silvermine and the Tokai plantation. It prefers less steep, low altitude environments and occurs rather distant from freshwater sources. It stays rather close to settlements and shows no preference for hiking trails.

The **Cape Large Spotted Genet** (*Genetta tigrina*; RAI=5,2; Ψ=0,47; $\hat{p}$=0,05) was as abundant as the porcupine, but utilized a smaller and more specific area. Their activity is largely crepuscular; diurnal activity decreases with human disturbance. The strongest populations were found at the Silvermine reservoir and in Orange Kloof. It avoids altitudes above 600m and transformed vegetation. It was mainly found close to streams, possibly hiding in the dense thicket from its only predator, the caracal. They do not access urban areas and prefer off-trail spaces.

The **Watermongoose** (*Atilax paludinosus*; RAI=5,6; Ψ=0,20; $\hat{p}$=0,11) was very specifically bound to lowland freshwater spaces in close proximity to urbanisation, where it occurred in large numbers. Its activity was entirely nocturnal with an evening maximum, contrasting the otter's morning maximum. It competitively shares its ecological niche with the otter. The highest activity was recorded in Fish Hoek, but it also occurred in the Tokai plantation and in Orange Kloof.

The **Cape Clawless Otter** (*Aonyx capensis*; RAI=4,1; Ψ=0,06; $\hat{p}$=0,36) was found to be even more specific in its lowland freshwater habitat requirements than the watermongoose. During the study it was only found in Fish Hoek Valley, but recent trapping data proves its occurrence at the suburban Liesbeek river (Okes, 2013). Because of its habitat requirements it is bound to live close to urbanization, but avoids human contact when possible. When present at a site it is highly detectable.

The **Cape Grey Mongoose** (*Galerella pulverulenta*; RAI=1,5; Ψ=0,27; $\hat{p}$=0,04) was less abundant than the watermongoose, but more flexible when choosing its environment. Its activity was completely diurnal and its preferred areas are Orange Kloof, the plateau of Table Mountain, as well as the Silvermine Reservoir. It is likely to be found on the steepest, highest altitudes, far away from freshwater. It stays in untransformed spaces and avoids proximity to settlements.

The **Caracal** (*Caracal caracal*; RAI=1,4; Ψ=0,27; $\hat{p}$=0,04) is the top-level predator and the largest carnivore of the study area. Its normally mixed activity pattern shifts to completely nocturnal behaviour throughout the study area. It is the only wild species that is likely to move between the two sections regularly. The Tokai plantation and Orange Kloof are their preferred areas. It is not found close to freshwater, as it serves its demand by prey intake. It mainly utilizes hiking trails and ventures close to the urban edge. The potential prey species are smaller rodents, birds, genet, grysbok, rock hyrax, klipspringer and possibly house cats.

The **Grey Squirrel** (*Sciurus carolinensis*; RAI=0,9; Ψ=0,16; $\hat{p}$=0,06) is an accidentally introduced, invasive alien species from North America and unable to ingest the fynbos vegetation. Therefore it can be found in low flatland forest settings (such as Tokai and Orange Kloof), but mainly stays in suburban areas near freshwater. Its activity is entirely diurnal.

The **Cape Grysbok** (*Raphicerus melanotis*; RAI=0,6; Ψ=0,39; $\hat{p}$=0,01) is rare, but still the most common species of antelope found. It displays a very elusive, mainly nocturnal activity and is targeted as prey by the caracal. Its strongest abundance was found at the Silvermine reservoir. It prefers thicket to trails and avoids presence at the direct urban edge. Its high area occupancy suggests that its true population density is possibly underestimated by the RAI.

The **Chacma Baboon** (*Papio ursinus*; RAI=0,7; Ψ=0,08; $\hat{p}$=0,02) has largely vanished from the study area and remains present with four troops consisting of 218 animals in and around the Tokai pine plantation. It is diurnally active and heavily habituated to human presence leading as far as repeated "raiding attacks" on closely situated suburban areas. To prevent unwanted interaction with humans, specialized field workers are employed to continually monitor and control the troops.

The **Himalayan Tahr** (*Hemitragus jemlahicus*; RAI=0,76; Ψ=0,03; $\hat{p}$=0,12; IUCN - Near Threatened) is an accidentally introduced invasive alien species from the Himalayas. The tahr prefers the highest and steepest slopes and only one pair, male and female, was found on the "backtable" of Table Mountain, which was captured during night and day likewise. The tahr population was subject to a recent extermination campaign in an attempt to remove possible competitors of the newly reintroduced small klipspringer antelope.

The **Klipspringer** (*Oreotragus oreotragus*; RAI=0,2; $\hat{\Psi}$=0,06) was native to the peninsula and became locally extinct during the 1930s. 37 individuals were reintroduced to the national park in 2004/05. Like the tahr, it prefers the highest and steepest slopes. It is active diurnally and stays distant from freshwater, because vegetation intake serves its water demands. Because of its preferred habitat on the plateau of Table Mountain it is suspected to be partially habituated to mass tourism.

The **Sambar Deer** (*Rusa unicolor*; RAI=0,1; $\hat{\Psi}$=0,03) is an accidentally introduced invasive alien species from South-East Asia. Only twice, a male individual was recorded in the lowland thickets of both, the western and the eastern side of the Table Mountain range. Remaining animals are likely to be eliminated or relocated.

One individual **House Cat** (*Felis catus*; RAI=0,1; $\hat{\Psi}$=0,06) was recorded twice in proximity to suburban settlements. The few captures indicate, that most cats stay in closest proximity to their owner's properties, so therefore only little interaction with wildlife has to be assumed.

Furthermore, numerous humans and house dogs were captured. Their profiles and impact are discussed under →5.3.

5.1.2 Spatial Population Quality

Following main objectives of this study are answered in this chapter:

1. Identification of biodiversity hotspots, which offer the highest habitability to terrestrial mammal wildlife.
2. Information about local densities of the remaining species.

Throughout the study area, three main hotspots could be identified, which are portrayed in this chapter to deliver landscape-level information which can assist decision makers in their efforts for future conservation measures.

These hotspots are (from N to S):

Orange Kloof	5,5 km^2	21,2% of RAIs	3,9% $^{RAIs}/_{km^2}$
Silvermine	11 km^2	23,4% of RAIs	2,1% $^{RAIs}/_{km^2}$
Tokai Plantation	7 km^2	32,7% of RAIs	4,7% $^{RAIs}/_{km^2}$

Together, these hotspots cover 23,5 km^2 (40% of the study area), but include a sum of 77,3% of the observed wildlife as measured by RAIs.

To provide comparable information on a species' occurrence, the local average RAI is shown in brackets. With the exception of the caracal, which is surprising with its comparatively high abundance despite the high territorial requirements listed in literature, most species display distributions, that do not need the assumption of large migratory effects between the identified hotspots to maintain their populations. Because of the special role of the caracal as the only top-level predator found in the study area, its spatial population quality is discussed separately.

Furthermore, the unexpected absence of the Rock Hyrax (Procavia capensis) is reviewed seperately.

5.1.2.1 Hotspot "Orange Kloof"

The protected area of Orange Kloof offers an abundance of vegetation diversity (including indigenous Afromontane forest), above-average precipitation and therefore a high availability of freshwater and access is restricted to humans. The valley is positioned relatively secluded from motorized traffic and mass tourism. These factors were found to generate a viable environment for the following species: Porcupine (7,2), Large Spotted Genet (4,1), Grey Mongoose (3,9), Caracal (2,5), Watermongoose (1,5) and Grey Squirrel (1,0). With a surface area of around 5,5 km^2, it can be considered large enough to sustain a few reproducing couples of all named species except for the caracal, even when complete isolation is assumed. For example the typical territorial requirement of a porcupine couple was found to range around 1km^2 (De Villiers, et al., 1994), which would theoretically allow for 11 individuals throughout the valley. The steep forested western slopes (eastern aspect) of the Orange Kloof valley seemed to provide the best environment for genet, grey mongoose and caracal, whereas porcupine, grey squirrel and watermongoose were found preferentially in the comparatively flat forested valley basin providing larger river banks. Lower presence of mammals in Orange Kloof was recorded for the eastern slopes (western aspect) covered by lowland fynbos vegetation. The substantially lower presence of humans (33,3) and dramatically lower presence of house dogs (2,0), resulting from a dog walking ban, indicates that Orange Kloof is not only the least disturbed part of the Table Mountain section, but also the least disturbed of all identified hotspots.

5.1.2.2 Hotspot "Silvermine"

The Silvermine Nature reserve encompasses a characteristic montane sandstone fynbos environment with restricted access and ranges in its northern subsection (the southern subsection was not sampled) from Ou Kaapse Weg (M64 main road) over the peak of Constantiaberg to the mountain pass of Constantia Nek, where it is separated from Orange Kloof by three roads. The highest densities of mammals were found in the high valley south of Constantiaberg in proximity to the freshwater reservoir, ranging over Noordhoek Peak down to Chapman's Peak Drive. Mammal presence north of Constantiaberg is more likely to be connected to populations in the Tokai pine plantation. The following species were found to prefer this section of Silvermine to most other spaces of the study area: Large Spotted Genet (8,9), Porcupine (5,2), Grey Mongoose (4,0), Grysbok (2,1), Watermongoose (1,2) and Caracal (1,0). For the grysbok, the area seems to be the largest connected habitat. The identified hotspot area covers a surface of approximately 10 to 12 km², allowing for isolated stable populations south of Constantiaberg (except for the caracal). The highest local mammal biodiversity was found between the reservoir and the northern end of the high valley. The more than double average presence of humans (260,8) and house dogs (47,4) in the area indicates a comparatively large disturbance. Species that show partially diurnal activity in completely wild environments (such as Genet, Grysbok and Caracal) were observed to shift their behaviour to a more nocturnal activity in highly disturbed areas. The generous spacing of hiking trails, as well as strictly enforced opening hours (08:00-18:00) help to limit the impact of recreational human activity.

5.1.2.3 Hotspot "Tokai Plantation"

The Tokai pine plantation habitat hotspot is not only the transformed environment consisting primarily of the commercial pine plantation and a recreational forest area ("Arboretum"), but also includes the bordering areas at the southern end to Ou-Kaapse-Weg and the northern end up to the less steep slopes of Constantiaberg at Hoerikwaggo Trail. The access up to the high plateau areas of Constantiaberg is eased by the availability of multiple hiking trails as well as a paved road built for maintenance of the radio antenna on the summit. The following species were found to prefer the plantation and the surrounding spaces to other areas: Porcupine (16,3), Caracal (5,2), Chacma Baboon (5,0), Watermongoose (2,7) and Large Spotted Genet (1,5). Grey Squirrel (0,3) and Grysbok (0,3) were found there, but seem to prefer other hotspots. This hotspot area covers a surface of approximately 7 km² including the accessible plateau slopes north of Constantiaberg's summit, allowing for a small, but sufficient number of isolated reproducing couples for all species displaying an RAI > 1,0, except for the caracal. Migration between the plantation and Silvermine is possible. The plantation is used very intensely by the local humans for recreational and sport activity. This is supported by the extraordinarily high average indices of humans (327,5), as well as house dogs (51,8). Although the central plantation area is not permitted for dog walking, the close surrounding areas receive a high number of local dog walkers from nearby suburbs. Porcupines in their strictly nocturnal activity pattern, as well as baboons, which are highly habituated to human presence in the area, seem to thrive especially well throughout the plantation and its surroundings.

5.1.3 Territory of the Caracal

The caracal's reported territorial requirements range at 7,6km^2 for females and between 15,6km^2 and 26,9km^2 for males in West Coast National Park (80 km to Cape Town)(Avenant & Nel, 1998). In the arid environment of Saudi Arabia the home range is known to increase up to 1116km^2 for a single male individual male (Van Heezik & Seddon, 1998). The home ranges of males and females overlap completely. Considering the smallest average habitats, a maximum of 4 male and 8 female caracals could exist within the study area. None of the identified hotspots by itself would provide a sufficient area for a single male caracal. Therefore it has to be considered highly likely, that the caracal's population moves throughout the study area, possibly even crossing the road at Constantia Nek. Prey availability is known to determine the size of the minimum home range, caracals territorialize. Potential prey species analyzed during the study are the large spotted genet, as well as the grysbok. Smaller sized rodents form a substantial part of the caracal's diet (→4.1.13.1) and were found in the study area (→3.3), but not quantified. The hypothesis remains speculative, that some caracals strongly prey on the rock hyrax populations, which were artificially stabilized by tourists feeding them in the past. Still, an overabundance of prey could not be found for any of the listed species, limiting the possibility that the caracal downsizes its home range because of an overly easy availability of natural food sources. Direct anthropogenic effects (such as feeding on pets or human waste), or indirect anthropogenic effects (such as unintended feeding of prey species) have to be considered a possible influence on caracal 's density.

5.1.4 Disappearance of the Hyrax?

An comparatively high abundance of caracals puts the formerly ubiquitous Rock Hyrax (*Procavia capensis*) population on Table Mountain under stress. Caracals were found to be the main regulator of hyrax populations in the Karoo (Fourie, 1983).

Additionally, the protection of the Verraux's Eagle or Black Eagle (*Aquila verrauxii*), as well as other regularly breeding raptor populations (Jenkins & Van Zyl, 2002) like Jackal Buzzard, Peregrine Falcon, Rock Kestrel and White-necked Raven make up a total of about 100 breeding pairs of cliff-nesting raptors and ravens on the peninsula. As the *Aquila verreauxii* population was considered severely depleted in 2002, conservation projects started to monitor the breeding process. According to the Southern African Bird Atlas Project 2 running since 2007 (Brooks, 2011), the reporting rate of the eagle increased on the Cape Peninsula especially in 2012 and 2013. Both pairs of eagles on Table Mountain breed where hyrax populations remained intact. At least for the ‘cable car’ eagle pair, visitors feed the hyrax and this (together with caracal activity) appears to have stabilised the well documented, but extremely localized population sufficiently to support the eagle's survival. This notwithstanding, more preyed birds are delivered to the Silvermine nest, indicating a dearth of hyraxes in the general environment (Simmons, et al., 2007). The fact that during the whole setup of this camera trap study not a single individual hyrax was recorded on camera traps, supports the hypothesis of heavily diminished populations by the means of predation. A complete loss of the "famous" Table Mountain hyrax population might also generate an unpredictable effect on tourism.

5.2 Review of Historical Biodiversity

5.2.1 First mentionings in Literature

First mentionings of larger terrestrial species on the Cape Peninsula in western literature have to be treated with care, because misidentifications were very common until 1800. Often the most likely species can be extracted from additional information given in the historical records. Historical records were based on Volume 1 of "Historical Mammal Incidence in the Cape Province" (Skead, 1980):

1591: Big red deer, possibly Red Hardebeest and other antelopes, "overgrown monkeys", well-fleshed "oxen" and "sheep, like in Syrie"; James Lancaster.
1601: "Roes", possibly Rhebuck, Grysbok, Steenbok or Duiker; Joris van Spilbergen.
1605: "Babious" = Baboons, "Foxes", Hares, Ostriches; Edward Michelbourne. Neither the Cape fox (*Vulpes chama*), nor the bat-eared fox (*Otocyon megalotis*) occurred then on the Peninsula, so possibly jackals are meant by these early records.
1609: "Antelope" at Liesbeek River, eastern mountain slope and flatland; William Keeling.
1610: Porcupines, Lions, Leopards and "Tigers", possibly meant Serval; Nicholas Downton
1612: Baboons and "Monkeyes", possibly Vervet monkeys; Thomas Best. But Skead argues that, if vervets would have remained until the arrival of Van Riebeeck, they would have been described by him in his 10 year long stay, concluding that there were no vervets on the Peninsula before the settlers arrived.
1615: Cape Blesmol; Walter Peyton.
1620: "Cervine deer" near today's Rondebosch and southern suburbs, David Pietersz de Vries.
1620: Black-backed jackal, Canis mesomelas; Augustin de Beaulieu
1629: "Cunnies", probably Rock Hyrax, Robert Stodard.
1640: Wild Bush-Dogs (*Lycaon pictus*); Nicolaus de Graaf
1652: *Genetta genetta* near Kloofnek, back then confused as "Civets"; Jan van Riebeeck
1656: "Steenbok", has to be treated with care and is possibly not *Raphicerus campestris*, known today as Steenbok but rather a red hartebeest or an eland; Jan van Riebeeck
1657: "Leopard sized Bush Cat" = *Felis serval*; Jan van Riebeeck
1666: "Large wolf" = Hyenas at Hout Bay and Kirstenbosch, collected 1901 by H. C. V. Leibbrandt, Cape Archives
1772: "Zorilla, *Viverra putorius*" = Stinkmuishond/Skunk, which means Cape polecat (*Ictonyx striatus*), O. F. Mentzel
1772: Grey Mongoose, Genets at Hout Bay and Constantia, "Lynx" = Caracal, Serval, Leopard and "Grey cat" = African Wild Cat (*Felis silvestris lybica*); Andreas Sparrman
1776: *Caracal caracal*, Table Mountain; J. C. D. von Schreber.
1787: Spotted Hyena (*Crocuta crocuta*); O. F. Mentzel
1797: "River Otter" = Cape clawless otter (*Aonyx capensis*); John Barrow
1816: "Wolves" = Hyenas, possibly strandwolf (*H. brunnea*) instead of Spotted Hyena (*C. crocuta*), Wild Dogs, Jackals and Leopards; Kirstenbosch and Newlands; C. I. La Trobe

Also, mammals that were never directly recorded on Table Mountain or the Peninsula, but an occurrence could be considered possible, have to be listed:

- Scaled Anteater or Pangolin; although the habitat fits its needs, it was restricted to Northern Cape province and the Eastern Cape (Queenstown).
- Honey badger (*Mellivora capensis*) was never recorded on the Peninsula, but might have well occurred because it was not as dependent on the vegetation, but rather wild beehives which occurred aplenty. The closest record to the study area was found in the late 1730's by Mentzel approximately 9 km west of Stellenbosch, which is about 30 km east of Table Mountain. The potential "reintroduction" of the badger to the study area was repeatedly discussed during the past years, but the historical occurrence is rather questionable.

- A Mountain Hare, described as being red tailed, was found by Mentzel close to the badger in the late 1730's and is possibly identified as Red Hare, *Pronolagus rupestris*.
- Aardwolf (*Proteles cristata*) was never recorded on the Cape Peninsula, but could have been there due to its strictly nocturnal and evasive habits. Records are available from the Cederberg area (more than 100 km to Cape Town).
- Cheetahs (*Acinonyx jubatus*) never occurred on the peninsula. Mistaken records are based on Raven-Hart 1966, who found the listing of Johan Schreyer 1679 ("leopard, panther, ...") as evidence that not only leopards, but also cheetahs must have been prevalent. Topographically the next record only shows up in Namaqualand, too far away from the Peninsula to be considered a related habitat.
- The Aardvark or Antbear (*Orycteropus afer*) was never found on the Peninsula itself, but C. Thunberg referred to a specimen in the Cape Flats in 1772 which would make an occurrence on the Peninsula likely, but later records are only found in the Malmesbury district, approximately 40 km North/North-East of Cape Town.

5.2.2 Documented Species Loss

The mammal biodiversity of the metropolitan area was subject to a severe loss of species practically since the arrival of the first settlers at the Cape (Rebelo, et al., 2011). Probably far from being complete for smaller mammals, the following species are known to have existed in the study area until approximately 1700 in substantial numbers (if known, the last evidence on the Cape Peninsula or the Cape Flats as well as IUCN Conservation Status are shown in brackets)(Skead, 1980)(IUCN, 2014):

Figure 45 - Categorization of IUCN Red List Status Abbreviations

- Cape Lion (1802, EX) *Panthera leo melanochaitus*
- Leopard (1920, NT) *Panthera pardus*
- Serval (1898, LC) *Leptailurus serval serval*
- African Wild Cat (unknown, LC) *Felis sylvestris lybica*
- Spotted Hyena (1818, EN for Cape Prov.) *Crocuta crocuta*
- Black-backed Jackal (1816, LC) *Canis mesomelas*
- African Bush Elephant (1702, EN) *Loxodonta africana*
- Black Rhinoceros (1787, CR) *Dicerus bicornis*
- African Bush Dog (1873, EN) *Lycaon pictus*
- Quagga (1826 (?), EX) *Equus quagga quagga*

A currently running project is trying to selectively re-breed the quagga near Rhodes Memorial, after molecular studies on mt-DNA showed, that the quagga was a subspecies of the plains zebra (Leonard, et al., 2005).

The following species were considered exterminated around the City of Cape Town and were reintroduced to the southern section of the national park on the peninsula near Cape Point:

- Common Eland (LC) *Taurotragus oryx*
- Mountain Zebra (VU) *Equus zebra zebra*
- Bontebok (EN) *Damaliscus pygargus pygargus*

The numeric decline resulting in local extinction of the Klipspringer (LC) *Oreotragus oreotragus*, was foreseeable by 1930. Reintroduction of 37 animals to the National Park was performed in 2004 and 2005. To provide a satisfactory habitat for the Klipspringer, the Himalayan Tahr (NT), as a competitive alien species, should have been exterminated likewise (→5.3.4)(Zimmermann, 2006).

5.3 Anthropogenic Influence

5.3.1 Historical Human Impact

The first major environmental impact by modern humans in the study area is believed to have happened between 2500 and 2000 years ago, when nomadic members of the Khoikhoi culture settled down at the Cape to herd their "Nguni cattle" (*Bos indicus* hybr. *Bos taurus*), as well as sheep and goats brought from the Bantu people residing further north (Boonzaier, 1996). Probably the Khoikhoi displaced the "San bushmen", subsistence hunter-gatherers who previously occupied the area.

On the arrival of the European settlers around 500 years ago, large herds of wild antelopes supporting a substantial variety of predators are reported. In the following 350 years, the highly abundant afrotemperate forest was used for a growing timber industry. Accessible and fertile fynbos patches were replaced by commercial agriculture. Habitat transformation and excessive game hunting (for meat and derived animal products) diminished the mammal biomass and diversity rapidly. Trophy hunting (mainly to serve demands for exotic products in colonial Europe) and protective predator eradication campaigns were unregulated and resulted in radical impacts on the ecosystem (Skead, 1980). A logarithmic expansion of the urbanized area, triggered by the spatial demands of industrialization in the 19th century, led to the construction of freshwater reservoirs on the mountain range, increased overall pollution levels and further decreased the extent of natural habitat spaces hosting (endemic) biodiversity. In the 1970s, the city inhabited 1 million people and superseded the vegetation area in size.

The growth of the city did not stop yet. In fact, it is likely that the threshold of 4 million inhabitants is reached before 2020, assuming that the migration rate stays as high as it has been recorded throughout the past decade (Small, 2001). The effects of urbanization and human activity have manifold impacts, dependent on the specific interactive system in question. The strongest effects are highlighted hereafter.

5.3.2 Settlement Development

Some species are highly adapted to the presence of settlements and frequently enter clearly defined human areas: Cape Porcupine, Watermongoose, Chacma Baboon and Grey Squirrel

High levels of direct interaction with humans in urban areas usually requires the diurnal activity of the wild animal, as well as its presence. Hence, only the baboon (activity overlap: 62%) and the squirrel (89%) fulfill these criteria. While the squirrel only possesses minor abilities to disturb suburban humans in their daily life, the baboon is often judged as a pest, believed to leave a great mess and endanger children and pets (for further information on the conflict of local baboon troops entering suburban space, see →4.2.10).

The porcupine and the watermongoose evade the presence of humans with their strictly nocturnal behaviour (overlap with humans <5%). This behavioural strategy allows them to utilize intermediate green city corridors as their permanent territory and potentially feed regularly on anthropogenic food sources. Patches of comparatively thick, undisturbed vegetation are still considered a basic requirement, to retreat throughout the day.

To other species, the borders of urbanization form the limit of their home range almost like a physical barrier: Large Spotted Genet, Cape Clawless Otter and probably the Caracal. These animals occur up to the urban edge, but refrain from entering settlements. Further expansion of the urbanized settlement areas would affect the habitat usage of these species directly, by narrowing their territory and hunting opportunities. On the other hand, it has to be considered possible that they opportunistically utilize prey sources which are unique to the urban edge environment, such as garden rodents. All of these species are potentially crepuscular predators which probably decrease their diurnal activity component when approaching the urban edge. This was especially clear for the caracal (→4.1.11).

The remaining species stayed on a further distance to urbanization: Cape Grey Mongoose, Cape Grysbok, Klipspringer and Himalayan Tahr. They were never found venturing closer than 150m to urbanized environments. Further expansion of the urbanized settlement areas would decrease the available space for these species quadratically, as they typically maintain a certain buffer distance. These species prefer inaccessible topography and retreat into the thicket when encountered by humans during the day (mongoose, klipspringer) or during their diurnal activity component (grysbok, tahr). The populations of the described species of this last category are potentially the most vulnerable, if more natural areas were transformed.

5.3.3 Recreational Activity and Tourism

Unfortunately, the absolute hotspot of direct human presence in the study area (3000 visitors per day) - the proximity of the Cable Car station - could not be surveyed for human activity by camera traps without risking the loss of equipment or data. Similarly, the popular Newlands area, as well as the central parts of the Tokai plantation were considered too publically frequented to leave a camera trap on the hiking trails.

The locally highest density of runners, hikers and mountain bikers was recorded at the intersection of Hoerikwaggo trail with the paved infrastructure road leading to the Constantiaberg antenna. The value of 89,1 humans per week was reached nowhere else and multiple discoveries of this camera trap were evident. Other hotspots include the public hiking trails of Silvermine (Reservoir and Noordhoek Peak; 44,8 humans per week; traps were also discovered), the southern end of the Tokai plantation at Zwaanswyk Estate (25,2), the mountain hiking path starting from northern Chapman's Peak Toll Plaza (18,1), the low mountain slopes at Camps Bay (15,7), the ring road of Orange Kloof and Disa Gorge (5,6), as well as the Liesbeek river in Bishopscourt (4,2).

The average RAI was 108,48; the average occupancy (Ψ) was 0,67 at a 24h detection probability ($\hat{p}$) of 0,16. RAI and Ψ both were the highest values found during the study. 24h detection probability if present at site ($\hat{p}$) was only surpassed by the otter. Humans were exclusively diurnally active in the study area. A total of 56,3% of human activity was registered on the weekend (Sat+Sun). Hiking trails are used by 92% ($p>0,001$). All other covariates tested were relatively equally dispersed within humans.

Recreational activity affects all species in the study area because of its ubiquitous presence. Generally, disturbance effects on those animals, which display a diurnal activity pattern or typically feature a diurnal component in their activity pattern, will be larger than on animals that are typically active nocturnally. Behavioural adaptations, to avoid the diurnal activity pattern of humans, were found for the caracal (which cuts out its diurnal component completely), for the watermongoose (which is active later in the night rather than in the evening), as well as for the grysbok and the genet (which are both likely to reduce their diurnal component when being close to humans). The genet was found to reduce its overall activity drastically between Saturday and Monday.

Feeding attempts by tourists were not recorded, but the strongest habituation effects are reported for the baboon and the rock hyrax (Sinclair, 2010). The problematic artificial feeding of baboons is reported to have declined so significantly, that breeding rates are back to a more natural level (Richardson/HWS, 2014).

5.3.4 Domestic Dogs

The study showed, that most domestic dogs regularly get walked in permitted areas. The highest dog densities were recorded next to the fencing system of Zwaanswyk Estate (13,3 dogs/week), on the mountain hiking path starting from northern Chapman's Peak Toll Plaza (12,4), in Silvermine (Gate 1 parking and Noordhoek Peak) (8,2), North of Constatiaberg at Hoerikwaggo Trail (4,6) and in the surroundings of Camps Bay (4,0).

The average RAI was 22,25; the average occupancy (Ψ) was 0,47 at a 24h detection probability ($\hat{p}$) of 0,11. A smaller Ψ than for humans indicates, that dogs are walked in more specific areas than the ones, humans choose for recreational hiking without dogs.

The average accompaniment rate found in the study area is 20,5%. In other words, approximately every fifth human was accompanied by a dog. No accompaniment rate could be calculated for the top of Table Mountain and Newlands, because the camera stations had to be hidden from trail access to prevent vandalism and theft. Official reports state, that 60% of walkers are accompanied by dogs in Newlands (SanParks/Setplan, 2001) providing much higher disturbance when anywhere else. Almost no mammal biodiversity (except for a single visit by a single porcupine) was found in Newlands, suggesting a severe eviction of wild mammals, which try to avoid frequent encounters with house dogs. On the peak of Table Mountain, almost no disturbance is expected, as the transportation of dogs is usually suppressed by the Cable Car Management.

Where local conservation regulations should prevent dog disturbance, only individual violations were evident. In the Orange Kloof area, where even hiking is restricted and dog walking is strictly forbidden, a maximum of 0,5 walked dogs per week was recorded.

Dog walking was seen to take place mainly during the late morning and late afternoon. Over 50% of dog walks were performed on the weekend (Sat+Sun), which temporally limits the disturbance for many species. The large overlap of human activity with dog activity (88,1%) and the absence of nocturnal or crepuscular dog activity allow the assumption of negligible wild dog / stray dog populations in the study area. 94% of dog occurrence was recorded not further than 15m from hiking trails ($p<0,001$).

Most observed wild species seem to tolerate moderate dog walking activity. The grysbok was the only species, which was solely found in locations where almost no dog walking took place, or the dog-walked hiking path was at least 50m away. Newlands, while being rich in indigenous plant diversity, can serve as a possible example for an overabundance of house dogs resulting in overall mammal biodiversity emigration.

5.3.5 Effects of Recent Conservation Measures

Although the Table Mountain National Park Management Board declared the alien species "Himalayan Tahr" and "Sambar Deer" as eliminated from the study area in 2004 by public notice of Brett Myrdal, this study found evidence of both species.

Considering the Sambar Deer, only the evidence of one male individual recognized by its antlers can be considered. As long as no female Sambar Deer can be proven in the study area, reproduction of this species has to be considered highly unlikely due to negative perspectives for external immigration.

The tahr was largely euthanized due to its expected competitive suppression of the indigenous klipspringer, which was reintroduced with 37 individuals in 2004/05 into the National Park. Of this species, an adult male and female were found moving together. This finding allows for a bottleneck situation and a newly emerging population would have to be expected in the next years, if no new displacement or extermination program is set up by the management boards. The build-up of a new population is expected to take place relatively quickly as the pre-2004 tahr population of approximately 140 individuals emerged from one fugitive pair near Rhodes Memorial in the 1940s.

5.3.6 Future Conservation Recommendations

The general landscape-level disintegration of transformed environments and alien vegetation patches is necessary to deliver space for the protected regeneration of indigenous vegetation such as fynbos and afrotemperate forest. This measure can increase the habitat space available for native terrestrial mammals and, by providing natural food sources, increases reproductive rates to stabilize populations.

Furthermore, the connectivity of the existing conservation area sections could be increased by building large-sized wildlife crossings with channelling fences under the roads of Constantia Nek (M63 and Bay Road) and at Chapman's Peak (Chapman's Peak Drive). The widely accepted measurement (concrete tubes, 1m diameter) would not only decrease habitat fragmentation (Haas, 2000) and reduce wildlife accidents (roadkills are reported to affect tourism negatively (Hobday & Minstrell, 1998)), but also increases road safety. Camera traps could be used to monitor the acceptance of the tunnels and estimate the population migration between the sections of the National Park (Donaldson, 2005). Only when substantial connectivity between the sections is proven, new reintroduction programs should be considered.

5.4 Critical Methodological Outlook

In total, the methods used, provide a decent overview of the landscape level mammal biodiversity found within the study area. Camera trapping seems the safest, most affordable and least invasive way to obtain reliable long-term data on the local behaviour of elusive species. The method reached its limit, when the amount of human activity at a designated sampling station was so high, that positions in close proximity to hiking paths could not be chosen anymore, because the equipment was at risk of vandalism or theft. This resulted in an obvious bias of the data on human activity, promoting high densities at medium-frequented locations, while leaving out data on the absolute peak activity locations. Technical solutions will decrease the risk of theft or discovery in the future, for example by miniaturizing sensors, accumulators and electronic components, while sensitivity and networking capabilites will increase. Therefore, a similar study setup should be performed in the coming years to increase data fidelity and to observe possible demographical changes in the species populations found. Another option to increase data fidelity, would be the short-term repeated surveying of the trapping locations, firstly off-trail on animal paths in the thicket and later directly on hiking trails.

Furthermore, direct data for the urban area itself, is still largely missing. The notorious problem of predicted equipment loss prevents the realization of a similar camera trap setup in the urban areas, because budget resources are usually too limited to invest into armoured steel housing or other extensive protection methods. Regular tampering with traffic cameras shows the extent of the problem (Audit Department, 2006). Generating direct data in heavily urbanized spaces is of uttermost importance to reach comparability to the results of studies in the near-metropolitan environment.

Finally, future locations of camera trapping stations were identified to be able to understand the usage of wildlife corridors, which potentially connect the mainly isolated populations in the studied subsections. Depending on the exact location of potential future conservation measurements, the monitoring of the following corridors is suggested for a follow-up study:

Constantia Nek

Ravine at Bay Road	(-34°01'00.4",+18°23'34.4")
Thicket at M63 Hout Bay Road	(-34°00'40.8",+18°23'56.9")
Forest Patches at the Traffic Circle	(-34°00'39.1",+18°24'16.6")

Noordhoek

Forest at Southern Chapman's Peak	(-34°05'48.8",+18°21'24.7")
Northern End of Long Beach	(-34°05'44.0",+18°21'12.0")
Ravine over Goedehoop Estate	(-34°04'59.0",+18°22'23.2")

The placement of camera traps at these locations could allow for baseline data on migratory exchange between the Table Mountain section, the Silvermine-Tokai section and the Southern Peninsula section. This data is critical to complete the full understanding of the local medium- to large-sized mammal biodiversity.

6 Abstract

Table Mountain and Silvermine-Tokai are the two mountain ranges and distinct sections of Table Mountain National Park in closest proximity to the metropolitan megacity of Cape Town, SA. This study used unbaited motion-triggered digital remote camera traps to determine species richness, relative abundance, occupancy, and spatial distribution of medium- to large-sized terrestrial mammals in the 60km² study range to assist future decisions of conservation stakeholders by providing unprecedented biodiversity baseline datasets. During 2038 trapping days, 410 individual visits by wild mammals, 1795 individual visits by humans and 351 individual visits by domestic dogs (*Canis lupus familiaris*) were evident on the 35 sampling stations. To assess the internal distribution of mammalian wildlife, trapping station were attributed with covariates like altitude, steepness of slope, mountain aspect, vegetation type and distance to permanent freshwater sources. The anthropogenic impact on the mammalian wildlife was estimated by attributing covariates to the trapping stations like distance to settlement, distance to public hiking trails and habitat transformation. The time stamps of the capturing events were used to obtain hourly and weekday activity patterns, which then were overlapped to obtain information on the likelihood of interaction between two species.

Humans (*Homo sapiens sapiens*) were by far the most abundant species. Domestic dogs, the second-most abundant species, accompanied 20,5% of humans. The occurrence of wild or stray dogs was found to be highly unlikely. Humans and dogs were active exclusively diurnally and remained on the hiking paths in over 92% of the cases ($p<0{,}001$).

Of all wild species, the Cape Porcupine (*Hystrix africaeaustralis,* LC) was the most highly abundant, being present in approximately 5% of the trap nights and being found to venture quite far into the suburban space. The Large Spotted Genet (*Genetta tigrina,* LC) was similarly abundant, but showed a much stronger avoidance towards human activity. The Small Spotted Genet (*Genetta genetta*, LC) was not recorded. The diurnally active Cape Grey Mongoose (Galerella pulverulenta, LC) avoids human activity by retreating to the higher altitudes. The Watermongoose (*Atilax paludinosus,* LC) was found regularly on the riverbeds of lowland streams, close to urban settlements. It shares its ecological niche competitively with the Cape Clawless Otter (*Aonyx capensis,* LC), which was only found in Fish Hoek Valley. An estimated maximum of 12 individual Caracals (*Caracal caracal*, LC) roam the study area as the only remaining top predator, to prey on rodents, birds, genets and small antelopes such as the Grysbok (*Raphicerus melanotis,* LC), which was less abundant, but occurred throughout the study area. The recently reintroduced Klipspringer (*Oreotragus oreotragus,* LC) was the only other antelope found, but occurred rarely. Three alien species were found in small numbers, namely the Grey Squirrel (*Sciurus carolinensis*, LC), the Himalayan Tahr (*Hemitragus jemlahicus*, NT) and the Sambar Deer (*Rusa unicolor,* VU). The two latter were claimed to be exterminated. None of the once ubiquitous rock hyraxes (*Procavia capensis,* LC) could be found, indicating a dearth of the population.

Three biodiversity hotspots could be identified, accumulating 77% of the observed mammal wildlife on just 40% of the surface area: Orange Kloof (a valley south of Table Mountain), Silvermine (a nature reserve at Constantiaberg), as well as the Tokai pine plantation, which is inhabited by the Northern Cape Peninsula's last Chacma Baboon troops (*Papio ursinus*, LC). In summary, the studied area offers a stable ecosystem for a small range of terrestrial medium- to large sized mammal species, but further conservation effort is necessary to increase the connectivity of the sampled subsections.


Big Momma
Spiky Birth #1
Spiky Birth #2

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9 Appendix

9.1 Setup Procedure

Setup Procedure (for treeless areas)

1. Choose spot in 50m radius where vegetation is clearable, preferably animal path crossing, as good as possible out of human sight. Measure exact GPS, Altitude, Slope and Aspect.
2. Predrill a hole in the soil with the manual drillbit.
3. Hammer the fence posting into the soil.
4. Attach camera trap with cable ties to the fence posting at 30 cm height.
5. Fix camera multiple times with coated wire (weather resistant, harder to cut with too simple tools)
6. Put 4 Alkaline batteries into the camera housing and switch to test mode.
7. Check SD Card.
8. Clear all vegetation that triggers the test mode.
9. Use wire and cable ties to camouflage camera with the cleared vegetation.
10. Configure settings (30s interval, picture recording) and put camera in testing mode.
11. Adjust camera and vegetation slightly to receive optimal coverage (red LED).
12. Arm camera.
13. Lock housing with padlock.

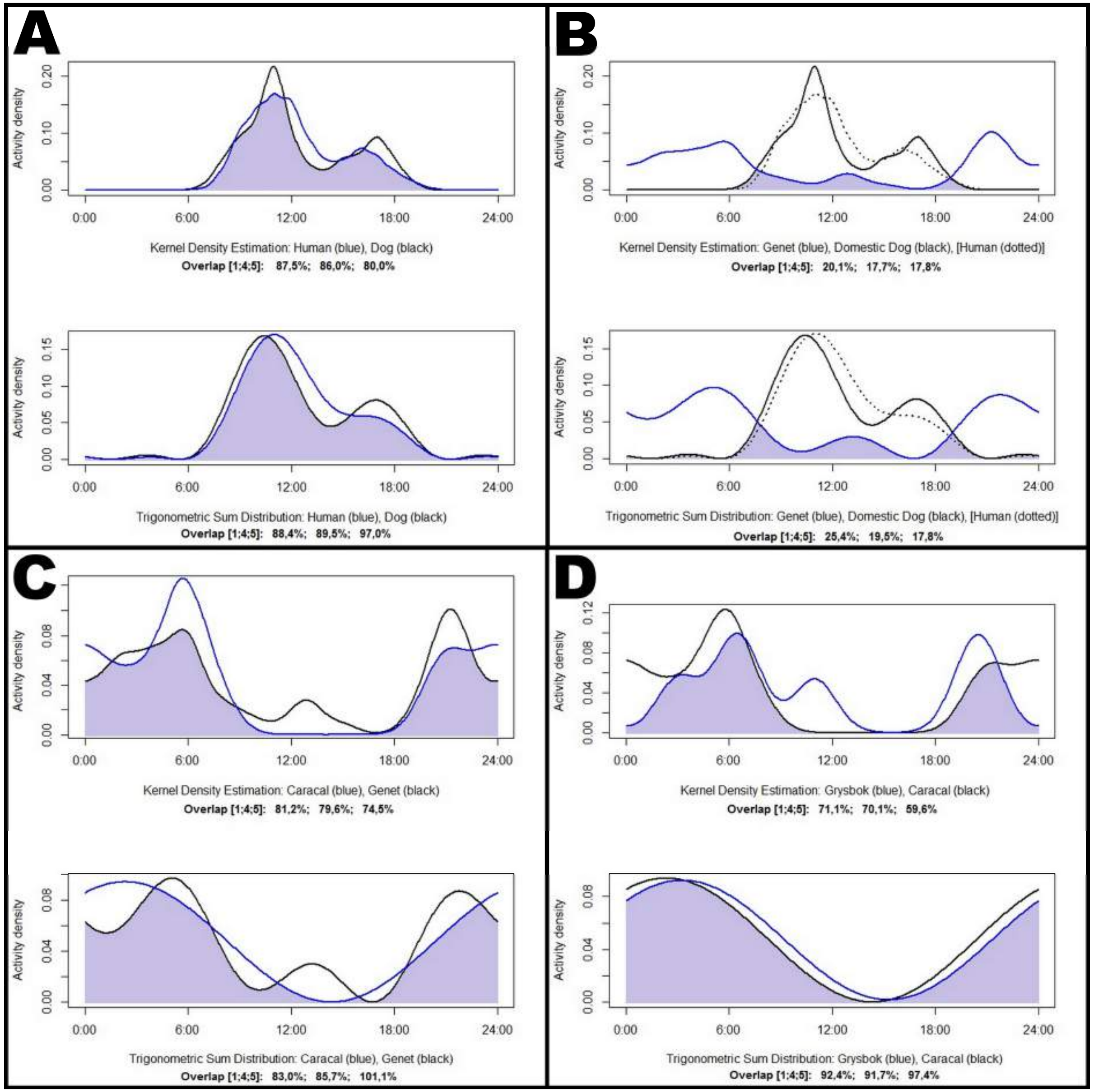
Readout / Rearm Procedure

1. Localize camera with GPS.
2. Trigger camera deliberately.
3. Clear vegetation if access is impaired.
4. Trigger camera deliberately.
5. Open padlock and camera housing.
6. Switch off.
7. If necessary, wait for the end of data processing (green LED), otherwise the SD card file system will be corrupted resulting in unretrievable imagery files.
8. Check SD Card content with a digital camera.
9. If the deliberate triggering events from step 2 or 4 are not shown, consider replacing camera trap by a new unit and redo "Setup Procedure", if SD-Card and batteries seem functional.
10. If the deliberate triggering events from step 2 or 4 are recorded, but no other relevant events are evident, consider repositioning the unit and redo "Setup Procedure".
11. Replace SD-Card by a tested and freshly formatted one.
12. Replace batteries, if estimated performance is less than 60%.
13. Check settings, switch to testing mode.
14. Adjust camera and vegetation slightly to receive optimal coverage (red LED).
15. Arm camera.
16. Lock housing with padlock.

9.2 Count Data and Timing

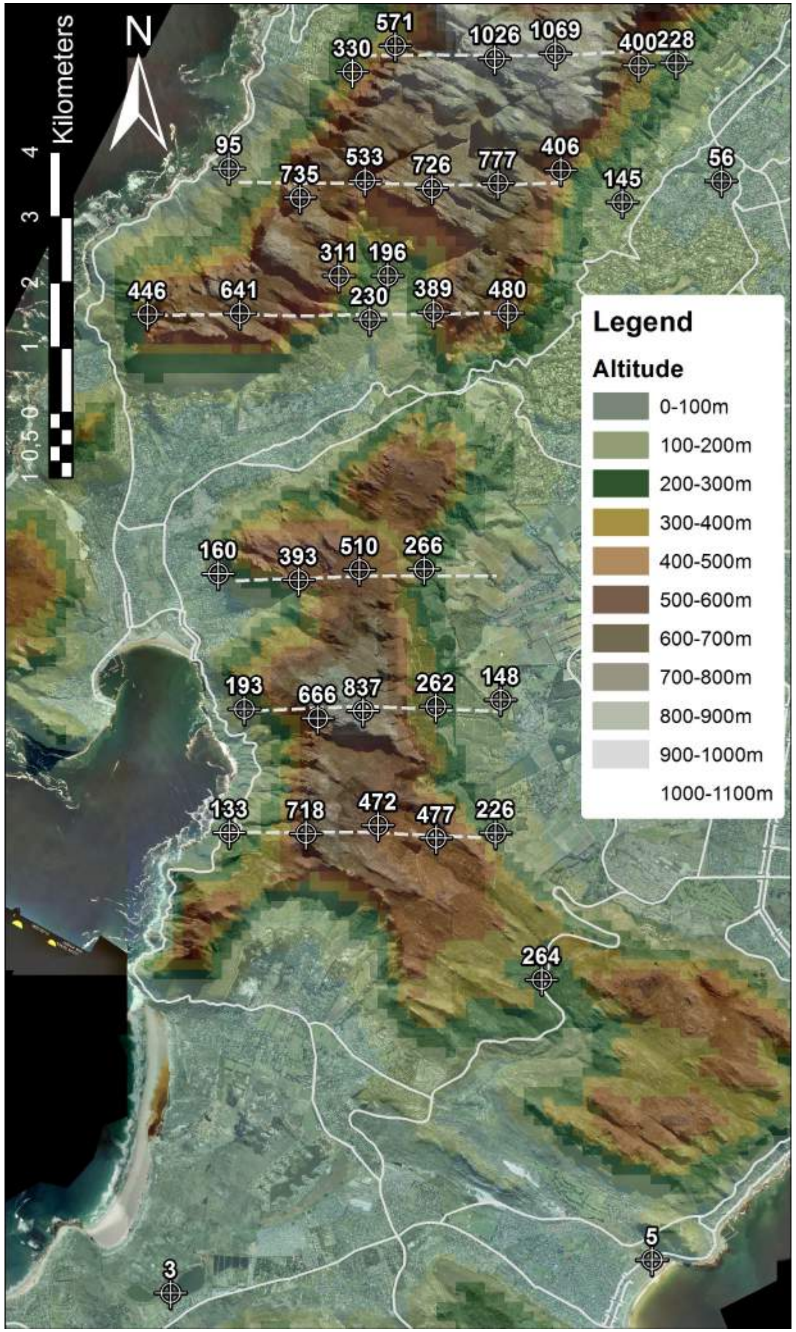
15.05.2013	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V1	V2	V3	W	X	Y1	Y2	Y3	Z1	Z2	Z3	H8	L10	L12	S0	S8	ZZ	Total
Humans (Hikers)	211	21	0	0	0	0	0	1	68	0	3	0	0	21	20	3	0	0	17	0	0	1	1	97	264	283	1	80	0	277	6	7	5	85	3	1	1	0	1477
Humans (Vehicles)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	18	0	0	0	283	5	0	0	0	0	0	1	0	318
House Dog	54	0	0	0	0	0	0	0	2	0	0	0	0	3	0	1	0	0	3	0	0	0	1	57	36	69	0	55	0	29	2	1	10	27	0	1	0	0	351
Porcupine	0	1	0	0	0	2	0	0	3	0	1	0	0	0	2	15	1	0	0	3	0	9	14	1	0	10	0	0	1	5	0	0	8	8	2	4	1	2	93
Spotted Genet	6	2	0	0	0	0	0	0	5	0	0	0	0	0	2	0	0	0	1	1	0	2	0	0	1	2	0	0	2	1	1	9	11	1	0	2	8	11	68
Grey Mongoose	0	0	6	0	0	0	0	0	2	0	1	0	0	0	5	0	0	0	0	0	0	0	0	0	2	2	0	0	1	0	0	3	0	0	0	0	0	0	22
Watermongoose	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	1	0	0	0	0	0	0	0	0	0	0	12	6	0	74	5	1	106
Grey Squirrel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	6	33	1	0	0	0	42
Chakma Baboon *	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
Grysbok *	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	1	0	0	2	0	0	0	0	0	1	7
Caracal	2	0	0	0	0	0	0	0	2	0	0	0	0	0	3	0	0	0	0	0	0	0	0	5	2	0	0	0	0	4	1	0	0	0	0	0	0	0	19
Otter	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21	0	12	33
Klipspringer **	0	0	0	3	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
Sambar Deer **	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2
Himalayan Tahr **	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
Domestic Cat **	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2
Rodents	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	4
Redwinged Starling	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	1	0	0	2	0	0	0	0	0	0	0	27
Guinea Fowl	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	5	0	0	17
Other	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1	0	0	6	0	1	2	0	0	3	0	0	0	4	4	0	6	4	3	39
Unidentified	0	0	0	0	0	1	0	1	1	0	0	0	0	2	0	0	0	0	0	1	0	0	0	1	0	0	0	0	3	0	0	0	0	2	0	6	0	0	18
																																							0
																																							0
Total wild animals	9	9	6	3	0	3	1	1	13	1	2	0	4	2	12	16	1	0	5	19	0	13	21	12	26	17	0	1	11	10	6	14	53	54	6	118	18	30	517
Total wild studied	9	3	6	3	0	2	1	0	12	1	2	0	4	0	12	16	1	0	1	17	0	13	14	11	5	15	0	0	5	10	2	14	37	48	4	101	14	27	410
Deployment	03.03.2013	25.03.2013	07.03.2013	07.03.2013	05.03.2013	03.04.2013	29.03.2013	06.03.2013	23.03.2013	06.03.2013	06.03.2013	05.03.2013	01.05.2012	13.03.2012	12.05.2013	01.03.2013	19.03.2013	05.03.2013	11.04.2013	11.04.2013	05.03.2013	11.04.2013	11.05.2013	11.05.2013	27.04.2013	10.04.2013	12.05.2013	09.05.2013	10.05.2013	26.04.2013	26.04.2013	27.04.2013	##	20.07.2013	16.09.2013	07.09.2013	02.07.2013	26.11.2013	
Last Readout	05.06.2013	28.05.2013	01.05.2013	01.05.2013	08.03.2013	26.05.2013	08.06.2013	12.05.2013	04.06.2013	07.05.2013	07.05.2013	07.05.2013	16.05.2012	01.05.2012	11.06.2013	21.05.2013	11.05.2013	08.03.2013	09.06.2013	10.06.2013	08.03.2013	10.06.2013	10.06.2013	10.06.2013	07.06.2013	27.05.2013	09.06.2013	09.06.2013	09.06.2013	09.06.2013	07.06.2013	07.06.2013	##	07.12.2013	28.12.2013	24.10.2013	25.09.2013	08.12.2013	
days running at last r	94	64	55	55	3	53	71	67	73	62	62	63	15	49	30	81	53	3	59	60	3	60	30	30	41	47	28	31	30	44	42	41	161	140	103	47	85	12	2047

9.3 Activity Overlap Exemplary Data

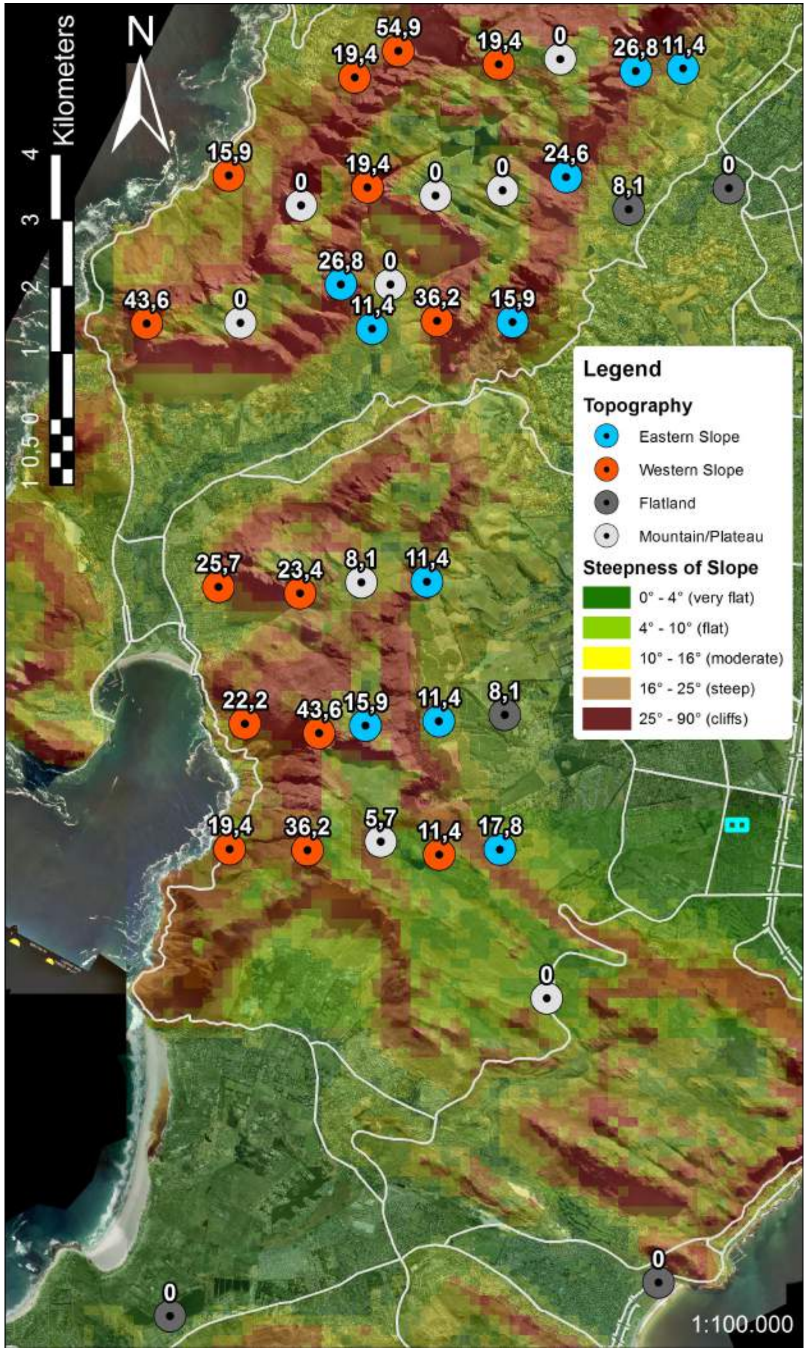


9.4 Covariate Maps

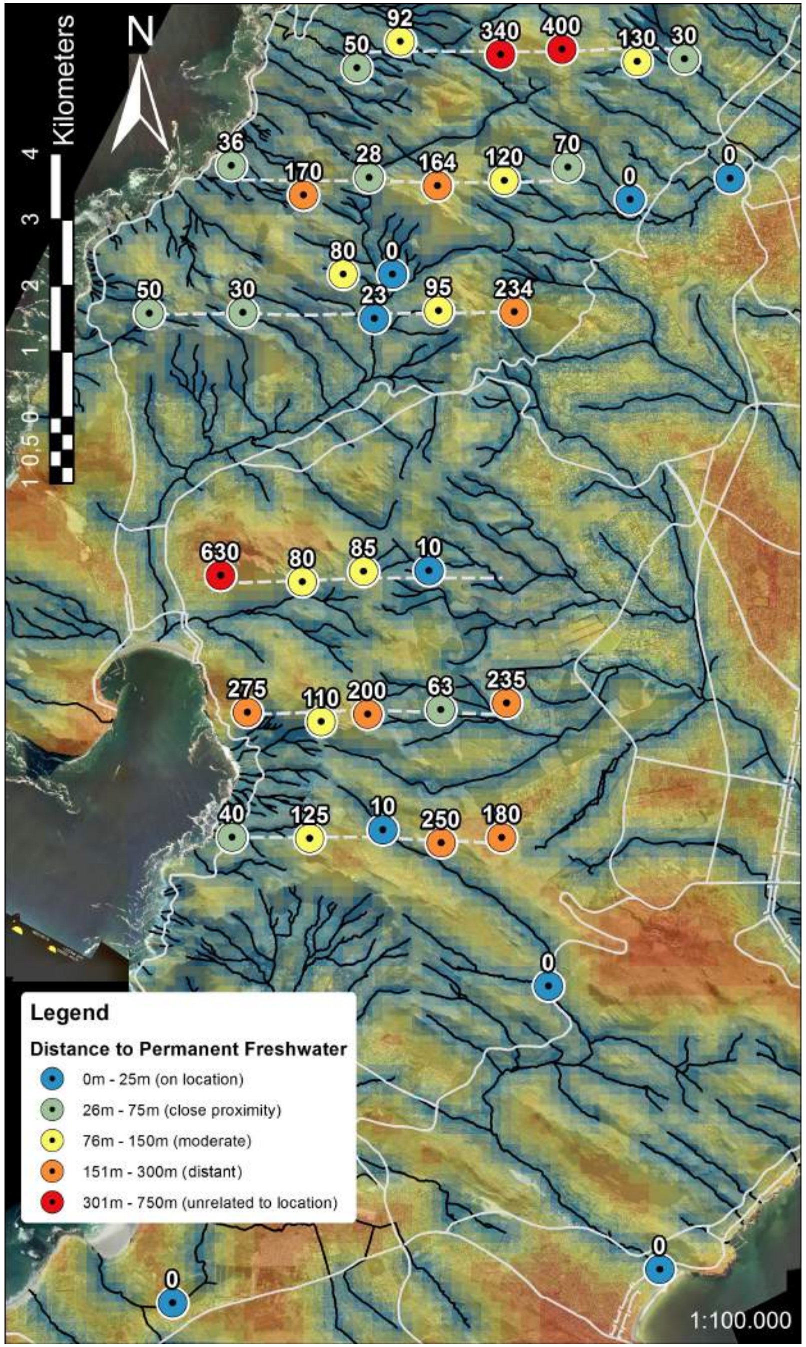
Map 0: Names of Areas Mentioned.



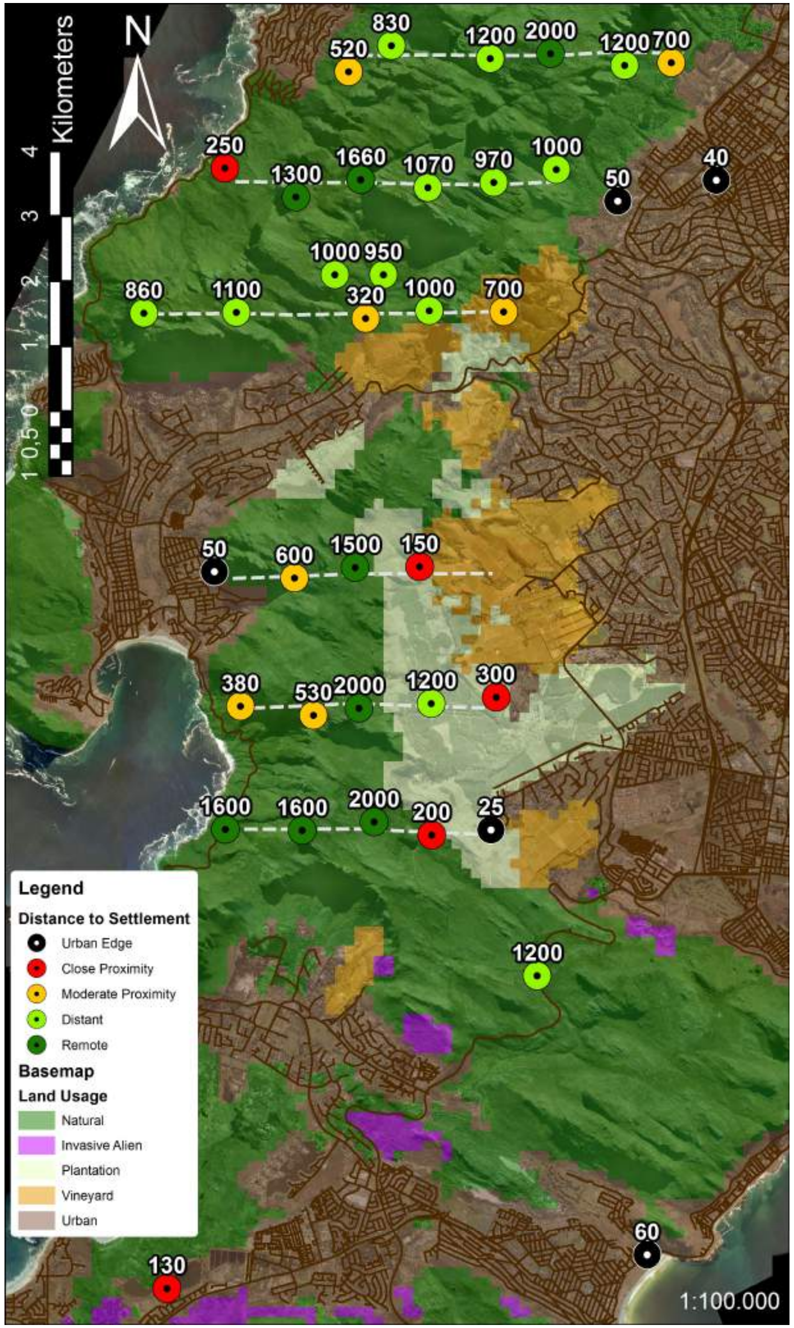
Map A: Altitude at Camera Locations in Meters above Sea Level.



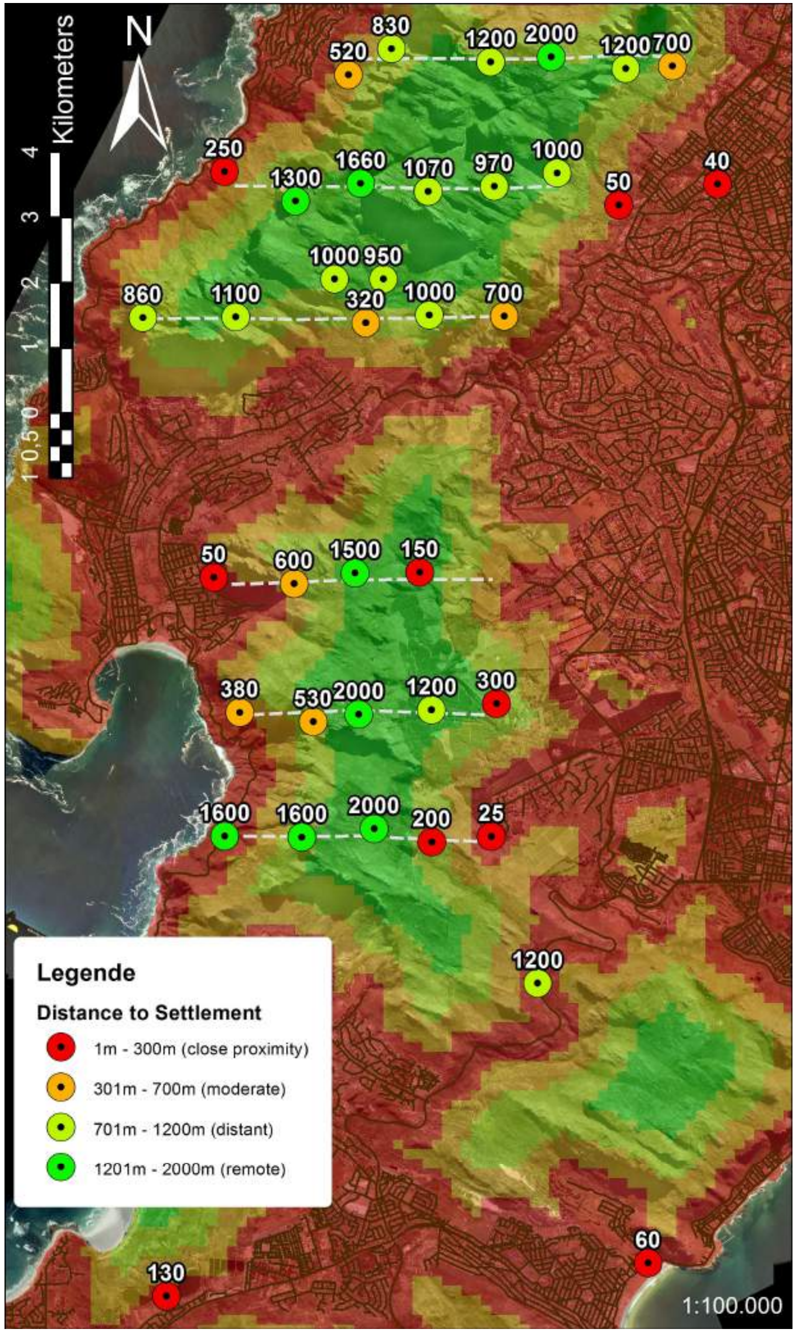
Map B: Steepness of Slope at Camera Locations in Degrees.



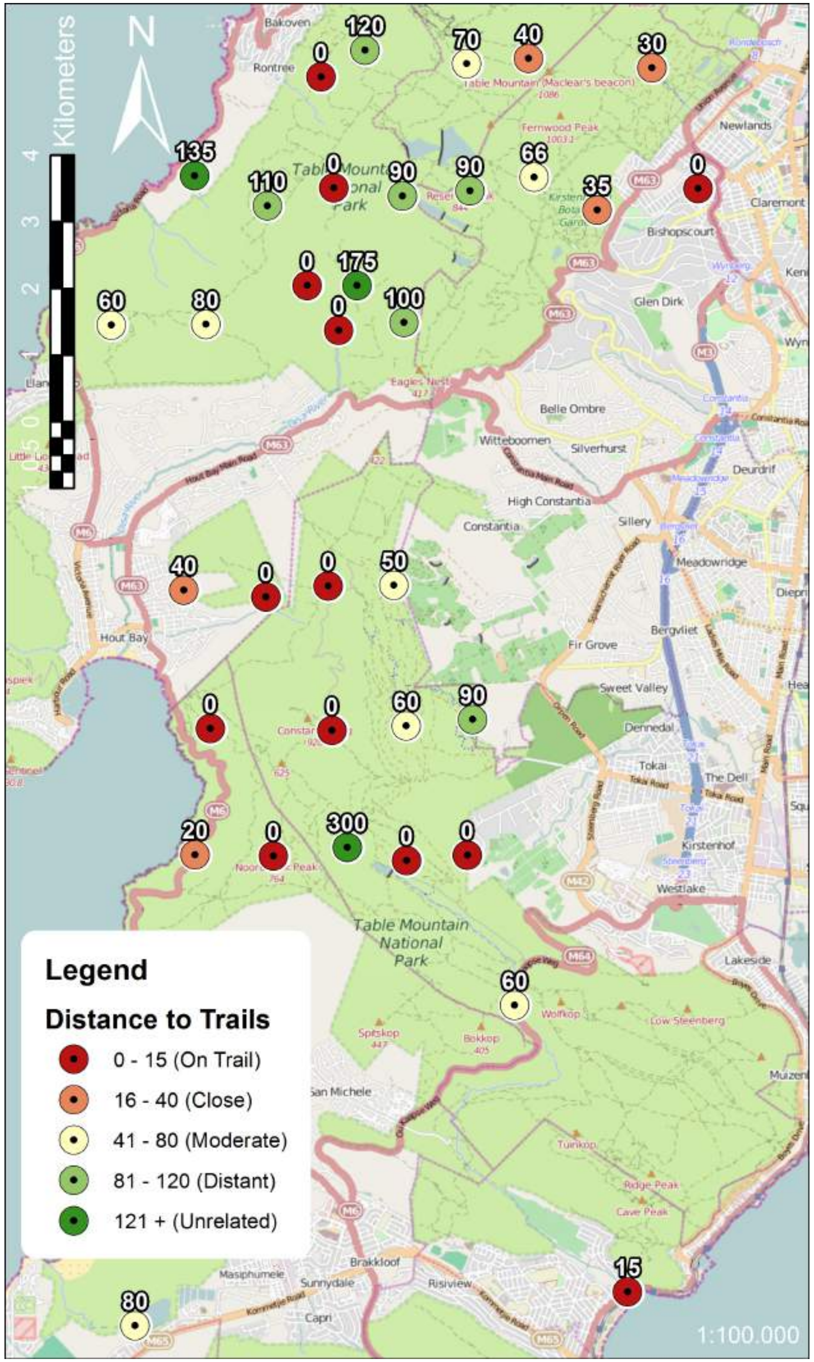
Map C: Distance from Camera Locations to Permanent Freshwater Sources in Meters.



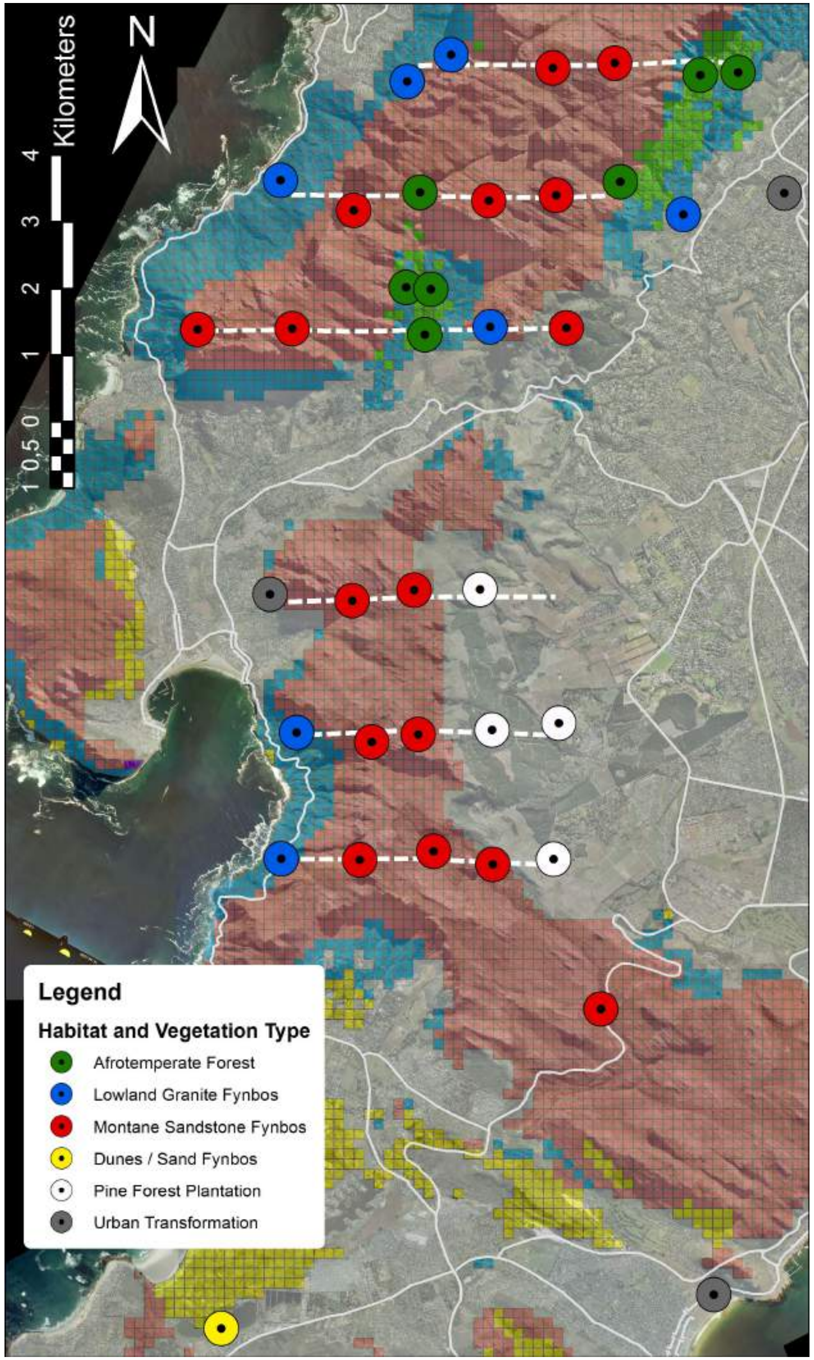
Map D: Distance from Camera Locations to Permanent Human Settlements in Meters.



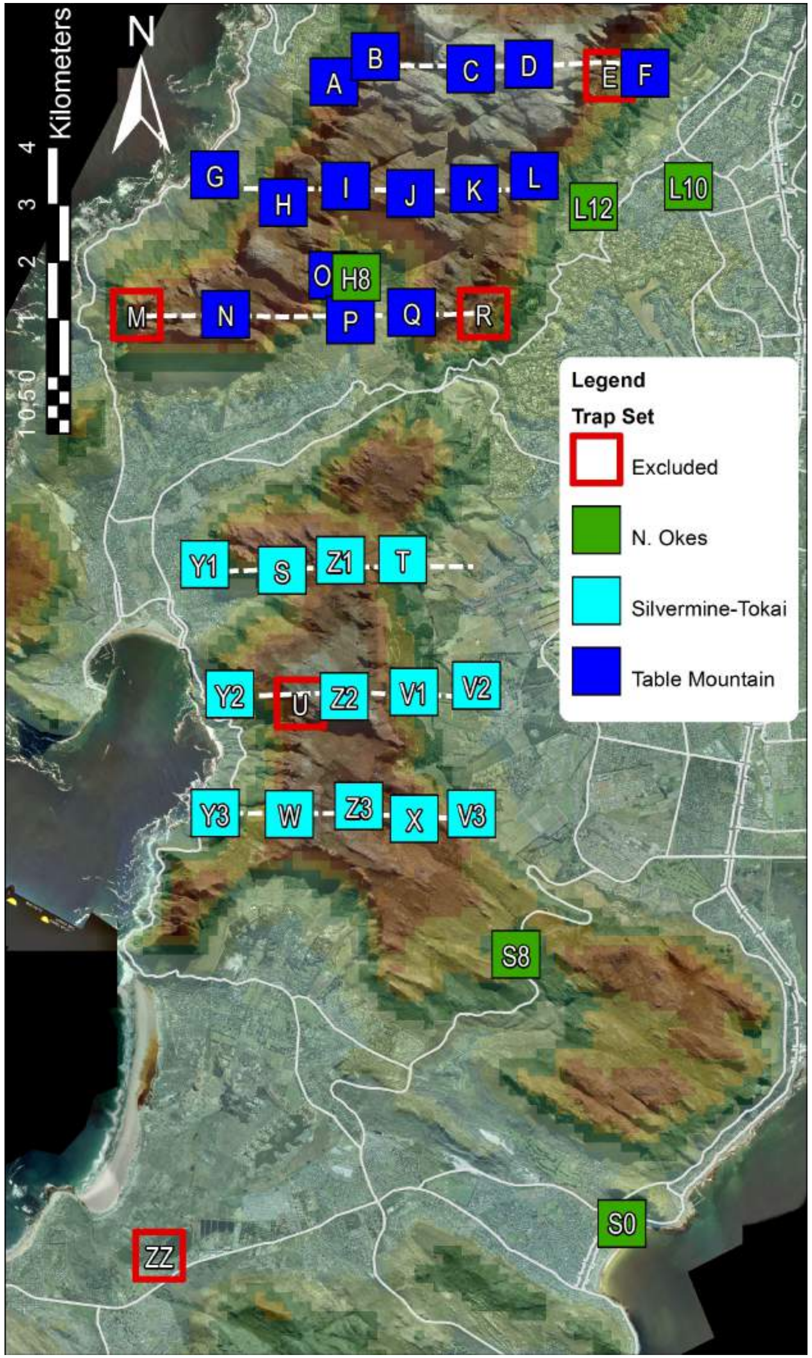
Map E: Distance from Camera Locations to Motorized Traffic in Meters.



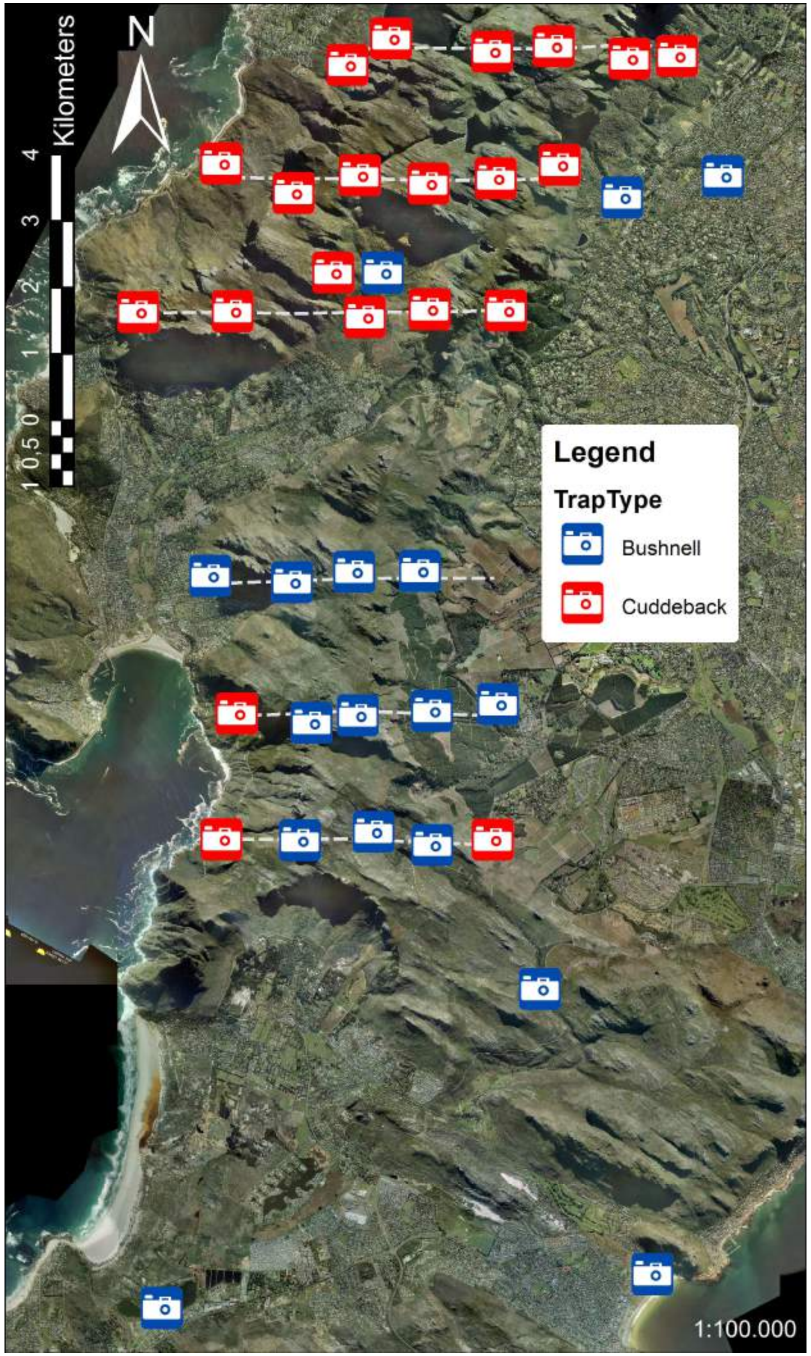
Map F: Distance from Camera Locations to Public Hiking Trails (brown dotted) in Meters. Basemap: OpenStreetMap 2014



Map G: Surrounding Vegetation Type of Camera Locations.



Map H: Numbering Key of Camera Locations showing Trap Sets.



Map I: Distribution of Camera Trap Types.

9.5 Covariate Statistics Results

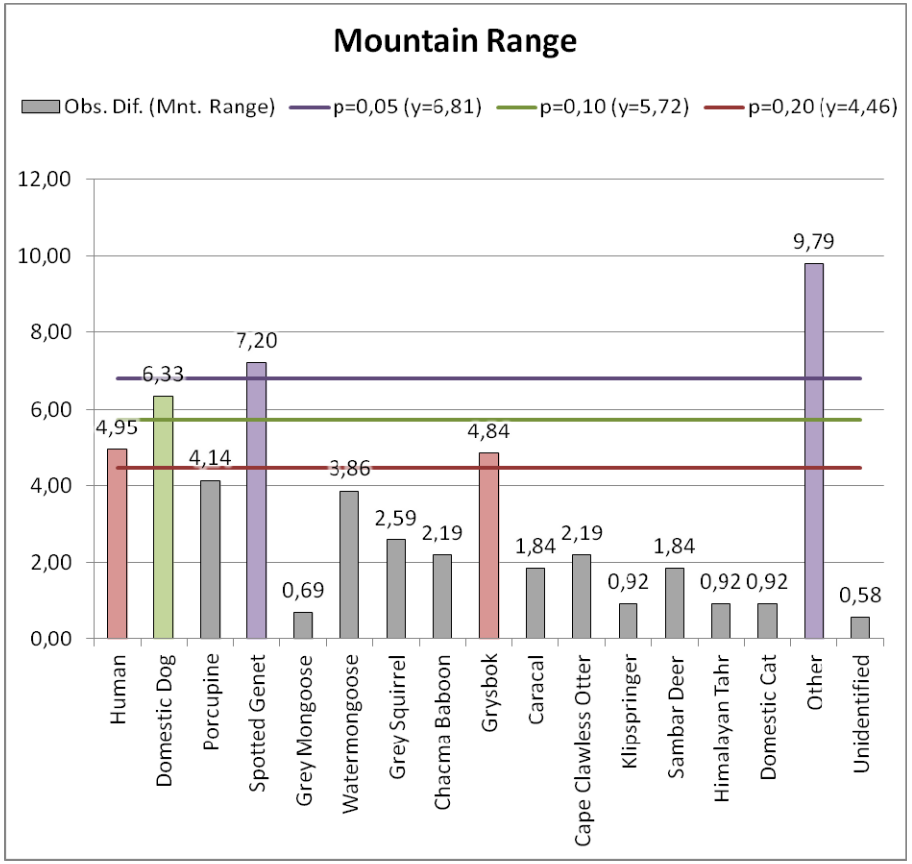


Figure 47 - Observed differences after Kruskal Wallis MC for Mountain Range sampled.

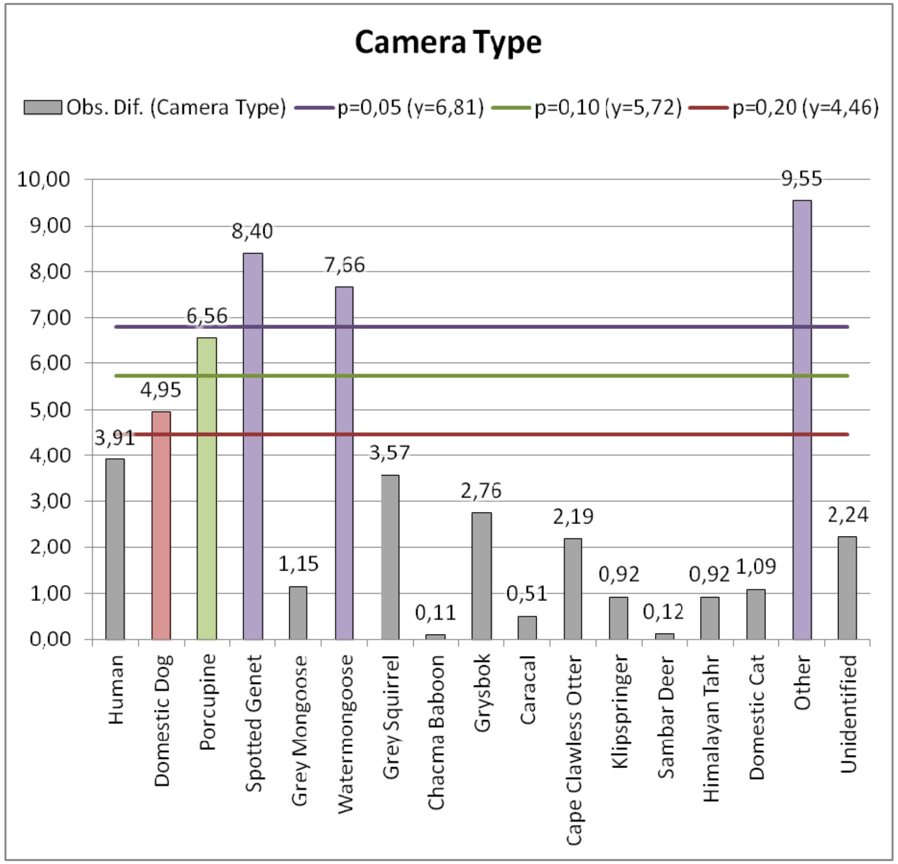


Figure 46 - Observed differences after Kruskal-Wallis MC for camera type used.

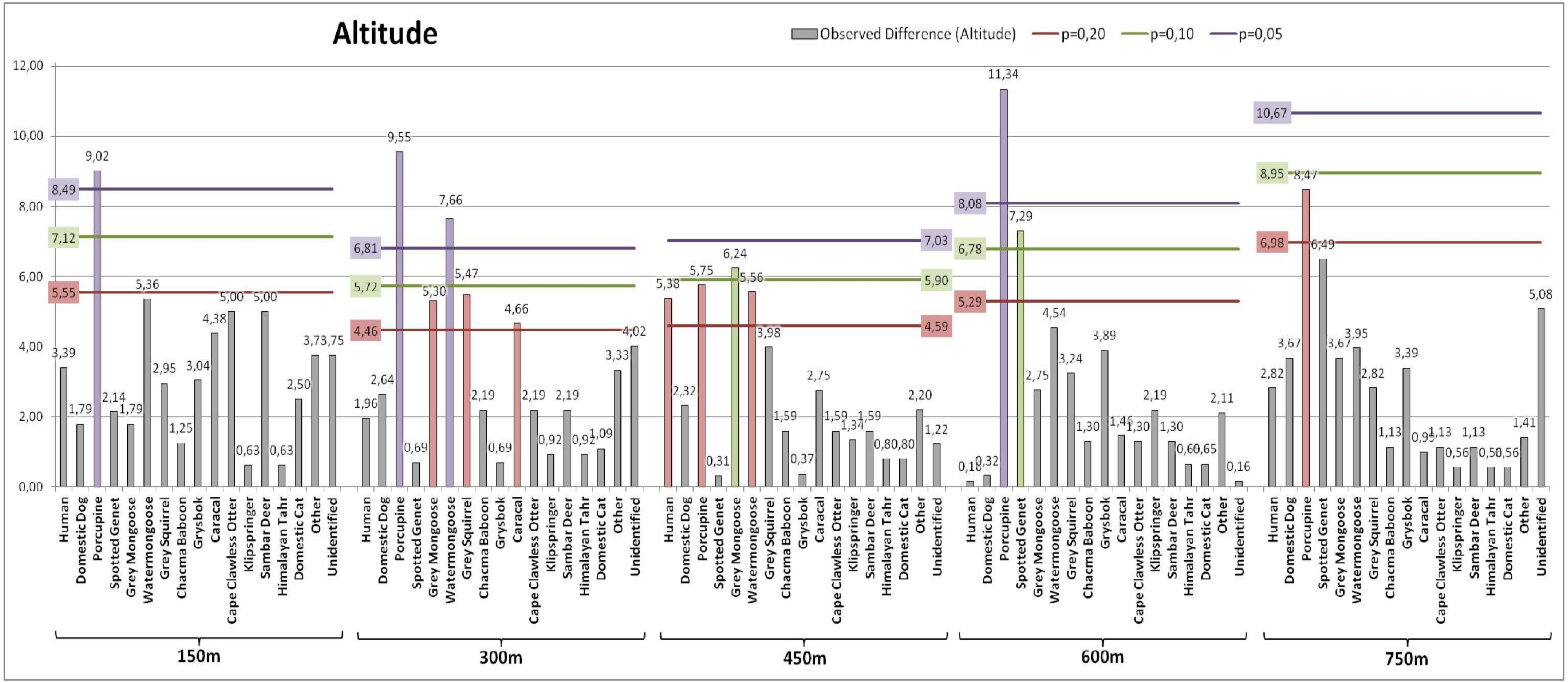


Figure 48 - Observed differences after Kruskal-Wallis MC for mountain altitudes studied.

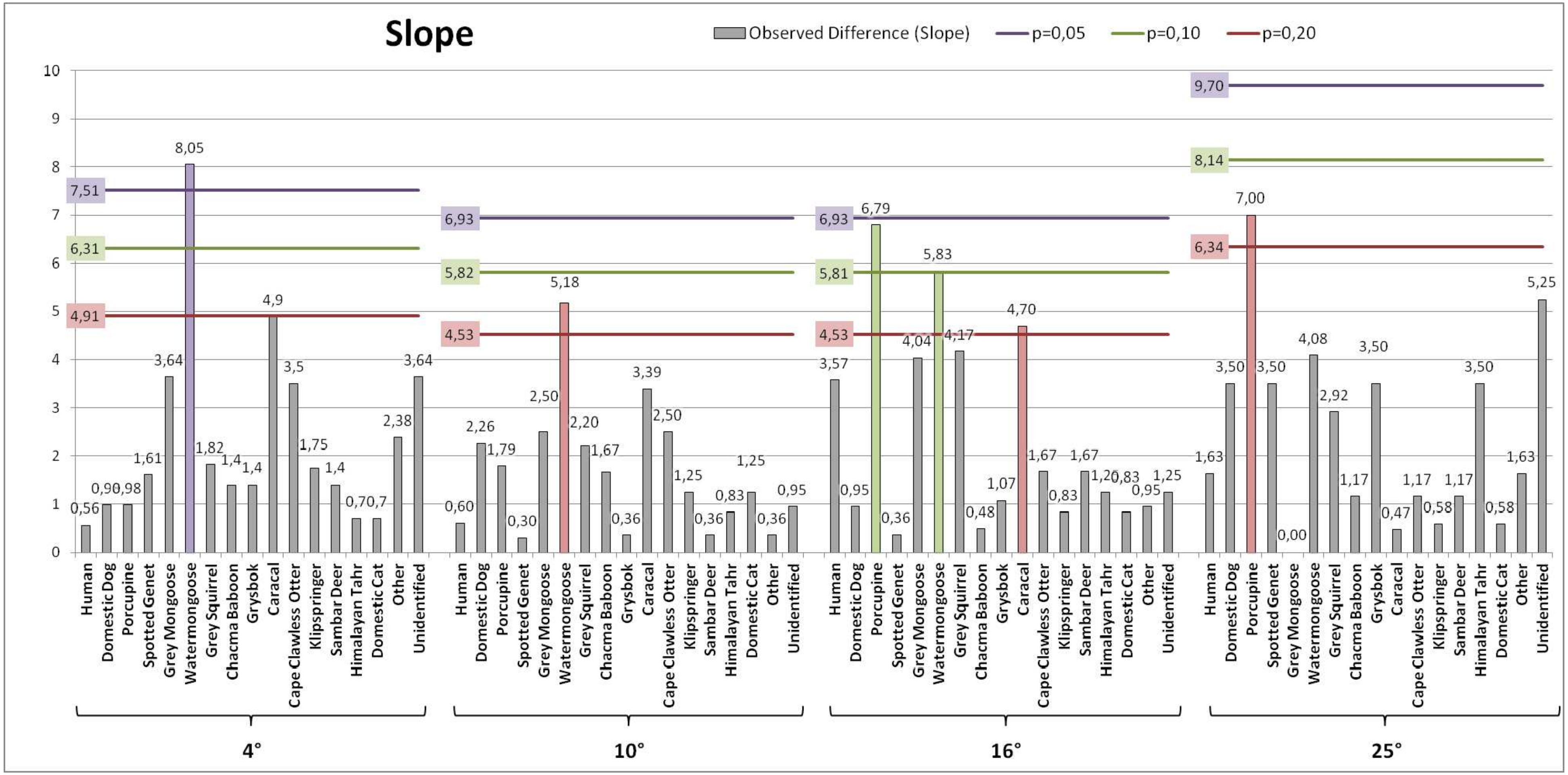


Figure 49 - Observed differences after Kruskal-Wallis MC for mountain slope studied.

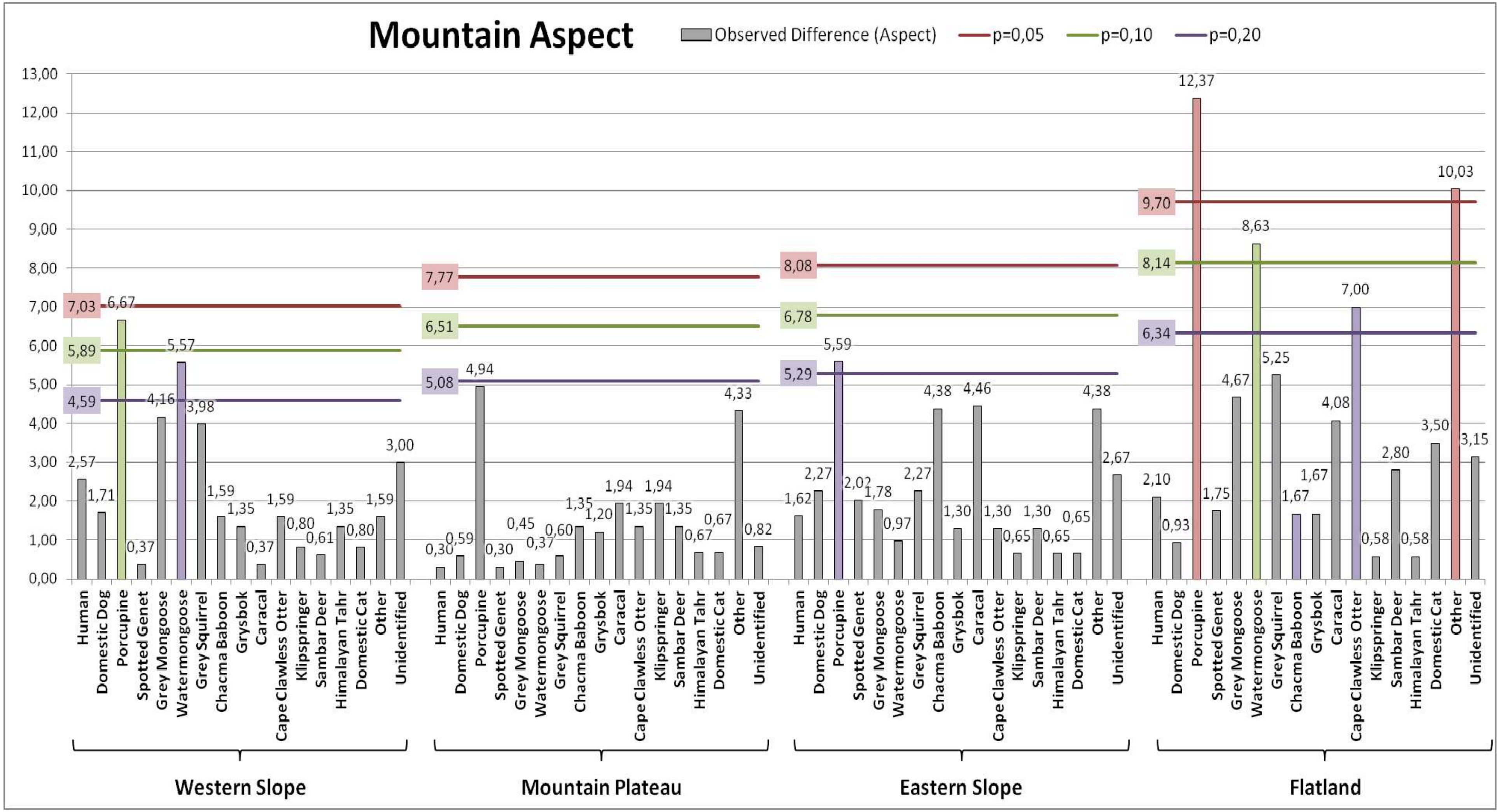


Figure 50 - Observed differences after Kruskal-Wallis MC for the mountain aspect classes studied.

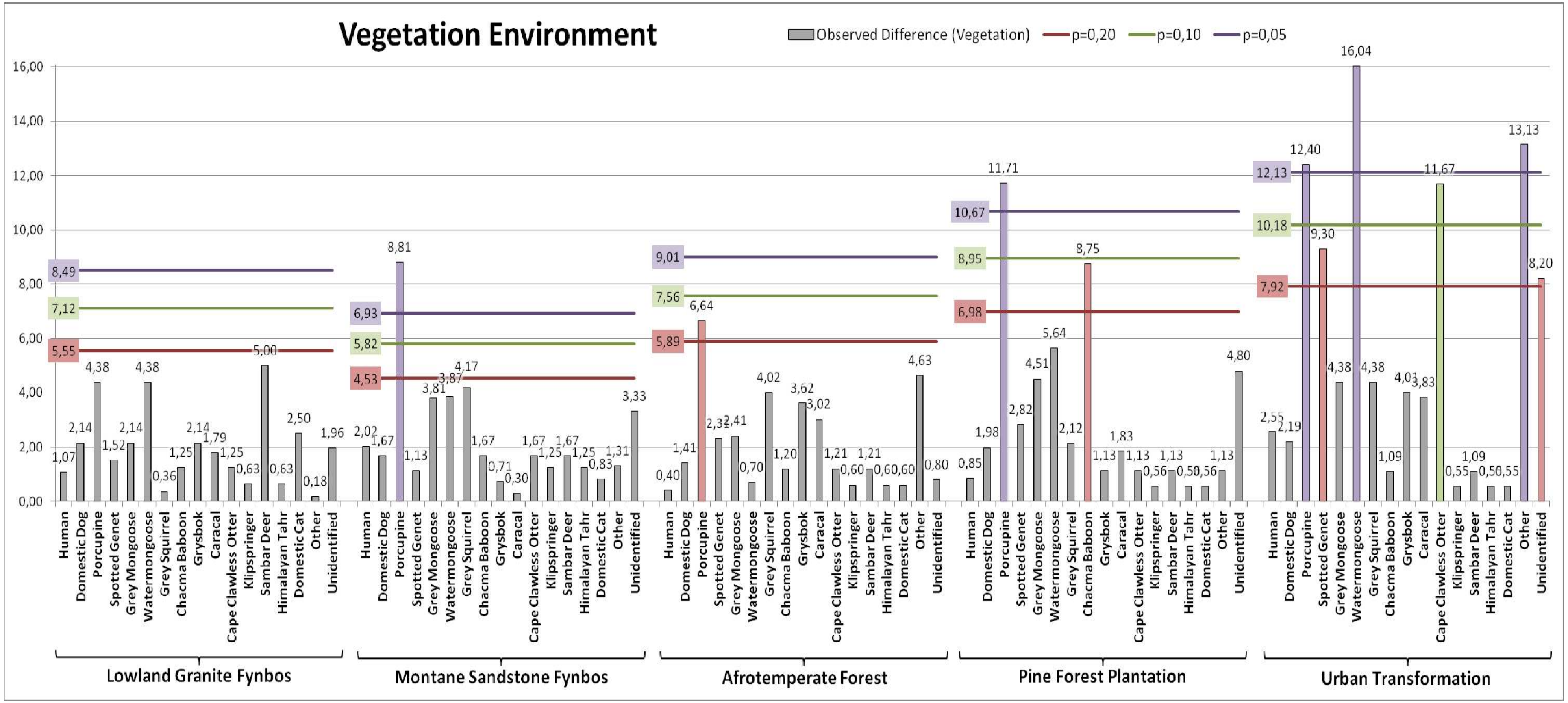


Figure 51 - Observed differences after Kruskal-Wallis MC for the vegetation environment classes studied.

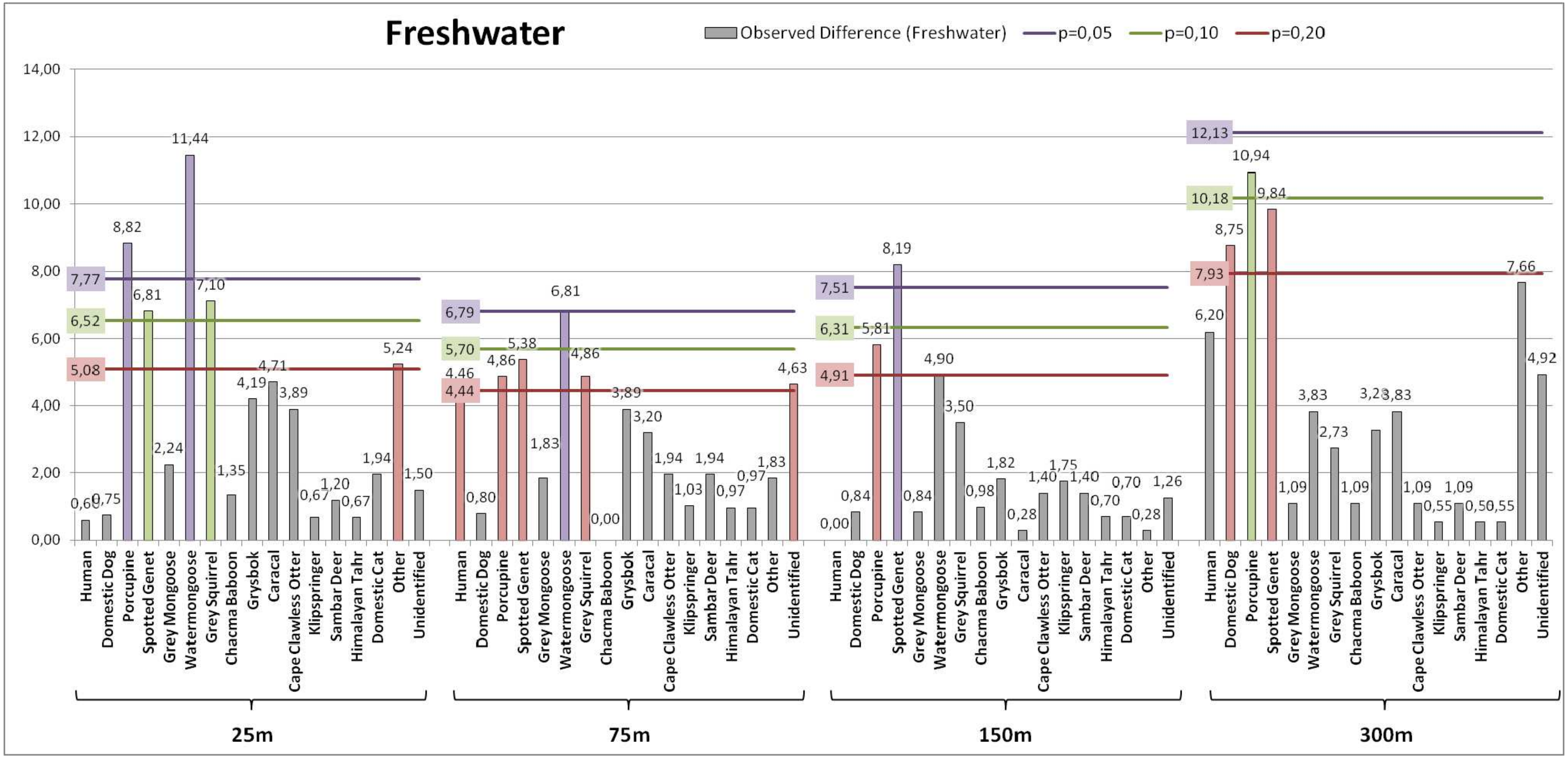


Figure 52 - Observed differences after Kruskal-Wallis MC for distance to freshwater sources.

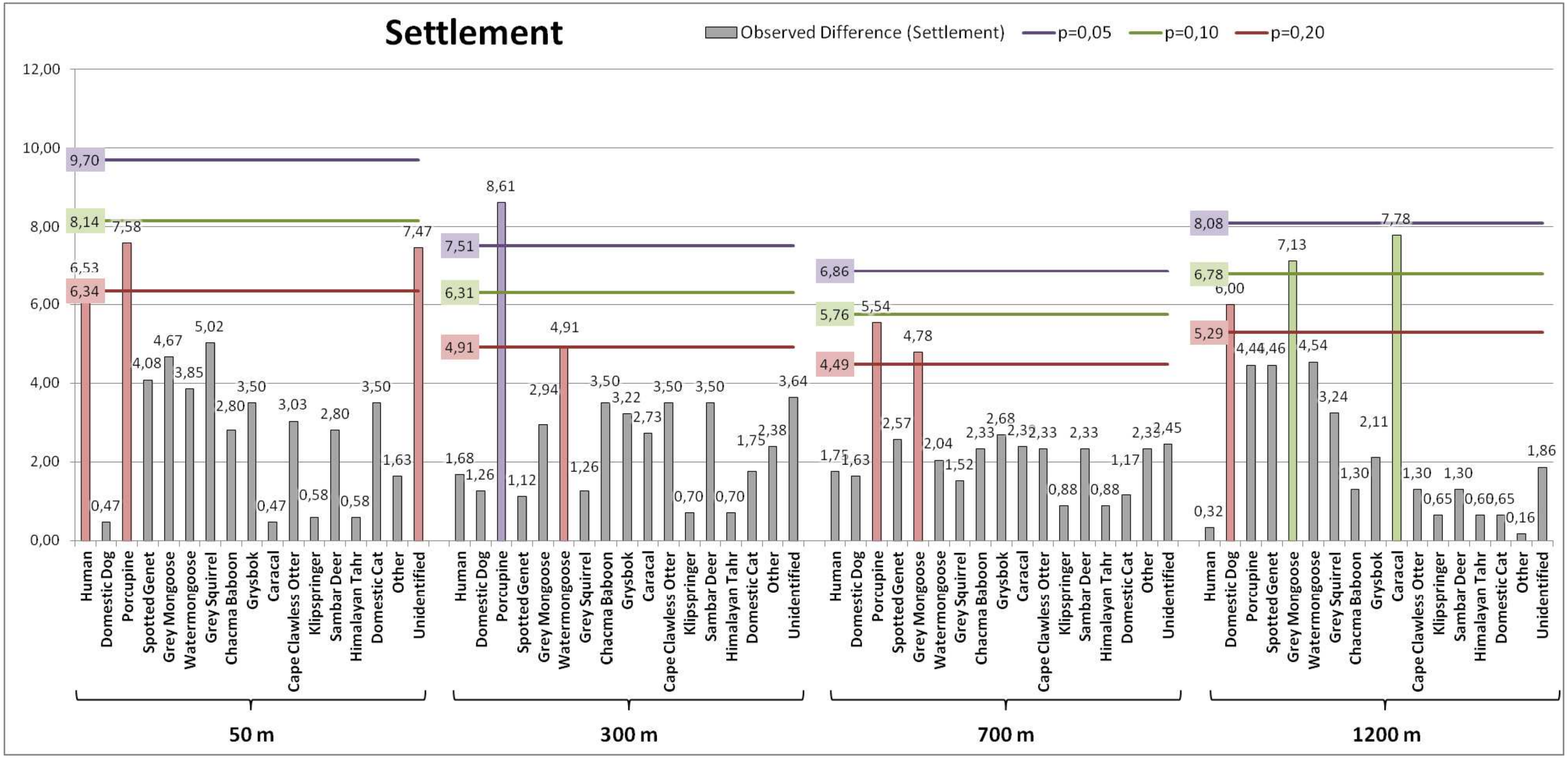


Figure 53 - Observed differences after Kruskal-Wallis MC for distance to human settlements.

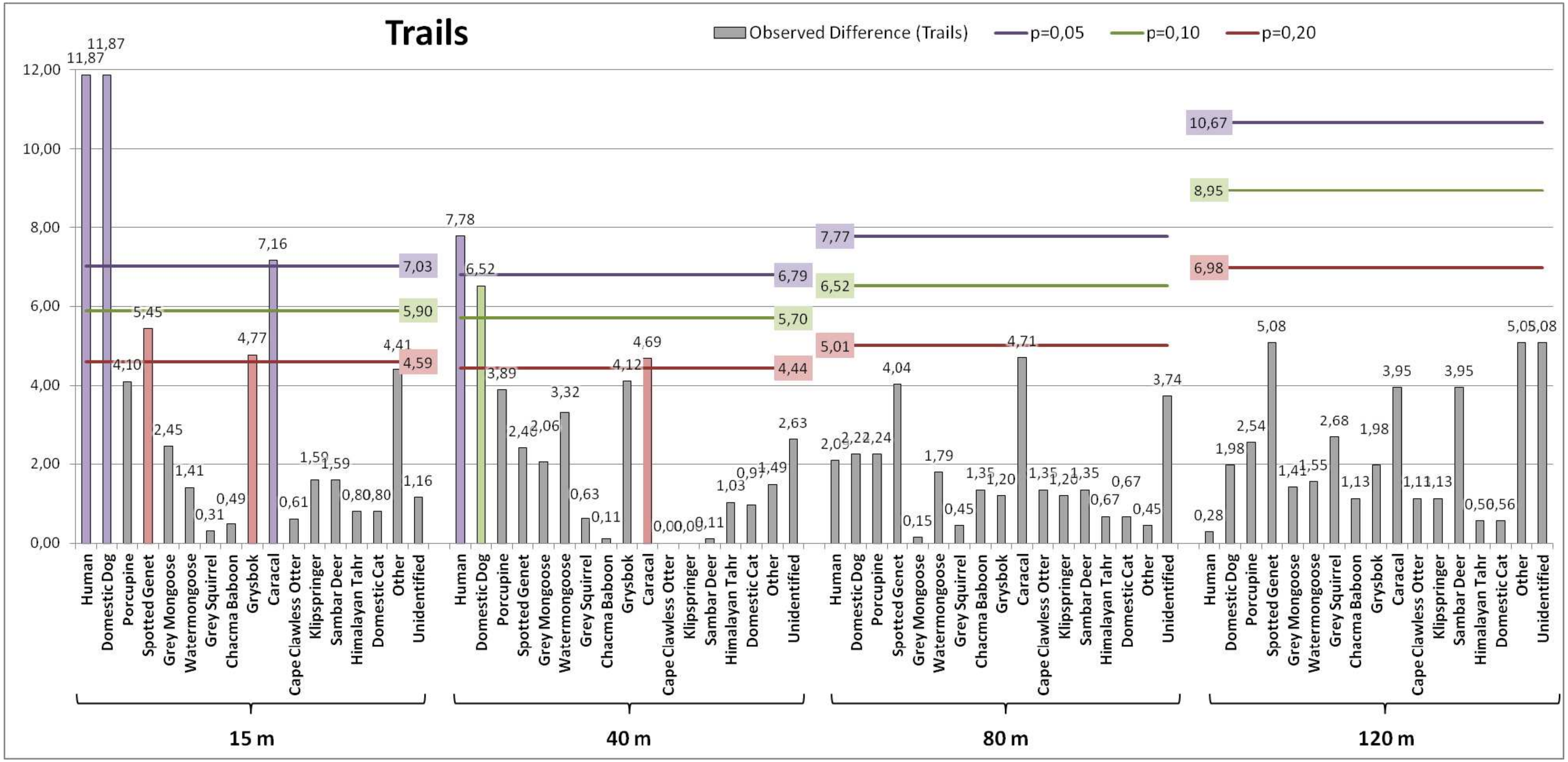


Figure 54 - Observed differences after Kruskal-Wallis MC for distance to hiking trails.