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**Marginalised herders: social dynamics and natural resource use in the fragile environment of the Richtersveld National Park, South Africa**

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## Abstract

In the contractual Richtersveld National Park (RNP), park officials and neighbouring communities jointly manage resources, with the aim to harmonize biodiversity conservation and human land use. Our socio-ecological approach compared herding practices and livelihoods of 36 livestock owners and 35 hired herders inside and outside RNP, and further assessed soil quality and vegetation characteristics under different livestock grazing patterns and access to natural resources. Hired herders were mainly in charge of animal movement patterns but were not included in formal agreements, which negatively impacted on natural resource management, livelihoods, animal well-being and communication amongst stakeholders. Soil properties and vegetation were generally negatively affected through grazing and herding practices in this fragile semi-arid biodiversity hotspot that encompasses many endangered and endemic species. Our research highlights the complex social relationships and dynamics between diverse stakeholders engaged in the contractual park and accentuates the need to improve herders' social and economic status.

**Keywords**

PASTORALISM, LIVELIHOODS, SOCIO-ECOLOGICAL APPROACH, RICHTERSVELD NATIONAL PARK

# 1 Introduction

## 1.1 Biodiversity conservation and pastoralists' livelihoods: conflicting issues

Two alternative land use strategies are often discussed concerning the environmental protection of areas: (1) land sharing, where agricultural practices that are performed in a wildlife-friendly way enable food production and biodiversity conservation on the same land, and (2) land sparing, where the land is strictly divided into high-yielding agricultural land and protected natural habitats (Phalan*, et al.*, 2011). Before the 1990s, wildlife management policies and conservation strategies had been prioritized over local peoples' needs (Makombe, 1993), which in some cases had forced local communities to leave the land they had inhabited for generations (Reid*, et al.*, 2004). From the 1990s onwards, conservation strategies have increasingly recognized and integrated local actors whose livelihoods were affected, with the aim to achieve sustainable use and management of resources (Carruthers, 1993; Hutton and Leader-Williams, 2003). The United Nations Educational, Scientific and Cultural Organization (UNESCO) has established Biosphere Reserves in 122 countries in order to include people in conservation

(UNESCO, 2016). This includes a focus on the sustainable joint use of natural resources, especially in the buffer and transition zones around protected core areas (Stoll-Kleemann and Welp, 2008; McNeely, 1994; UNESCO, 2016). One such example is the Kruger to Canyons Biosphere Reserve in South Africa which includes the Kruger National Park (KNP) and the impoverished communities living around KNP, with the aim to improve the socio-economic situation of people after apartheid era displacements (Coetzer et al., 2014).

Worldwide, pastoralists often use bio-diverse grazing areas in close vicinity of National Parks (Lindsay, 1987). While pastoralism is often seen as a successful livelihood strategy in these regions, where environmental variability is high and overall biomass productivity is low (Berzborn and Solich, 2013), pastoralists are often forced to move out of such areas for the sake of conservation (Kiss, 1990). It has been argued that pastoralists should be guaranteed basic grazing and foraging rights, which have to be protected (Blench, 2001). However, protection of wildlife is often prioritized, in light of its global importance for conservation and for eco-tourism. Studies from various regions illustrate the different arrangements with regard to conservation and human use of National Parks. For instance, in the Ngorongoro Conservation Area (NCA) in northern Tanzania, Maasai pastoralists have shared the land with wildlife since 1959. The NCA is regarded as a successful conservation area, but pastoralists claim that their grazing areas are declining in quality and, thereby, lowering their food security (Galvin, *et al.*, 2002). In Nepal, Indigenous peoples are allowed to live inside the Royal Chitwan National Park, with their livelihoods secured through the extraction of natural resources from the park (McLean and Straede, 2003). Pastoralists in Lesotho, Namibia, Botswana and South Africa, among them the Nama in the Richtersveld area, have been denied rights of access to areas they have historically used for grazing, as a result of nature conservation initiatives (Berzborn and Solich, 2013). In South Africa, colonial expansion beginning in 1652, the discovery of minerals and industrialization at the end of the nineteenth century, and the politics of apartheid in the twentieth century led to loss of access to land, and loss of livelihoods (Kepe, *et al.*, 2008).

Although many studies have focused on the potential conflicts between National Parks and human land use (Hough, 1988; Igoe, 2002), only few have focused on socio-ecological approaches to identify the direct influence of conservation incentives on the livelihoods of pastoralists (Biggs, *et al.*, 2011; Dougill, *et al.,* 2006). To understand pastoralist systems, the link between the environment, pastoralist livelihoods and involved institutions, e.g. National Park boards, needs to be understood (Dougill, *et al.*, 2010).

Over the last 30 years there has been a trend in several African countries of local businessmen and farmers investing in livestock and hiring herders to take care of their livestock (Little, 1985; Toulmin, 1992; Turner, 2009). For example, in Northern Kenya, the reason for overgrazing and overstocking was seen in "part-time" herders taking little responsibility to maintain the quality of the grazing site (Little, 1985).

Herding is often seen as a task that does not require expertise, and opinions vary on whether herding by hired herders directly influences livestock productivity or not (Turner, 2009). In the Richtersveld area, most livestock owners nowadays employ herders for the daily herding routine, while the owners themselves are working in nearby diamond mines. In previous studies this diversification of livelihood strategies was found, e.g., among coloured[1] farmers in the Namaqualand area of the Northern Cape Province, South Africa (Salome, 2001). These farmers were financially more successful than other farmers who did not diversify their activities (Anseeuw*, et al.*, 1994). According to Moritz *et al.* (2011) the employment of hired herders for herd management is increasing in Africa and the understanding of herding contracts will play a crucial role in future. Our case study makes an important contribution to this field by (1) providing indications of complex social relationships and dynamics between hired herders, livestock owners and the Richtersveld National Park (RNP) management as well as their different roles and socio-economic positions and (2) by assessing soil quality and vegetation characteristics under different livestock grazing patterns and different access to natural resources. The combination of social relationships and ecological conditions highlight how social aspects might drive movement patterns of herders affect the use of natural resources and, subsequently, how these impact soil and vegetation quality.

## 1.2 Pastoralism in the Richtersveld National Park: social and ecological impacts

In South Africa, an attempt to combine conservation and securing local people's livelihoods has been made through the implementation of 'Contractual' National Parks. In these parks, land is owned by local communities and simultaneously managed by South African National Parks (SANParks). Landowners and SANParks are linked through a joint management agreement and

[1] The ethnic terms "black", "coloured", "white" and "Indian" are still widely being used in post-apartheid South Africa, although these terms are highly contested. "The apartheid laws intended for "racial classification" designed a social hierarchy, attempting the imposition of these "race groups" on individuals in a single, complex system. This categorization has some basis in reality and also in apartheid history. Reference is made in this article to coloured farmers (of a more "mixed" origin, and mostly Afrikaans-speaking)". Further information regarding the discourse on race in South Africa is available from the following sources: Durrheim et al. (2011), Erasmus (2008), Posel (2010), and Seekings and Nattrass (2005).

both parties are represented in a joint management committee (Reid, 2001). This contractual concept is being applied in the Richtersveld National Park (RNP), founded in 1991. Here, the land rights and concerns of the Nama pastoralists who had previously lived in the area are being recognised (Berzborn, 2006). For these Nama pastoralists, traditional semi-nomadic herding practices had been a livelihood strategy for over 2000 years (Webley, 2007). Nama people have adapted to changing environments and preconditions over hundreds of years, with rural areas becoming more dependent on wage labour during apartheid and post-apartheid periods (Cousins, 2007). In RNP, the land is owned by local communities of the Richtersveld and 26 pastoralists are allowed to let their livestock, i.e., goats and sheep, graze within the boundaries of the National Park (Boonzaier, 1996). This is meant to ensure the conservation of plant species richness and accommodate pastoralists' traditional semi-nomadic livelihoods, two aims which are often seen as contradictory (Hendricks*, et al.*, 2002). While a study from Boonzaier (1996) showed an unsatisfactory relationship between RNP management and livestock owners, the role of hired herders and their impact on conservation has, as yet, received little attention (Hendricks *et al*., 2004).

The Richtersveld area represents a biodiversity hotspot for succulents in a semi-arid climate and has one of the highest numbers of endemic species in a single ecosystem (Cowling*, et al.*, 1999). Livestock grazing, often a major cause for land degradation (Dregne*, et al.*, 1991) has reportedly damaged and shifted the vegetation composition of the Succulent Karoo biome in Namaqualand, with especially endemic species being under threat (Desmet, 2007). At the same time, forage for livestock is a major ecosystem service (Sandhage-Hofmann*, et al.*, 2015) and soil and vegetation conditions are often directly linked to livelihoods in semi-arid environments (Allsopp, 1999). Several studies show that pastoralists have sound ecological knowledge, which they apply in their daily pasture management. The most common strategy in Africa is transhumance (Sieff, 1997), where summer and winter grazing grounds are utilized, as was the case with the Khoekhoen pastoralists in Namaqualand during the pre- and early-colonial period of South Africa (Boonzaier, 1996). As our study area is characterized by semi-arid winter rainfall (MacKellar*, et al.*, 2007), the Orange River is a crucial water source for livestock and wildlife in RNP (see Fig. 1) (Hempson, *et al.*, 2015). While our study cannot identify whether pastoralism itself has shaped the unique landscape of RNP over millennia (Webley, 2007), our focus was on quantifying the direct influence of herders' daily decisions on soils and associated plant resources in and around RNP. Hempson *et al*. (2015) stated that herder movement decisions can be compared to natural seasonal migration patterns.

However, livestock production is seen as major cause for land degradation in arid and semi-arid regions (Dregne*, et al.*, 1991) where nutrient losses from the upper soil layers have been reported when vegetation was disturbed (Charley and Cowling, 1968). In the Richtersveld area, livestock tends to graze mainly around stock posts, thus locally reducing plant species richness and vegetation cover (Hendricks*, et al.*, 2005a). To date, no research in the region has investigated the influence of grazing on soil properties.

Under high grazing intensity, soil bulk density often increases on cattle grazing areas (Dormaar and Willms, 1998). Further, trampling impact by livestock tends to be enhanced around the animal enclosures, i.e., stock posts (Butt, 2010). Soil carbon (C) and nitrogen (N) contents can decline under high grazing pressure (Bisigato*, et al.*, 2008) but N and phosphorus (P) contents can also increase in areas with high urine and dung depositions, as was found in bomas (livestock-enclosures) in East-African savannas (Augustine, 2003; Treydte et al. 2006). We expected livestock dung deposition to be high close to the stock post, which would result in high nutrient contents in the soil. An overall low soil fertility and productivity in highly grazed areas can influence the sustainability of an ecosystem (Dormaar and Willms, 1998), which would be of high concern in the Richtersveld area.

Furthermore, the effects of livestock grazing on vegetation are a much debated topic (Anderson and Hoffman, 2007). While light grazing pressure can increase species numbers (Reid, 2012) and plant diversity (West, 1993), often the evidence for negative impacts of intensive grazing is more pronounced (Fleischner, 1994). When grazing intensity increases, particularly around stock posts, this results in vegetation cover loss (Shaltout*, et al.*, 1996), as well as decrease of plant species richness (Hendricks*, et al.*, 2005a, West, 1993). According to Cowling and Pierce (1999), in Namaqualand the biggest threat to biodiversity is overgrazing. Herder mobility is dependent on diverse social, environmental and agricultural factors (Samuels*, et al.*, 2008) and often protected areas contribute to a reduction in mobility. While several studies focused on how livestock foraging and mobility influence vegetation (Samuels, *et al.,* 2016; Samuels, *et al.*, 2013; Samuels, *et al.*, 2007; Samuels, *et al.*, 2008), none of these studies supplemented this information with soil analysis to address the long-term effects on the highly fragile Karoo ecosystem. Little information is available on the impact of livestock grazing around the stock posts, especially on soils in and around RNP, and how this is influenced by herder movement patterns.

For the understanding of pastoralist systems, according to Dougill, *et al.* (2010) three pillars are important: (1) The influence of herders on the environment and vice versa, (2) the livelihoods

of livestock owners and herders, and (3) the link between these actors, the environment, and the respective institutions.

In this paper, we focus on the following aspects based on the three pillars:

- the link between contractual arrangements (institutions) and livelihoods of livestock owners and hired herders;
- the link between herding patterns and impact on soil and vegetation.

# 2 Methods

## 2.1 Study area

Research was conducted in and around the Richtersveld National Park (RNP), South Africa (Figure 1), over a period of three months (August to October 2015). The RNP, with an area of 162,445 ha (Hendricks, *et al.*, 2002), is situated in the Northwest corner of the Northern Cape. The Orange River forms the border to the northern side. Richtersveld is located in the Namaqualand district and is located botanically in the Namaqualand-Namib Domain of the Succulent Karoo (Jürgens, 1991). The soils in the Richtersveld are characteristically shallow lithosols and the sandy red soils of the Sandveld region are of aeolian origin (Francis, *et al.*, 2007).

Insert Figure 1 here.

The climate in the Richtersveld is characterized by semi-arid temperatures in a winter rainfall region (MacKellar, *et al.*, 2007). In this semi-arid ecosystem rainfall varies between 30–300 mm per year with moderate mean annual temperatures. Coastal fogs are supplementing water availability and play a crucial role by increasing humidity in an otherwise dry environment (Cowling, *et al.*, 1999). Namaqualand is one of the two globally recognized biodiversity hotspots in an arid climate (Gil, *et al.*, 2004).

## 2.2 Data collection

### 2.2.1 Structured interviews with livestock owners and hired herders

In total, 71 interviews were conducted with livestock owners and their hired herders, applying quantitative structured questionnaires. The focus in interviews with livestock owners was on their financial situation, the contribution of herding livestock towards their livelihoods and livestock numbers and losses. Additional information was gathered through observations over three months in 2015 and during two follow-up studies in 2016 and 2018. The Sustainable

Livelihood Framework (SLF) (DFID, 1999) was used as a basis to develop interview questions, which were adapted to the specific context after consultation with local actors. Scoones (2009) outlines how the Sustainable Livelihoods Approach (SLA) can provide an understanding of social relationships and embedded power dynamics in complex systems, despite the often simplistic applications of the SLA framework that have generally shifted away from the contextual, transdisciplinary, and cross-sectoral SLA influenced perspective. In line with Scoones (2009), Lemke and Bellows (2016) argue that SLA research still offers a valuable and holistic approach for an integrated analysis of complex local realities and can further facilitate engagement and learning between local people and outsiders.

More recently, the SLA has been applied in rural development research in the context of tourism (Laeis and Lemke, 2016; Bennett, *et al.*, 2012; Tao and Wall, 2009; Shen, *et al.*, 2008), empowerment and alternative rural livelihoods of women (Lemke, *et al.*, 2012). This approach has further been integrated with agroecological data (Amekawa, 2011) and with a socio-ecological framework, explaining human development and adaptation in the context of the coupled human-environment interactions (Motsholapheko, *et al.*, 2011).

In our study, interviews with hired herders were focused on their daily routine and practices while herding sheep and goats. During interviews with hired herders, information on their socio-economic position emerged, and was recorded. One open-ended question was included in interviews about the relationship between RNP and livestock owners. Further, the triangular relationship between RNP officials, livestock owners and hired herders was examined to identify the entitlements of each group. At the time of our study, only 18 livestock owners were exercising their right to graze livestock inside RNP, all of them were included in the study. Of these, four herded their own animals and 14 employed herders. As a comparison group, 18 livestock owners outside RNP, who did not have the right to access RNP resources, were interviewed. Four of them herded their own animals, 14 employed herders, of whom one was not accessible. These livestock owners were selected based on a list of registered livestock owners in the Richtersveld. We compared livestock owners/hired herders inside and outside RNP to identify the potential benefit of livestock owners/hired herders to be able to use a wider grazing range (communal grazing areas, as well as grazing areas inside RNP). This comparison is especially important, due to the major Orange River access and, therefore, valuable riparian vegetation inside the RNP area.

### 2.2.2 Soil and vegetation data

Inside and outside the RNP, eight winter stock posts, where herders stayed overnight with their animals, were selected to compare the different grazing areas. The animals are mostly locked overnight in a so-called 'kraal' (fenced area), as is common practice in many African pastoralist areas (Augustine, 2003), while the herders stay in a tent or traditional hut nearby the kraal (Hendricks*, et al.*, 2005a).

Sites were selected according to comparable attributes concerning relief, soil and vegetation. Stock posts inside and outside RNP were chosen at the four most commonly used winter grazing sites (inside: Rooilepel and Helskloof; outside: Sandveld and Ploegberg; see Fig. 1), and at each site, two spots were selected as replication, summing up to four sample sites with eight spots in total. The sites were located 40 km and 20 km apart from each other inside and outside RNP , respectively, whereas the different spots within the sites both inside and outside RNP where 4 to 10 km apart from each other. Soil and vegetation samples were taken in three directions (North, Southeast, Southwest) along 750 m long transects (Riginos and Hoffman, 2003) around the stock posts as middle point, to identify the grazing impact of livestock on vegetation and soil quality.

Soil samples were taken inside and outside RNP to determine the grazing influence on the soil condition such as nutrient contents and compaction. Along each transect, samples were taken after 25 m, 100 m, 500 m and 750 m, totalling 95 samples inside and outside RNP as one point inside was not accessible. This scheme was chosen after two herders were accompanied and their daily routine was observed. Soil cores were taken with a cylinder of 5.5 cm diameter after the upper 2-10 cm of soil crust was removed (Blume*, et al.*, 2011). Soil fresh matter (FM) was recorded for bulk density calculation and samples were air dried for further analyses. Total carbon/nitrogen ($C_t/N_t$) ratios were conducted with an element analyzer, whereas phosphorus (P) was analyzed according to the method of Bray and Kurtz (Bray and Kurtz, 1945) at the University of Hohenheim, Stuttgart, Germany.

Plant sampling was conducted inside and outside RNP on the same sample sites where soil samples were taken. The plant cover was determined through two different methods: (1) A 1 $m^2$ quadrat was thrown randomly at each sample point towards the right and left side and the plant cover in percentage in the quadrat was determined through visual estimation (Smith*, et al.*, 1990). (2) From the middle point of the quadrat the 'distance to the next tuft' was assessed along the four main compass directions (North, East, South and West). The functional group of each plant was recorded and classified into succulent, shrub, herb, grass or tree (Kent and Coker, 1992). The distance to the next tuft was measured with a measuring tape, where the distance

was recorded at the first branch hitting the tape. The plant cover at the sampling sites was determined at every sample point (n=95) in two directions (right and left side from the sample point), totalling n=190. As the distance to the next tuft was measured from every quadrat in all four compass directions the total sum for distance to the next tuft measurement was n=760. The average of all repetitions per sampling quadrat along the transect was taken for further statistical tests. Means per sample point of all three transects were calculated.

## 2.3 Data analysis

### 2.3.1 Analysis of structured interviews

Data from structured questionnaires were analysed using descriptive statistics. Answers to the open-ended question were evaluated by ranking the main categories that emerged. The Sustainable Livelihood Framework (SLF) (DFID, 1999) was adapted to our research context to illustrate the impact of the contractual park agreement in RNP on livelihoods of livestock owners and hired herders, the relations and interactions between these actors, and the impact of resulting herding patterns on natural resources.

### 2.3.2 Analysis of soil and vegetation data

Soil and plant data were analysed statistically with SPSS version 22 (SPSS Inc., Chicago, USA) to compare soil properties and vegetation quality inside and outside RNP, as well as between the sites itself. Univariate ANOVA compared ‘sites’ (Rooilepel, Helskloof, Sandveld and Ploegberg) inside and outside RNP and ‘spots’. A significance level of $P < 0.05$ was defined. To fulfil the preconditions of an ANOVA the homogeneity of variances was assessed with the Levene Test and normal distribution was verified through the normal distribution of the residuals by means of histograms and scatter plots with regression lines. Univariate ANOVA tested the significant differences between the sites, between the distance away from the stock post and the interaction of site and distance, as well as site and spot.

The C/N ratio and N content data was log transformed. Simple regression was conducted for testing relationships between compaction and livestock numbers, as well as between N contents and dung deposition. The outcome was then graphically plotted with means and standard deviation or standard error using Sigma Plot 10.0.

# 3 Results

## 3.1 Socio-economic characteristics of livestock owners and hired herders

In total, 71 livestock owners and herders were interviewed (18 livestock owners inside and 18 outside RNP; 18 herders inside and 17 herders outside RNP). Out of 18 livestock owners, who were entitled to use grazing areas inside and outside RNP, 33% had used these resources before the park was founded and, thus, were listed as 'permanent' by the RNP management. The remaining 67% livestock owners were listed as 'affiliates', who were relatives of permanently registered members, mostly their sons and brothers. More than half (59%) of these livestock owners were involved in discussions about general issues during the initial process of establishing the park and resulting consequences for Nama pastoralists. The majority of livestock owners inside RNP were male, with only five female owners. The age of livestock owners inside and outside RNP ranged between 35 and 87 years. Livestock owners and herders came from the villages Kuboes and Sanddrif and household size was between three to five members.

For livestock owners inside RNP who answered this question (n=15), income derived from livestock represented a larger part of their total income as was the case for livestock owners outside RNP, who could only use communal grazing lands (n=18). Inside RNP, 59% of livestock owners had no other job opportunity apart from livestock keeping, while 41% had an additional job, with 29% working in the nearby diamond mines (Figure 2). Family support and government grants played a crucial role for about 50% of livestock owners. Outside RNP, where half of livestock owners relied solely on livestock while 33% worked in mines, a similar dependency on family support and government grants was reported. Inside and outside RNP, in 44% and 33% of the cases, respectively, adult children contributed financially to household resources.

Hired herders who provided information on their income situation inside (n=11) and outside RNP (n=11) were paid an average monthly salary of 66.24 $US[2] and 65.08 $US[3] by livestock owners, respectively. Herders further received water and food, however often on an irregular

[2] Exchange rate on 08.03.2018: 1 $US = 11.91 ZAR (http://www.xe.com)
[3] Average monthly salaries in the non-agricultural sector were 1,387 US$ in November 2016 (www.statssa.gov.za)

basis, and not always in sufficient amounts. During the time of field research, herders stayed in the park day and night, indicating that they had no other employment during this time.

Insert Figure 2 here.

### 3.2 Decisions and responsibilities of livestock owners and hired herders

The majority (83%) of livestock owners employed a herder, mostly based exclusively on verbal agreements. Hence, hired herders were also not officially registered in the joint management agreement between livestock owners and RNP management, while largely being responsible for livestock movement patterns (78% inside, n=18). Decisions such as slaughtering or selling animals were, however, taken by livestock owners (89% inside, n=18). According to livestock owners, inside RNP, 27 animals on average were lost over the last year (2014/2015) due to jackal (*Canis mesomelas*) attacks, drought and diseases. Outside RNP, on average 47 animals were lost (ranging from 5 to 300 animals), mainly because of drought and jackals. According to the hired herders inside and outside RNP, a major threat for the animals was the so-called plant poisoning 'krimpsiekte'[4], after consuming plants of the family *Crassulaceae* (Botha*, et al.*, 2000). However, only 4 animals inside RNP had died over the past year from this cause. We observed on several occasions that hired herders did not guide animals, which could lead to the death of unattended animals through diseases or predators. In 2015 and 2016, a jackal and baboons, respectively, were observed to attack livestock while the herder was not with the livestock (personal observation). All livestock owners reported losses through jackals, which was, in their opinion, directly related to the herders' neglect of their daily duties. Herders, however, considered livestock losses as a problem of the livestock owners. We observed that herders, if they were employed only for a short time span, for example for a few weeks, felt less responsible for livestock than did herders who were employed for longer time spans, for example for several years.

Most livestock owners and hired herders used 2 - 4 stock posts per year and shifted their herd from winter to summer sites, the latter being close to the river banks. The grazing area outside RNP had only limited access to the river, mainly due to mining companies operating along the Orange River outside of RNP. Herders outside RNP saw this as a disadvantage while livestock owners inside RNP were free to choose whether to use the grazing sites inside RNP or outside on communal grazing lands (Figure 1). The most frequently used winter and summer sites inside RNP were around Rooilepel and Helskloof, and along the Orange River, respectively.

[4] ‚Krimpsiekte' is a so-called shrinking-disease, a paretic syndrome of goats and sheep, caused by cumulative, neurotoxic effects after consuming certain succulent plants (Botha, et al., 2000; Botha, 2003).

Livestock owners and hired herders outside RNP had no clearly defined winter and summer sites, but shifted between the Sandveld and Ploegberg. In the hot summer season they were dependent on water resources from boreholes and natural springs.

Generally, herders left the stock post with their livestock approximately at 8.30 a.m. and returned at 4.30 p.m. Average (±SD) walking distance inside the park was 2638 m (± 2787 m), while outside RNP, this was about a third with 847 m (± 951 m), but without significant differences ($t(13) = 2.130$, $P = 0.053$). Overall, 69% of herders inside RNP claimed that grazing sites were adequate regarding quantity, proximity, and forage availability. The majority (71%) of herders inside RNP surprisingly reported that the field quality had improved over the past five years, which they attributed mainly to increased rainfall, while outside RNP 54% of herders claimed that the quality had decreased. Reasons for the decline were attributed by the latter mainly to less rain (71% of herders outside) and heavy winds (43% outside).

### 3.3 Relationships and dynamics between livestock owners, hired herders and RNP management

To facilitate communication with the RNP management, livestock owners, who are entitled to use the RNP resources, elected a representative to inform them about scheduled meetings and to pass their concerns and needs on to the RNP management board. The majority of livestock owners (88%) regarded these meetings as the major communication possibility with the RNP management. However, only half of them attended these meetings regularly, 39% sometimes, while 11% never attended meetings. Other communication ways were personal information passed on by the representative (59%), information received from other livestock owners (24%), and information transfer through notifications and signboards (18%). Only 28% of livestock owners were satisfied with the activities of and respective communication with the RNP management, 39% were not satisfied and 33% said they think the relationship is neither bad nor good. Overall, 81% of livestock owners wished to be more involved in decisions taken by the RNP, especially with respect to reintroduction of wildlife into RNP. Further, the schedule of meetings was often inconvenient for livestock owners due to their herding practices or other commitments such as working in shifts in the diamond mine. As hired herders were not officially registered they did not directly engage with RNP management (Figure 3). However, several hired herders wished to be officially recognized by the RNP management to establish a more formal status vis-à-vis livestock owners to improve their personal safety and to avoid irregular food and water supplies as experienced by them. Regular monitoring visits at stock posts by RNP rangers were rarely performed. This was due to considerable distances between

stock posts, and as only one RNP ranger, who was a livestock owner himself, was familiar with the locations of stock posts and hired herders.

Insert Figure 3 here.

## 3.4 Grazing impact on the environment in and around RNP

### 3.4.1 Grazing impact on soils

Herders kept goats and sheep, with an average herd size inside RNP of 149 (±86) animals, and an average herd size outside RNP of 166 (±157) animals.

The soil bulk density differed significantly across sites inside RNP ($F_{1,2}$ = 19.7, $P$ = 0.044) (Fig. 4), with higher bulk densities in Rooilepel than in Helskloof, and outside RNP ($F_{1,2}$ = 70.1; $P$ = 0.014) with higher bulk densities at Ploegberg than in the Sandveld. Variations were twice as large inside RNP as outside RNP.

Insert Figure 4 here.

Most livestock dung was distributed within the first 100 m of the stock posts and declined with increasing distance away from the post, particularly inside RNP ($F_{1,28}$ = 28.87; $P$ < 0.001) (Fig. 5). Outside RNP, no significant relationship could be found ($F_{1,28}$ = 1.80; $P$ = 0.190).

Insert Figure 5 here-

The average (±SD) $C_t/N_t$ ratio inside was $C_t/N_t$ = 16 (±7) while outside RNP ($C_t/N_t$ = 40 (±35)) the $C_t/N_t$ ratio declined significantly with increasing distance away from the stock post but only at one site in the Sandveld ($F_{3,29}$ = 3.1; $P$ = 0.044). Soil nitrogen (N) contents differed slightly across sites inside RNP ($F_{1,2}$ = 16.2; $P$ = 0.056) and outside RNP ($F_{1,2}$ = 21.1; $P$ = 0.035). Soil N contents inside RNP were with 477 mg $kg^{-1}$ more than twice as high as those outside RNP ($F_1$ = 40.4; $P$ < 0.0001) but were not significantly related to dung deposition inside RNP ($F_{1,45}$ = 0.02; $P$ = 0.9035) or outside RNP ($F_{1,46}$ = 1.8; $P$ = 0.1925). Soil phosphorus (P) contents inside RNP varied greatly between <0.001 mg $kg^{-1}$ and 84.27 mg $kg^{-1}$and outside RNP between <0.001 mg $kg^{-1}$ and 91.37 mg $kg^{-1}$. Overall, P contents inside RNP were influenced by the interaction site x spot ($F_{2,37}$= 7.9; $P$ < 0.001), with generally declining values with increasing distance away from stock posts. Outside RNP, no significant relationship was detected ($F_{2,38}$ = 3.1, $P$ = 0.056).

### 3.4.2 Grazing impact on vegetation

At Rooilepel inside RNP, the distance between tufts was significantly different across sites ($F_{1,2}$ = 489.0; $P$ = 0.002) (Fig. 6) and became smaller with increasing distance away from the stock post ($F_{3,37}$ = 3.6; $P$ = 0.022;). Outside RNP, significant differences across distance ($F_{3,38}$ = 2.8; $P$ = 0.055) were observed and for the interactions between site and distance ($F_{3,38}$ = 3.006; $P$ = 0.042) as well as site and spot ($F_{2,38}$ = 3.7; $P$ = 0.033).

Insert Figure 6 here.

Vegetation cover declined closer to the stock post, especially inside RNP ($F_{1,2}$ = 42.7; $P$ = 0.023), while outside RNP only slight differences across sites were observed ($F_{1,2}$ = 16.1; $P$ = 0.057). Vegetation cover inside RNP was significantly negatively correlated to increasing browsing activity ($F_{1,14}$ = 7.2; $P$ = 0.0180). Functional group distribution (succulent, shrub, herb, grass and tree) of plants was more uniform inside RNP than outside. Inside RNP, the major plant species were succulents, followed by shrubs whereas outside RNP in the Sandveld grasses were as frequent as succulents and shrubs.

## 3.5 Impact of livelihoods and institutions on natural resource use

The SLF (Figure 7) illustrates how the joint management agreement as constituted in a 'Contractual' National Park concept impacts on the livelihoods of livestock owners and hired herders. The contractual park agreement enabled livestock owners to use the RNP resources, leading to enhanced access to natural capital such as enlarged grazing areas and water sources, and to the adaptation of movement patterns. This reduced vulnerability in times of droughts, as the joint management agreement allows livestock owners to use the valuable water and riparian vegetation resources along the Orange River, thereby positively influencing the natural capital of livestock owners if fewer animals are lost to drought, enhancing the financial asset base. Besides, through the contractual park agreement, livestock owners have access to additional assets, like the installation of water pumps inside RNP (physical capital) and medication for animals (financial capital). However, the improved situation of livestock owners had no positive influence on the livelihoods of hired herders, as they are not included in the contractual park agreement and are not benefitting from the structures and processes put into place through this agreement, despite their crucial role for the overall well-being and movement patterns of animals, and therefore use of natural resources. The SLF clearly illustrates the marginalized position of hired herders within this construct, who remain highly vulnerable with regard to insecure employment conditions, low wages, lack of food and water, and lack of social security. The SLF further brings to the fore the negative impact on natural resources, especially on

vegetation, due to power dynamics and the resulting marginalised position of herders, and related movement patterns.

Insert Figure 7 here.

# 4 Discussion

## 4.1 Social impact of the contractual RNP on herders

### 4.1.1 Pastoralism: current and future livelihood perspectives

In line with Berzborn (2006), our results show that major income sources, besides livestock production, are employment in mining, governmental social grants, and wage labour in other sectors. This diversification of livelihood strategies, or so-called "pluri-active strategy", has been found to be most successful in the agriculture sector of Namaqualand (Anseeuw and Laurent, 2007). According to our findings, livestock owners, who use the RNP resources, invest more time and financial resources for keeping livestock production economically viable, due to long distances and poor road conditions inside RNP, compared to livestock owners outside RNP. Slaughtered animals were mostly for own consumption, providing a valuable food source in a remote area, where food prices are higher than in urban areas (Minten and Kyle, 1999). Hence, for livestock owners, livestock production in the Richtersveld contributes to overall food security and livelihoods. In contrast, hired herders, who seldom own livestock, depend on small incomes and on food rations supplied by livestock owners. Our observations revealed, and as were confirmed by a RNP manager (Interview: N. d. G., 19.10.2015), that herders frequently experience irregular and insufficient food and water supplies as well as delays in their salary payments, which was partly due to areas inside RNP being very remote.

Livestock owners inside and outside RNP were of similar age, ranging between 35 and 87 years. A follow-up study revealed that the younger generation was mainly interested in other job opportunities than pastoralism, although they stated they could imagine to continue this tradition if the conditions were better. Hendricks, *et al.* (2004) assume that the tradition of semi-nomadic pastoralism might not continue in the RNP in future as the younger generation perform pastoralism rather on a part-time basis, besides engaging in other livelihood activities. Herders in our study were mainly under 60 years of age, which highlights that herding is a strenuous practice, which is not performed any more at higher age.

### 4.1.2 Social dynamics and structural barriers

Since the inception of RNP, certain mistrust by livestock owners about the stated reciprocal intentions entailed in the contractual park agreement, especially concerning conservation, was reported by Boonzaier (1996). The same study reported mistrust by local people in Namaqualand towards tourism in general, and underrepresentation of their perspectives and needs in the promotion of the Richtersveld area. Our research revealed various barriers regarding communication, which could be partly attributed to structural conditions. A key issue in this regard was that hired herders were not officially registered with the park management, and no written contracts existed between livestock owners and hired herders. This lack of formal contracts resulted in RNP management having no documented overview of hired herders. This put herders in a weak social position, who are in fact in charge of herding animals inside RNP. Additional information obtained during follow-up interviews in March 2018 revealed that, while herders appreciated the idea of becoming officially registered, livestock owners had mixed feelings. Unfortunately, we were not able to talk to RNP officials about this issue due to gaps in communication. Ideally, livestock owners should be able to trust herders to take good care of their animals, as these are a precious financial asset. This includes finding good grazing areas, keeping an eye on toxic plants, and protecting animals from natural enemies such as jackals (Berzborn, 2006; Spittler, 1998). According to Boonzaier (1996), local populations of the Richtersveld are aware that they are responsible for future generations, especially with regard to conservational aspects. A positive example, where development and conservation objectives are being jointly addressed, is the Makuleke region of Kruger National Park in South Africa, showing positive outcomes with regard to local livelihoods and preserving biodiversity (Reid, 2001), as well as the Kruger to Canyons Biosphere Reserve itself (Coetzer et al., 2014).

Furthermore, our study revealed that livestock owners inside RNP experienced the entitlement of using RNP resources as privilege, while livestock owners outside RNP raised concerns about not having access to these resources, and felt left out. Prioritizing one group of livestock owners through the contractual park agreement creates unequal chances and social tensions between community members.

### 4.1.3 Use of RNP resources by herders

Herding and livestock management practices of Nama pastoralists were overall similar inside and outside RNP. In our study, the incentive for winter movement with livestock was forage scarcity while water availability is the reason for summer movements (Hendricks, *et al.*,

(2005b). As the RNP climate is characterized by winter rains (MacKellar, *et al.*, 2007) herders inside RNP use winter sites at a time of the year when grazing resources would normally be able to recover from intensive grazing. Herders outside RNP also alternated between their grazing sites according to grazing site quality and proximity to water resources. However, herders outside RNP often mentioned that herders inside RNP were able to use the river areas in summer, which they regarded as an advantage, while they had to rely on boreholes and natural fountains, leading to high numbers of animals in the vicinity of water sources. The stock posts were rotated every four to six months, which is similar to results by Berzborn (2006) who reports an alternation of three months inside and outside RNP. In comparison, the pastoral Maasai in Kenya rotated their stock posts on average every two months or less (Western and Dunne 1979). Furthermore, (Hendricks, *et al.*, 2005b) report more movements in times of increased rainfall in the RNP. According to the RNP management, 310 registered stock posts exist inside RNP (Interview: N. d. G., RNP manager, 24.08.2015), while we found that in total only 45 stock posts were used. The potential further use of possible stock posts is, therefore, not fully utilized. In our study, livestock owners frequently mentioned that no new stock posts can be established inside RNP. Outside RNP, some herders reported that, as grazing grounds had been good in the past year, they decided to extend their stays in certain places. As observed in this study, the change between stock posts is dependent on the time schedule of the livestock owner and the availability of a vehicle, as was also reported by Berzborn (2006). Nowadays, herders are more reluctant to move due to time and organizational constraints.

Movement decisions by hired herders were determined by a detailed knowledge about water resources as well as vegetation status (Hendricks, *et al.*, 2004), reflecting the herders´ knowledge about temporal and spatial variability of their environment and their animals' needs (Fernandez-Gimenez, 2000). Hence, the movement activities by herders enable the livestock´s specific diet selections (Samuels, *et al.*, 2016). However, we observed that the herders' personal situation, concerning low financial reimbursement, insufficient food and water supplies and few granted leave days, influenced the motivation of herders to perform their daily tasks. Baker and Hoffman (2006) also reported the influence of the social, economic and personal situation of herders on daily movement decisions in Namaqualand, affecting the efficiency of livestock production and environmental management. Our study confirmed that the daily and seasonal movement patterns of herders and livestock owners were dependent on their current personal situation and led to an increased grazing pressure on vegetation in the closer vicinity around stock posts. We conclude that joint management between RNP and livestock owners, which will include herders in decision-making processes, will be an important step towards sustainable

use of the highly fragile Karoo ecosystem. Based in our findings and feedback meetings with the local communities after completion of the research there is a strong interest from all sides – RNP management, livestock owners and hired herders- to continue the contractual agreement with RNP.

## 4.2 Ecological impact of pastoralism on the contractual RNP

We found high variation in soil characteristics across all study sites, which was also reported in other parts of Namaqualand (Allsopp, 1999).

### 4.2.1 Soil bulk density and livestock

Our generally high soil bulk densities of 1.61 mg $kg^{-1}$ inside RNP are characteristic for loamy soils (Blume*, et al.*, 2002) but bulk densities varied strongly. Inside RNP, trends of higher bulk densities closer to stock posts suggest that soils were influenced by livestock trampling, particularly up to 100 m around the stock posts. Similar patterns were observed by other studies, e.g. in New Zealand, the UK and South Africa (Greenwood and McKenzie, 2001).

### 4.2.2 Soil nutrients and livestock

As expected, we found most dung depositions up to 100 m away from the stock posts, similar to results by Hendricks*, et al.* (2005a). However, against our expectations, this did not affect soil N values. We found more than twice as high soil N values inside RNP than outside, where lower average herd sizes reside, and similar C/N values were found in the Succulent Karoo (Büdel*, et al.*, 2009). The $C_t/N_t$ and N soil contents did not differ significantly with distance to stock post nor with the amount of dung deposition. Brouwer and Powell (1995) found that cattle dung has a faster decomposition time and higher nutrient leaching potential compared to sheep dung. Allsopp (1999) also excluded the influence of higher dung depositions through higher stocking rates on nitrogen contents. The lower N contents outside are mainly due to the sandy soils of the Sandveld, a soil type of generally low soil organic matter (SOM) and N (Wolkowski et al. 1998). Our soil P values inside and outside RNP were classified as low (Sandhage-Hofmann*, et al.*, 2015), with P contents inside RNP slightly declining further away from the stock posts. This trend is common around livestock camps where higher P contents are often found directly around the camps due to higher dung depositions (Haynes and Williams, 1993; Haynes and Williams 1999). Sandhage-Hofmann*, et al.* (2015) also observed decreasing P values along a decreasing grazing gradient away from highly utilized water points.

### 4.2.3 Vegetation cover under different grazing pressure

As expected, the average vegetation cover across all grazing sites inside and outside RNP was slightly above the critical value of 20% for rangelands (Lang and McCaffrey, 1984), below which soil loss and surface run-off increase to unsustainable levels. In many semi-arid and arid regions, ground cover is less than 70% (Goodall 2009), highlighting the low resource availability and need for movement in a sustainable arid rangeland regime. As vegetation cover corresponds directly to variable rainfall, it is often difficult to differentiate between seasonal climatic variability and grazing effects (Bastin*, et al.*, 1993). According to the majority of herders inside RNP, the grazing quality had increased over the last five years, which they surprisingly attributed to more rainfall and respectively more river water, although, climate observations showed that the winter rainfall region in Namaqualand is decreasing (MacKellar, *et al.*, 2007) Although most of the herders outside RNP perceived the available grazing areas and the respective field quality as sufficient, they reported a decrease of field quality over the last five years. Herders outside RNP attributed this to lower rainfall, as well as to occurring drought periods, heavy winds and overgrazing. We assume that drier periods inside RNP are not as harsh as outside RNP, due to herders' opportunity to use grazing sites along the Orange River. Furthermore, herders inside RNP can move out of the park when winter rainfall is low in the hilly areas inside RNP. Therefore, they can make use of a wider grazing radius and higher availability of resources. Flexibility in terms of higher mobility seems to be the key of coping with different environmental conditions in this area and herders and livestock owners inside RNP, therefore, have an advantage over those outside RNP. Samuels*, et al.* (2007) argue that pastoralists are facing constraints when access to greater grazing areas is not provided, especially in times of drought.

We found grazing gradients as reflected by the intense dung deposition up to 200 m away from stock posts inside RNP, as well as lower vegetation cover closer to the stock post inside and outside RNP. Overall, browsing was very high, indicating the intensive utilization by livestock when stock posts are only changed two to four times a year. Grazing gradients around artificial water holes can lead to bush thickening (Moleele and Perkins, 1998), shrub mortality (Andrew and Lange, 1986) and shifts in plant species composition (Riginos and Hoffmann, 2003), and therefore influence the heterogeneity and productivity of landscapes. Several studies showed that plant community changes along grazing gradients with intensity of grazing period (Adler, *et al.* 2004; Nangula and Oba, 2004). Hoshino, *et al.* (2009) showed that plant communities along grazing gradients change from perennial species to annual species close around stock posts. In our study, different sites were dominated by different plant functional group

communities, highlighting the diversity of highly endemic plant species and their adaptation to various environments. Stock post changes were scarce and the overall daily walking distance of hired herders inside and outside RNP was rather short, however, similar to other areas of Namaqualand (Samuels*, et al.*, 2007). This high grazing impact around stock posts is especially of concern in sensitive environmental areas inside RNP (Hendricks*, et al.*, 2005b).

# 5 Conclusions and recommendations

Various stock posts inside RNP showed grazing gradients and the vegetation in the vicinity around the stock posts was clearly negatively impacted. The RNP is one of the major biodiversity hotspots worldwide in a semi-arid region and hosts a huge variety of endemic succulent species (Cowling*, et al.*, 1999). Hence, this fragile ecosystem seems to be threatened by a spatially unbalanced grazing regime. Outside RNP similar trends were found, although the grazing influence seems to be more evenly distributed. Pastoralist practices in the Richtersveld National Park strongly influenced vegetation cover but had less influence on soil properties. As vegetation develops only slowly in drylands, any reduction in cover will lower the productivity and resilience for both wildlife and livestock foraging in RNP. Hired herders have the highest impact on soil quality and vegetation conditions through their decisions regarding daily movement patterns. At the same time, they are highly marginalized and at the lowest end of the social hierarchy, lacking social security. This is due to the lack of formal agreements and employment contracts, low financial reimbursement, and often insufficient supplies of food, water and being granted leave. This lack of social security results in a low motivation of hired herders to perform their daily assigned tasks. Thus, hired herders often let livestock walk on its own around the stock post on a small grazing radius, severely impacting on the vegetation, especially when the stock posts are only rotated every four to six months. Considering the triangular relationship between the three main actor groups involved in this study - livestock owners, hired herders and RNP officials - hired herders are the most under-represented and under-recognized group. This makes transparent monitoring of herding practices and the impact on ecological aspects inside RNP difficult. Marginalised herders often value environmental concerns less as they just want to ensure that they are paid for keeping the animals alive. Hence, disconnecting of the herders from the management of the grazing resource may be detrimental to the long term integrity of the ecosystem. The RNP as contractual NP has a large potential to combine the often seen controversial objectives of biodiversity conservation and traditional semi-nomadic livelihoods if communication obstacles between the three main groups involved - livestock owners, herders and park management - could be overcome. We claim that

conservation needs and sustainable livestock management can be integrated, in line with the contractual agreement of RNP, provided that the social and financial situation of herders is improved and their position strengthened, e.g. through official registration of herders. Official registration of herders inside RNP would make it easier for RNP rangers to keep track of occupied stock posts and record vegetation status on grazing areas. This would furthermore improve herders' personal safety and avoid the currently encountered irregular food and water supplies. We suggest that the RNP management could offer training for herders to raise environmental awareness and to make permanent herding more attractive to herders and livestock owners. In addition, sharing grazing and water resources along the Orange River at certain times or seasons, especially in times of drought, would improve access to these resources for herders outside RNP. This could contribute to improving social relations between herders and livestock owners inside and outside RNP.

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**Compliance with Ethical Standards**

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