Patterns of plant diversity and cultural meaning in a rural landscape in the Albany Thicket: Effects of land-use and topography

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ABSTRACT

South Africa is the world's third most bio-diverse country, but pressures on this biodiversity are many and widespread. It is now well recognised that protected areas on their own are insufficient to protect biodiversity, and increasing emphasis is placed on developing models for ensuring the persistence of biodiversity in agricultural and rural landscapes. One of the major challenges, especially in rural areas, is the need to reconcile people's need to use natural resources with biodiversity conservation. This study aimed to (1) examine the ecosystem services people derive from the natural vegetation and how this is distributed in space and (2) the effects of land use and topo-edaphic factors on species richness, composition and structure and how this is spatially distributed. I investigated two land-use types, i.e. a rural village and adjacent lightly used game farm(s) by comparing 20 sites under each land-use representing the range of topographic position. I sampled respondent's uses and values, species richness and composition, woody density, structure and composition at these 40 sites. This allowed for comparison between the two land uses but also allowed me to examine the effect of topography and relative soil moisture (both known to have a string influence on vegetation in semi-arid areas), and to relate the ecosystem services to plant species richness, structure and woody composition.

People derived a wide range of ecosystem services and this differed with distance from the village and vegetation type. Men and women performed different tasks and had different feelings and derived different use values across the landscapes. Both men and women showed a great appreciation for the thicket forest, *Pteronia*-dominated and grasslands sites. They recognised these areas and as sacred grounds where they have a strong connection with their ancestors. Women preferred utilising areas closer to the village because they feared crime and wild animals in more remote thicket or forest, while men utilised all areas across the land, but more frequently closer to the village. The older generation had a strong attachment to nature, perceiving it as a provider. The younger generation, especially the young women did not express such a deeply felt connection, but enjoyed getting to see where some of the medicinal plants and useful wood structures were harvested. Younger men would go far into the forest quite regularly, often as far the Great Fish River, when they hunt with their peers. Although a diversity of perceptions were presented, and not all conformed to traditional views and practices, most respondents derived a mix of ecosystem services, with the areas closer to the village providing recreational and direct use value to more people on a more

regular basis but spiritual values associated with deep forest persisted, especially among the older generation.

Species richness and composition was analysed in relation to Topographic Relative Moisture Index (TRMI), land use and distance from the village to see the effect of topography versus land use on the vegetation. The total number of plant species recorded was 386 for both study sites. Two hundred and ninety two species were recorded in Ntloko and 265 on the game farms. Of the species that were sampled, 121 were recorded in Ntloko only, 94 in the game farms only, and 171 species were shared. The number of useful plant species (fuel, medicine, forage, cultural and edibles) was recorded to be 110, 83 in Ntloko and 63 on the game farms. There was no significant difference in species richness and alpha diversity between the study sites, but the game farms had a higher projected total number of species, reflecting higher beta diversity in the game farms than the communal area.

The point-centered quarter method (PCQ) was used to describe woody plant composition, tree density and structure. The woody structure and composition was analysed in relation to the above-mentioned factors and I found no significant difference in the density and overall woody structure and composition between the two study sites. Sites at Ntloko had a positive correlation between soil moisture and woody plant density and a higher density of palatable and unpalatable species. The game farms showed no significant changes in woody plant density with TRMI.

This study showed that the communal area maintained comparable plant species richness and vegetation structure and composition to game farms. The rural landscape comprised a gradient from sites close to the village that were heavily impacted, not considered particularly special or sacred but safe, familiar and of utilitarian importance, to sites farther away with denser, less transformed thicket vegetation, which are considered to be of greater cultural, spiritual and aesthetic importance but less safe, familiar and accessible. This suggests that conservation outcomes can be achieved outside protected areas, and that biodiversity is valuable to local residents. Resource management should be implemented to maintain the ecosystem services provided in rural areas in a way that integrates local peoples' perceptions, goals and values with ecological evidence.

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CHAPTER 1 – GENERAL INTRODUCTION

Rural communities and natural resources

Rural communities in the developing world depend on natural resources to meet their basic living requirements and to mitigate poverty (Shackleton et al. 2001; Twine, 2003). These resources are used for household consumption and to generate income (Shackleton et al., 2001). Vegetation is a key resource that contributes to rural livelihoods as it provides products such as wood for fuel, fruits and medicinal plants. High population densities in communal areas combined with low levels of economic development drive most households to at least some degree of dependency on natural resources (Shackleton, 2001; Scholes, 2009). Studies have shown that traditional ecological knowledge assists in protecting and maintaining these natural environments (Wiersum, 2000; Cunningham, 2001), but factors such as high population densities and ineffective local institutions for common property management have resulted in over-use in many areas (Greenberg, 2010; Vetter, 2013).

In South Africa, a great number of households in communal areas depend on natural resources and trade a variety of products locally to well off households (Shackleton et al., 2001; 2002). A study by Shackleton & Shackleton (1997) showed that women traded some of the natural resources only when they needed money for a particular reason, such as school expenses. Such trading is often done part-time using natural resources as a “safety net” in times of financial difficulties by generating income by selling raw and processed natural products (Twine et al., 2003, Shackleton & Shackleton 2004, Babulo et al. 2008, Shackleton et al., 2008 Vetter, 2013). However, not all communal households use natural resources; the degree of use depends on resource availability, accessibility, employment and income levels, as well as personal and cultural preferences (Shackleton et al., 2001). Commercial activities within communal rangelands are unacknowledged but constitute a significant portion in rural livelihood strategies (Vetter, 2013). They have a strong economic value and are socially differentiated among the rural poor especially women (Cousins, 1999). According to Palmer (1997), many villages in the former Ciskei have developed into peri-urban settlements, depending not only on natural resources, but also on other forms of income such as local employment or migrant labour, social grants and other remittances. Electrification and social grants have in some areas led to a reduced reliance on natural resources, including fuel wood, but these resources continue to play an important role in local livelihoods (Twine et al., 2003; Shackleton & Shackleton 2004; Madubansi & Shackleton, 2006).

While the importance of natural resources to livelihoods has been well documented in South Africa in the last two to three decades (Cousins, 1999; Twine, 2003, Shackleton & Shackleton, 2004, Babulo et al., 2008), the feelings and values the local people attach to their surroundings landscapes have been explored far less, and only more recently (Cocks et al. 2012, 2016). This is because cultural values were not clearly understood and so it was difficult to integrate people's values and practises with conservation planning and implementation without proper knowledge (Maffi, 1998; 2005; Anthony & Bellinger, 2007). Cocks et al. (2012) reported that many of the interviewed people showed an appreciation of cultural ecosystem as they mentioned that they enjoyed the peace, beauty and tranquilities of these areas and they also get the chance to escape worries of home. The variety of ecosystem services are defined and explained in the (Millennium Ecosystem Assessment, 2005) and they include non-material benefits that people obtain from the ecosystems through of spiritual, religious and aesthetic value. These services are thought to enhance mental health and improve the subjective matter of sense of place (Millennium Ecosystem Assessment, 2005). These ecosystem services provide health benefits that are less tangible than standard health indicators, yet are highly valued by the people.

Concern about degradation

Overgrazing by livestock and harvesting of fuelwood are considered important drivers of land degradation (Hoffman & Ashwell, 2001). The communal areas have been identified as the most degraded areas in South Africa, especially when compared to inaccessible and conserved areas (Archer et al., 1989; Ward et al., 1998; Hoffman & Ashwell, 2001; Knight & Cowling, 2003). Land degradation in arid parts of Africa has been documented to be caused mainly by overgrazing and resource harvesting. Communal areas are often characterised as unproductive, overstocked, overgrazed and degraded, although there has been considerable debate about this (Boonzaier et al., 1990; Shackleton, 1993, Vetter, 2005). These discussions were initiated in response to rising concerns about the mismanagement of communal rangelands, assumed to be due to the inevitable "tragedy of the commons" (Hardin, 1968; Scholes, 2009). Vetter (2005) reviewed two models that were used to understand and subsequently reduce degradation in arid and semi-arid rangelands. The equilibrium and non-equilibrium models focused on the ecology and management of these systems and both showed differences in maintaining communal rangelands in that the equilibrium model focused on biotic factors such as herbivores and their resource, while the non-equilibrium model focused on abiotic factors responsible for primary production and livestock dynamics (Vetter, 2005). After much debates researchers finally agreed that both equilibrium and non-equilibrium models were found in rangelands occurring at different space and time scales. Spatial heterogeneity and temporal variability of semi-arid rangelands shifted the attention away from the equilibrium-non equilibrium dichotomy since it was acknowledged that dryland systems are affected by various other factors including social, cultural and others at temporal and spatial magnitudes (Vetter, 2005).

The division of land into generally more lightly stocked commercial and heavily stocked communal areas in South Africa led to the assumption that communal tenure is the cause of vegetation and soil degradation (Rutherford & Powrie, 2013). This is based on the controversy that severely degraded areas under communal tenure are caused by domestic livestock through heavy grazing (Shackleton, 1993; Ward et al., 1998). A study by Todd & Hoffman (1999) in commercial vs communal areas showed stocking rates to be roughly twofold higher in communal than the commercial areas. There has been considerable debate about this and the accepted wisdom these days is that unmanaged commons are the problem (Harding, 1994). Communal rangelands can be managed effectively but traditional institutions for managing the commons were eroded during the apartheid years and there is a legacy of "open access" now (Ainslie, 1999; Bennett et al., 2010).

Human activities have been identified as one of the causes of biodiversity loss globally and this is raising concerns with people and conservation organisation (Biggs et al., 2004). The maintenance and wise use of resources is dependent on understanding the ecological processes as well as linking the complex relationship between social order and the natural environment (Hoare, 2002). This means that the use of resources in South Africa differs for different social structures and the environment is exposed to different pressures; be it anthropogenic or environmental. Areas that are vulnerable to overgrazing and overuse of resources have experienced severe degradation and high biodiversity loss (Pueyo & Alados, 2001)

Savanna vegetation has been widely reported to be impacted by livestock and resource harvesting (Shackleton et al., 2001; Twine, 2003; Vetter & Bond, 2012). Arid savannas in southern Africa have experienced biodiversity loss because of land degradation (Scholes & Biggs, 2004). Noticeable structural and floristic changes have occurred in many rural areas caused by cutting and collecting wood for fuelwood (Hoffman & Todd, 2000 ;Berry et al., 2005). Palatable and perennial grasses have declined in many savannas under communal tenure (Skarpe, 1992; Rutherford et al., 2012; 2013). Continuous heavy grazing has also resulted in bush encroachment in many communal areas, although browsing by goats and fuelwood harvesting have resulted in lower rates of bush encroachment in many communal areas than nearby commercial farms where grazing by cattle and sheep dominates (Wigley et al., 2009). In savannas dominated by *Colophospermum mopane* (Rutherford et al., 2012), a tree that is well known to yield strong construction wood and exceptional firewood (Mashabane, et al., 2001), this tree has been overharvested for timber and has largely disappeared in Namibia (Cunningham & Davis, 1997), experiencing high declines in Zimbabwe and Malawi (Musvoto et al., Chikuni, 1996). The study on *C.mopane* was comparing the effects of heavy grazing between a communal and commercial farm on plant species richness and diversity, abundance, vegetation structure and soil characteristics. The findings were structural more than compositional changing the mopane savanna from woodland to scrubland as they found no significant differences in species richness, diversity and soil characterises.

The effects of heavy grazing and browsing between communal and commercial areas is also well documented in subtropical thicket vegetation (Fabricius & Burger, 1997; Evans et al., 1998, Rutherford et al., 2012). Declines in species richness have occurred in thicket vegetation as a result of heavy grazing (Hoffman & Cowling,1991; Lechmere-Oertel et al., 2005). The main impact seems to be heavy browsing by goats which eliminates woody species, most notably destroying the *Portulacaria afra* matrix in thicket vegetation types where this is a dominant vegetation component (e.g. Sundays River and Great Fish River valleys). Unsustainable browsing by goats changes the dense thicket vegetation into open savanna-like vegetation and decreases species diversity. (Hoffman and Cowling, 1990; Stuart-Hill, 1992; Stuart-Hill and Aucamp, 1993; Moolman & Cowling, 1994). Communal and commercial farmers experience degradation because of heavy grazing and browsing by domestic and natural herbivores. However, the effects are greater in communal areas because of wood harvesting.

While the effects of heavy utilisation on thicket vegetation have been widely reported and mapped at a regional scale (Lloyd et al., 2002), finer scale variation in thicket degradation in relation to settlements and land use has received less attention. The spatial distribution of degradation is not uniform, and assessments of the extent and severity of degradation can be biased by the fact that the most easily accessed parts of the landscape (along roads and near settlements) tend to experience the greatest resource use pressure and are more likely to be degraded than less accessible areas. This is based on human observation where trees are cleared for settlements, cultivation and timber products are collected, transforming dense vegetation into open fields and settlements sites (Palmer et al., 1999). Studies mapping land degradation have been done at regional and global scales (Dregne, 1983; Middleton & Thomas, 1992; Oldeman et al., 1990; UNEP, 1997) and have been criticised as 'incomplete and inaccurate' because of limited data and their findings were based on expert opinions (Hoffman & Todd, 2004; Wessels et al., 2008). Communal areas are normally characterised as severely degraded areas because of their unstable land use (Shackleton, 1993; Hoffman & Todd, 2004;) mostly wood collecting, while more remote and less accessible areas are often in good condition (Shackleton, 1994; Pote et al., 2006). In thicket, the distance effect may be even more pronounced than in savanna, as thicket tends to be more impenetrable than savanna and the contrast between areas surrounding villages and those at some distance away can thus be more pronounced than in savannas.. Also, visible changes in vegetation structure with distance from human settlements do not necessarily mean that the woody species are not present. In some cases, the disturbance (for example wood collecting, which promotes resprouting) has altered the size and density of the trees and shrubs while the species pool has not changed substantially (Pote et al., 2006; Rutherford et al., 2012).

The term *degradation* has generated debates about the suitable term to use in communal areas. Definitions and assessments of degradation have been challenged in order to find a practical definition of degradation (Shackleton, 1993). Land managers suggested that the term *land degradation* be defined according to the land user's objective in sustaining livestock production and that both economic and ecological assumptions be considered (Sandford, 1983). Scholes (2009) defined degradation as an irreversible, continuous decline in the overall ecosystem services. This definition, under the ecosystem services concept suggests that changes in vegetation structure, composition and biomass are not automatically considered degradation if the ecosystem services derived are still similar in magnitude and continue to be provided. Defining degradation under the basket of ecosystem services helps alleviate debates about what constitutes degradation and promotes new ways to quantify economic and social costs, which are thought to be drivers of degradation in communal areas (Biggs et al., 2004; Scholes, 2009).

Ecosystem services

Ecosystem services are the outcome of social and ecological systems that produce a sustainable provision of services (Bennet et al. 2015). They are defined as the benefits that people obtain from the environment (Millennium Ecosystem Assessment, 2005). There are different types of ecosystem services and they are categorised as provisioning services (including food, water and other agricultural products), regulating services (e.g. flood and disease control), cultural services (spiritual, recreational and psychological benefits) and supporting services such as nutrient cycling, which sustains life's condition on Earth (Millennium Ecosystem Assessment, 2005). Ecosystem services play an important role in the livelihoods of people living in communal areas. Local people are dependent on the ecosystem services they receive from the land even though they have other forms of income such as wages and social grant from government (Scholes, 2009). Research has been done to try and understand various benefits that ecosystem services provide for people (Russell et al., 2013) which can assist in decision-making and improving the management of ecosystems for human well-being (Bennett et al., 2015). Provisioning, regulation and supporting are the main ecosystem services identified and they generally receive more attention and are better studied than cultural ecosystems (Milcu et al., 2013).

Cultural ecosystems services characterise the intangible connection between people and the ecosystems they live in. They can be described as either spiritual, social or psychological creating a link between culture and the environment (Russell et al., 2013). Sacred sites, including the species inhabiting these areas, are protected by indigenous people in many parts of the world as they are regarded as ceremonial places or places harbouring spirits (Vershuuren, 2010; Irani et al., 2011; Negi, 2012). Rural landscapes are heterogeneous and they differ with respect to human activity with the environment (Irani et al., 2011). Natural areas around the world have become local biodiversity “hotspots” because they are considered sacred places for religious and cultural purposes, hence they are known to supporting tangible and intangible cultural works (Verschuuren et al., 2010). However, the sustainability of communal areas is of concern because of high biodiversity loss compared to protected areas (Fabricius & Burger, 1997; Fabricius et al., 2002; 2003).

Ecosystem services and degradation in rural areas in SA

Rural areas in South Africa are characterised as overpopulated, poor and degraded, in contrast to most commercial farming areas and conservation areas (Shackleton, 1993; Hoffman & Todd, 2000; Hoffman and Ashwell, 2001). However, the basket of ecosystem services derived in these landscapes has not been well explored and compared to that in commercial and conservation land (Kumar & Kumar, 2008). While the provisioning ecosystem services (natural resource use, farming) have been documented by. Cousins (2000), Shackleton et al (2001), Twine (2003) and others, the nature and value of cultural ecosystem services has been largely overlooked in communal areas. The multiple use and cultural values the total basket of ecosystem services in a heavily used communal area may be greater than in a single-use commercial farm (Cousins, 1999; Shackleton, 2001). Secondary resource use, (which is the widespread use of natural resources by communal households for reasons other than livestock), is common, and usually considerably higher than the use of rangeland for livestock as shown in (Shackleton et al. 1998; Shackleton & Shackleton, 2000; Shackleton et al. 2005; Shackleton & Shackleton 2005; Madubansi & Shackleton 2007). Livestock sales and services do not provide sufficient income as secondary resources in communal rangelands (Cavendish, 2000; Shackleton & Shackleton, 2000; Babulo et al., 2008).

Local community perceptions of nature and biodiversity are not well understood or accorded much value in South Africa (Cocks et al., 2012). According to Kepe (2008), studies have been done in the 20th and mostly the 21st century in different areas of Africa where various disciplines sought to understand and measure the value of vegetation as a resource and how it is used a survival tool and in rural people’s lifestyle. Biodiversity, in particular plant diversity, plays a significant role in ecosystem services, i.e. a greater diversity of plant species produces greater resources available for people to use (Hooper & Vitousek, 1997). Certain plant species have direct relevance in local people’s lives as they depend on them for food, fuel, medicine and other services (Garibaldi & Turner 2004) hence they value them as natural and cultural resource. The disappearance of a species changes the ecosystem services that are connected with that species (Millennium Ecosystem Assessment, 2005). Such modifications occur as a result of land use change which affects all the ecosystem services including species diversity and composition (Hooper et al., 2005; Millennium Ecological Assessment, 2005). The impacts of environmental changes are different for different types of species and ecosystems, thus causing different patterns of biodiversity modification (Sala et al., 2000).

Socio-economic impacts and cultural characteristic of land use in Eastern Cape, South Africa

Humans in the south-eastern region of the Eastern Cape were sparsely distributed before the arrival of the colonial settlers in the 1800s (Mucina & Rutherford, 2006). The arrival of Dutch and British colonists in the 1700s was the initial stage in confining amaXhosa into areas beyond the Great Fish River (Thompson, 2001). The Great Fish River acted as a natural border between the white-owned western part of the river and the communal tenure on the eastern side. Native reserves between the Kei and Great Fish Rivers were created as an outcome of The Frontier War which happened in 1834-1835 (Thompson, 2001) segregating black people into designated homelands or 'bantustans'. This led to the creation of two homelands, namely the Transkei in 1951 and the Ciskei in 1961 (Hamann & Tuinder, 2012). People were forced to resettle from their scattered homesteads surrounded by arable fields into planned villages in the 1960s as part of so-called Betterment Planning during the apartheid era, which limited the available land to the people as the human population increased (Manona,1999). Such decisions were argued to be effective in terms of agricultural usage of the remaining land, but largely failed to halt or reverse land degradation (De Wet, 1989).

The concentration of large and growing numbers of people and domestic livestock into small concentrated boundaries led to the transformation of much of the thicket vegetation into more open vegetation dominated by karroid shrubs, less palatable plants, and alien species (Kerley et al., 1995). The AlbanyThicket Biome (Mucina & Rutherford 2006) has a variety of land use types which occur adjacent to each other (Lloyd etal., 2002). Evans et al. (1998) found significant differences in species composition and structure between commercial (freehold farming), communal and conservation land use types in the Great Fish River valley. Commercial farming is mainly driven by economic and regulatory laws which primarily benefit the owner depending on income gained by crop and livestock production. In the 1960s, thickets in the Eastern Cape experienced one of the worst degradation events known as the mohair boom (Smith & Wilson, 2002; Scholes, 2009). This phenomenon was an additional cause of overgrazing in the Albany Thicket Biome, mainly on commercial farms, and has left many thicket areas as “pseudo-savannas” with scattered canopy trees and an ephemeral herbaceous layer (Lechmere-Oertel et al., 2005).

The extinction and disappearance of mega- and medium sized herbivores after the arrival of the settlers in the early 1800s was followed by an increase of pastoralism (Zachar, 1982). The introduction of fences, acaricide dip (to prevent tick-borne diseases) and boreholes allowed commercial farmers in the subtropical thicket to increase their stock numbers and exploit new areas of the thicket (Mucina & Rutherford, 2006). Many farmers overstocked goats to “open up” the dense bush and that, coupled with slow regeneration of the thicket vegetation, resulted in a degraded biome (Mucina & Rutherford, 2006). Conventional agricultural operations were the main activity in white-owned land across the Eastern Cape (Brooks et al., 2011), but a range of economic, socio-economic concerns and opportunities has resulted in large areas being converted to game farming (Brooks et al., 2011). These included rising input costs for livestock farmers, and increased opportunities to tap into the global tourism market in post-apartheid South Africa (Kerley et al. 2005). The shift started in the early 1980s in South Africa and accelerated from the early 1990s, and more recently a documented 25 % annual increase in generated income was recorded in commercial use of wildlife on private land compared to livestock farming (Smith & Wilson, 2002). Moreover, in 2000 an additional 48 % of pastoral farmers had changed to game farming in the Eastern Cape alone (Jolliffe, 2001). The change in land use from livestock to game farming is thought to be more environmentally and economically sustainable considering how indigenous herbivores are able to withstand environmental disturbances including drought (Horn, 2008). Indigenous herbivores such as antelopes are able to digest secondary digestive compounds and are more resistant to tick-borne diseases, which are a big problem for livestock farmers in the thicket (Robbins et al., 1987). Game farming has been found to have an overall, but minor effect on vegetation regeneration and that the response is occurring gradually (Horn, 2008).

This study was located in the Great Fish River valley near the town of Peddie in the Ngqushwa municipality. IsiXhosa-speaking people of the Cape Nguni descent (Cocks et al., 2012) inhabit the study site, which falls within the Maputaland-Pondoland-Albany Hotspot (MPA) in the Eastern Cape. It is the second richest floristic region in southern Africa and is located within the Albany Thicket Biome which and has the highest species richness and endemism in the South Africa (Di Minin et al., 2013). It is part of an area that suffers from high levels of poverty and unemployment rates and constitutes of areas that have been described as degraded (Evans et al., 1997, Ainslie 1999, Kakembo, 2001; Fabricius et al., 2003).

Local people in parts of the eastern Cape were found to have a strong appreciation for the provision including livestock ownership, and cultural ecosystem services provided by the

Thicket forest (Ainslie 2005; McAlister,2012; Cocks et al.,2012). They regard the forest as a sacred place where they can communicate with their ancestors and a rich place for collecting fuelwood and other natural resources. Although recent developments in villages have hindered daily visits to the forest, the people still respect and appreciate their spiritual and cultural activities (Cocks et al. 2012, 2016). They identify spending time in the forest as a therapeutic need and also as a way of keeping in touch with the ancestors as they are able to cleanse them spiritually. The ancestors are recognised as benevolent protectors of the family, household and the entire clan (Berg, 2003). The interaction between the living and the ancestors is done in their homes and in the forest usually through consulting traditional healers, who mediate on behalf of the people. Such rituals usually involve the slaughtering of cattle or goats, thus playing a significant role in the livelihood of rural communities. Livestock, particularly cattle, are recognised as cultural icons and valuable commodities which have great cultural and economic significance, including the maintenance of meaningful connections among people in a community as well as with the ancestors, (Ainslie, 2005; 2013). Cattle represented wealth in bantu-speaking agro-pastoralists for centuries and remain significant in the local economy. They were, and are still, used for bride wealth and other social exchanges, and cattle ownership confers social status (Smith, 1992; Ainslie, 2013).

As elsewhere in the developing world, local communities in the Eastern Cape experience rapid change because of socio economic processes, which are influenced by the constant diversification of rural livelihood and that of rural and urban linkages (Cocks, 2006). This has major impacts on landscape change especially in areas where the community is dependent on natural resources. Plants have always improved life experiences for humans, directly and indirectly, especially the thicket vegetation which has cultural importance to the people in the study area (Henry, 2005; McAlister, 2012). Rural and peri-urban people living in the Albany Thicket Biome of the Eastern Cape displayed a strong appreciation for specific natural vegetation and plant species. These places provided various spaces important for their well-being through communication with the ancestors, areas for religious rituals and a wealth of culturally-inspired uses of species (Dold & Cocks, 2012; Cocks et al. 2012, 2016).

Aims, scope and overview of the thesis

The aim of my study was to examine the effect of land use on plant richness and composition but also the ecosystem services people derived, in a spatially explicit manner (along a gradient from close to the village to deep in the Fish River Valley). This research assessed the nature, degree and spatial distribution of vegetation change in a communal area situated in the subtropical thicket of the Great Fish River valley by comparing it with a privately owned adjacent area used for wildlife conservation and hunting. Since topography and resultant differences in soil moisture have a strong effect on vegetation composition, the influence of topo-edaphic factors was included in all analyses of vegetation characteristics.

Cultural ecosystem services in rural landscapes are poorly understood and little is taken into account when assessing the state of areas from a conservation/ agricultural point of view (Millennium Ecosystem Assessment, 2005; Cocks et al., 2012). The knowledge and skills contained by the indigenous people could add value in improving management strategies for better conservation and social development (Fabricius & Burger, 1997). This can be done through the integrated paradigm of biological and cultural diversity in order to sustain better development (Maffi, 2005; Pretty et al., 2009), but such attempts have been slow in communal areas of South Africa (Knight et al., 2010). Local people associate with different landscape elements through direct use and cultural values which they derive from and attribute to different components of their natural vegetation. The concept of ecosystem services is an important factor in linking the functioning of ecosystems to human well-being thus it is important to understand the basket of ecosystem services provided by the rural landscape (Fisher et al, 2009). This is achieved by investigating the multiple uses and values local people in the communal area associate with different landscape elements through a qualitative analysis based on interviews and transect walks in different parts of the rural landscape. Therefore, the study aimed to explore direct use and cultural values that the local people attached to their natural vegetation. It also aimed to investigate the relationship between age/gender and the characteristics of the vegetation through the resultant activities and mobility.

Most ecosystems lose their biodiversity because of incompatible land use, a process that requires management strategies to reduce biodiversity loss (Schulze & Mooney, 1994). Vegetation degradation in the Thicket Biome has resulted in huge biodiversity loss because of high grazing pressures and land use change (Hoffman & Everard, 1987; Birch et al, 1999; Biggs et al., 2004). The intensity of degradation depends on the type of land use and the applied land management practises (Evans et al., 1997). Species richness is widely used as a natural measure of biodiversity as it gives a detailed account of community and regional diversity (Magurran, 1988; 2003). Plant species richness is important in measuring biodiversity because of primary ecological functions they perform. The study aimed to investigate the effects of land use and topography on plant species richness and composition though quantitative vegetation assessment. This was achieved by comparing two landscapes units in a communal area and game farms, at sites that cover comparable topographic positions (slope and aspect) with similar environmental conditions. Although landscape and plant communities can be strongly shaped by anthropogenic processes, abiotic factors such as water availability have a significant influence on plant composition and diversity in semi- arid systems (Wear et al., 1996). According to Pueyo & Alados (2001) the survival of plants, their ability to compete, and their dispersal efficiency is reduced in water-limited systems. Thus, the physical features of landscapes influence land use, sequentially land use affects vegetation dynamics (Pan et al., 2001). Soil moisture was used as determining factor, which was used to quantify the effects of topography on plant species richness, composition and structure. I expected steep, inaccessible and south-facing slopes to have a higher species richness than flat, accessible areas close to the village. Since people residing in communal areas are well-known for using natural resources, I expected to find a disturbance gradient indicated by distance from settlements in the communal area, where human disturbances decrease with distance from the settlements. The impact of land use was expected to be severe near the communal settlements because of high utilisation of natural resources which decreased with distances to the river creating a mosaic of vegetation types ,that is, consists of open grass field and karroid shrubs closer to the village followed by an open thicket vegetation type and dense thicket in closer to the river.

The removal of desirable species through harvesting of firewood or building material and browsing by domestic livestock changes vegetation structure. Selective harvesting puts pressure on woody species where species of a certain size class are targeted, changing the size class distribution and hence vegetation structure (Luoga et al., 2000). Under high browsing pressure and poor livestock management, palatable species are often reduced in quantity and replaced by weedy unpalatable species (O'Reagain & Grau, 1995). Plant composition and structure contribute to the biodiversity of an area, thus playing a significant role in landscape functioning (Noss, 1990). The study therefore investigated the effects of land use on woody vegetation structure and composition between a communal area and game farms. I expect a significant impact of harvesting and browsing on the structure and composition of the dominant woody species with effects on browse potential and availability of useful woody plants. A disturbance gradient was expected through land use where fuelwood harvesting and browsing is expected to decrease with distance from communal settlements.

The study presents botanical and social aspects in order to determine the types of ecosystem services a communal area provides through the natural resources present. It also acknowledges people's perspective in what they make use of and value, the provisioning they get from these ecosystem services. Chapter 2 describes local people's assessment of the ecosystem services provided by the vegetation in the communal area. Chapter 3 focuses on the effect of land-use and topography on plant species richness and composition in the communal area and the adjacent game farms. Chapter 4 focuses on the effect of land use and topography on the structure and composition of the woody component in the two study sites. Total species richness in chapter 3 is used to quantify biodiversity while composition and structure of the dominant woody element is linked to functional characteristics such as browse potential. Chapter 5 is the conclusion of the study, which summarises the key findings in relation to the key research questions and discusses the implications of the findings.

CHAPTER 2 – CULTURAL VALUES AND OTHER ECOSYSTEM SERVICES ASSOCIATED WITH DIFFERENT PARTS OF THE RURAL LANDSCAPE

Introduction

This chapter will focus on cultural values and other ecosystem services derived in different parts of the landscape by village residents in Ntloko. It starts by giving an overview of the location, biophysical and land use characteristics of the study area. It then provides an in-depth focus on the study design, and how the study sites were selected to allow comparison of plant species composition, richness and structure between the two land use types. Lastly, it reports on walk-in-the-wood interviews (Cocks et al. 2012) to determine the uses, values and associations ascribed by men and women of different ages to different landscape components in Ntloko, from the open grasslands surrounding the village to the dense and inaccessible thickets deep in the Fish River Valley. The information gathered from this chapter sets the scene for interpreting the vegetation patterns explored in Chapters 3 and 4.

Methods

Study area characteristics: location, biophysical characteristics and land-use

The study area lies along the western and eastern banks of the Fish River in the Eastern Cape between -33.28, -33.30 -33.32, -33.31° S and 27.05, 26.95, 27.07, and 26.94° E. The area encompasses a single village (Ntloko) and its associated communal rangelands, and two game farms across the Great Fish River (Figure 2.1). Ntloko is a small village located in the Peddie district, which forms part of the former Ciskei homeland in the Eastern Cape, South Africa (Ainslie, 1999). The village is situated along a ridge-top with sparsely located homesteads comprised of big yards that are often used for subsistence farming (McAlister, 2012). Grazing and browsing by domestic livestock and harvesting of natural resources, including firewood collection, has resulted in a visibly altered vegetation, particularly close to the village. Like other parts of the former homelands, the communal rangelands of the Nqushwa Municipality are considered to be overgrazed and degraded (Kepe et al., 2002; Ainslie, 2005).

Study sites in the communal area were characterised by vegetation attributes, as well as ease and frequency of access. Different areas were predicted to provide different ecosystem services, such as provision and cultural benefits, to the people in Ntloko. Men and women in rural areas have different landscape needs because of the different activities they perform (Mayer, 1992, Cocks et al. 2012). Men herd livestock and gather wood for their cattle kraals while women collect wood for fuel and young men and boys hunt (Cocks et al. 2008; 2012; McAlister, 2012). The introduction of electrification and relocation to urban areas has altered resource use patterns, but use of resources and values attached to areas of thicket or forest remain (McAlister, 2012).

The game farms are part of historically white-owned land, which is used for commercial agricultural use, mainly livestock and game farming (McAlister, 2012). The two game farms (Sportvale and Radies Vlei) that were included in this study have a long history of livestock farming and introduced game about 7 years ago when the owners bought the farm. The farmers have a combination of livestock (cattle, sheep and goats) and game. There are private game lodges and gravel roads for easy vehicle access. While by no means unaffected by human activities, stocking rates have been lower and land use less intense than in the communal rangelands across the river, and areas of dense and apparently untransformed thicket are evident (ArcView image. Figure 2.2). As in other studies aimed at assessing the impact of land use on vegetation (Evans et al., 1997, Birch et al., 1999; Rutherford & Powrie 2013) the game farms are here assumed to represent a human modified – natural landscape (McAlister, 2012) under conservation management in relatively undisturbed condition. They thus serve as a judiciously managed control to the heavy impact in the communal rangelands.

Relations between the land owners and users on the two sides of the Great Fish River have not changed much since the apartheid regime and are characterised by lack of communication and mutual distrust and resentment. The villagers perceive the game farms beyond the river as part of their land and believe that they have a right to use it. The game farmers on the other hand see the villagers as disrespecting their property and perceiving them as dangerous poachers.

The geological features found in this area are a result of the east-west trending Cape Fold Belt (Mucina & Rutherford, 2006). The bedrock consists of Adelaide and Estcourt Formations (Beaufort Group and Karoo Supergroup) mudstone and arenite, which gives rise to shallow and clayey soils (Mucina & Rutherford, 2006; Fabricius & Burger, 1997). The underlying geology and topology are responsible for the soil types found across the land, where rocky soils cover the upper slopes and fine textured soils are found in deep valley floors (Palmer, 2004).

The Great Fish Thicket lies in the semi-arid area of the Eastern Cape and has a variable rainfall range of 300 – 600 mm, which peaks in March and October (Mucina & Rutherford, 2006). The study area experiences an annual rainfall of ~400 mm with high inter-annual variability. The unpredictable rainfall gives rise to prolonged drought periods which lasts for several months (Palmer, 2004). Temperatures range from 1 – 8 °C in winter up to 50 °C in summer (Vlok et al., 2003).

The vegetation at the study area is classified as Great Fish Thicket, which is part of the Albany Thicket Biome (Mucina & Rutherford, 2006). This vegetation type is characterised by dense thickets of shrubs and trees that are woody, semi-succulent, highly thorny and with a height that ranges between 2 – 3 m (Mucina & Rutherford, 2006). The Great Fish Thicket has a wide variety of growth forms, which include deciduous and evergreen tall trees, shrubs and small plants including herbs, succulents, geophytes and grasses (Kerley et al., 1995). Intact subtropical thicket is a dense, impenetrable thorny vegetation. Small ungulates create narrow pathways, which make some areas more accessible than others. The lack of identifiable strata separates thicket vegetation structurally from the forest and savanna biomes.

The Great Fish Thicket is susceptible to overgrazing caused by intensive grazing and overuse by people (Fabricius & Burger, 1997). Therefore, much of the vegetation has been transformed and is vulnerable to degradation (Kerley et al., 1995; Mucina & Rutherford, 2006). The upper slopes of the Albany thicket close to the Ntloko village are heavily transformed, and stands of thicket have been replaced by expanses of the karroid dwarf shrub *Pteronia incana* (blue bush) and scattered *Aloe ferox*. As one moves westwards and away from the village into the Fish River Valley, a different vegetation type occurs. It is a dense valley thicket punctuated by scattered *Euphorbia* trees (*E. grandidens, E. tetragona and E. triangularis*) running down into the forest valley slopes and ultimately dropping off a steep slope into the Great Fish River (McAlister, 2012). The dense vegetation in the Fish River valley has a similar appearance on both land use types (Ntloko village and game farms). From Google Earth images, the area of the game farms looked like it was largely undisturbed and did not appear to be structurally transformed, and hence it was chosen as a control site representing a relatively pristine reference site for the study.

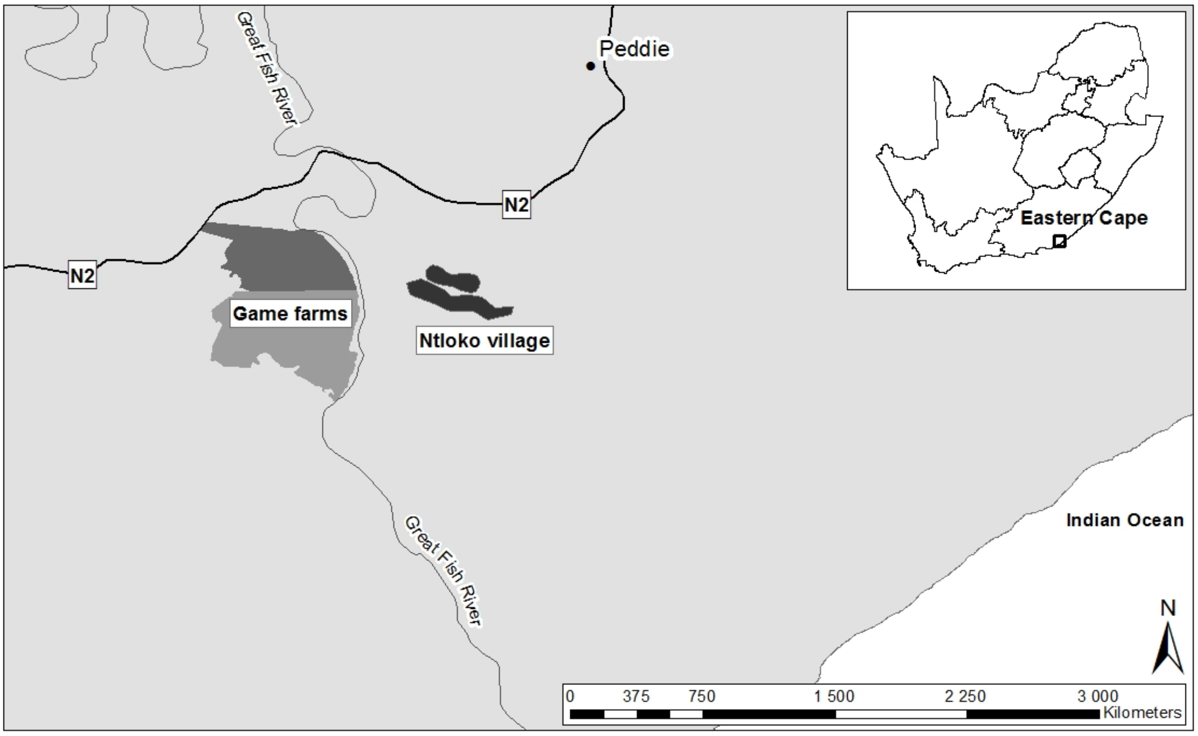

Figure 2.1 Map showing the study area in the Eastern Cape. The Great Fish River acts as a boundary between the game farms and Ntloko.

Data collection

Interacting with the local people through interviews provided me with information on the type of ecosystem services provided by the vegetation in different parts of the rural landscape. Attention was focused on getting the respondents' perceptions and feelings about, and uses of the different places. This included whether they perceived them to be (heavily) impacted, whether they have observed any vegetation changes, the spiritual and cultural significance they attribute to different landscape elements, and how they feel about the different parts of the vegetation. Differences and similarities between men and women regarding the types of activities they carried out and their mobility were observed.

Semi-structured interviews with focus groups composed of both men and women were based on an ecosystem services approach, where I wanted to get a sense of how the respondents viewed and used their landscape. Men and women in groups of 6 or 7 (2 men and 4/5 women) were interviewed in Ntloko. I had one session with all four groups; the majority of respondents were women between the ages of 20 and 55, while the men ranged between the ages of 25 and 60. Most of the participants were unemployed and depended on social grant money for income. The local hall was used as the meeting place, where an A3-sized map based on a Google Earth image was placed on the floor and the participants gathered around the map and familiarised themselves with the areas shown on the map

The interviews were facilitated by a list of questions of the different areas, the roles they played and getting an understanding of their cultural values that linked to the different sites. I conducted the interviews in IsiXhosa, which is my own home language and that of the respondents. Interviews were recorded and later transcribed and translated into English. Interviews started by asking respondents to point out areas on the map that were important to them. For each area identified, I asked:

- What type of vegetation is it?
- Why is this an important site to you?
- How often do you come here?
- Do you feel safe in this area?
- Have you observed any vegetation changes in the area? If yes, what do you believe to have caused them?
- How would you feel if this area was completely destroyed? Is there anything you can do to protect the area?

The information gathered from the group discussions assisted in compiling a questionnaire to elicit answers about a common set of questions at the different study sites. Only sites in Ntloko were included, as the privately owned game farms were off-limits to Ntloko residents.

People in Ntloko were taken on walks to the study sites where vegetation sampling took place and asked to answer the questions based on the study site. In some instances, especially in sites on very steep slopes where some of the respondents found it difficult to access, the respondents were shown by pointing to the actual study site and asked to answer questions based on what they saw. In such instances I would verbally instruct the respondents to see other sites as being representative to a similar site (with respect to slope, aspect and distance). This allowed me to group them into four recognisable vegetation types (Figure 3.1) identified by the respondents based on the vegetation structure and composition by referring them to their local names:

ibhobhosi – *Pteronia incana*-dominated ridges at the top of the Fish River valley (hereafter referred to as "*Pteronia*")

ithafa – grassland on the flat areas above the valley ("grassland")

ihlathana – open thicket in the Fish River valley ("open thicket")

ihlathi – dense thicket in the Fish River valley ("dense thicket")

The first two non-thicket vegetation types were classified according to the dominant plant species at the site (*Pteronia incana* and grasses, respectively) and the last two were classified according to the structure of the thicket vegetation (open vs. dense). The questions were then summarised according to the four vegetation types in order to understand the different areas that respondents most likely consider sacred and to provide particular ecosystem services. Only a small portion of people in Ntloko participated in the questionnaire walks as the majority of the population is men and women over the age of 50 (McAlister, 2012). Older respondents complained of health problems and felt unable to participate in the walks. Because of the above-mentioned challenge, I conducted gender-mixed focus groups that consisted of 11 men and 15 women in total. The age range was categorised into 10 year intervals and the composition of respondents in each age group (number of men : number of women) was as follows: 3:8 between 20 – 30 years, 3: 2 between 31 and 40 years, 2:4 between 41 and 50, 2:1 between 51 and 60 years and only 1 male > 60 years.

Each respondent was given 20 copies of the questionnaire, one to complete at each of the 20 sites visited along the walking route. The questionnaire consisted of 13 questions. The first asked about the frequency of visits to the sites before moving on to the activities that occur in that specific site or one like it. Possible answers were rankings from 0 to 3, where 0 indicated that one has never been to this or a similar site and 3 indicated that one goes to the site frequently, which is more than twice a month. The rest of the questions took the form of statements where the questionnaire had a 6 – point Likert scale with the options 'strongly disagree', 'disagree', neutral, 'agree', 'strongly agrees' and 'not applicable'. The data were then coded 1 ('strongly disagree') to 5 ('strongly agree'), where anything marked not applicable (N/A) was changed to a coding of 1 – 'strongly disagrees' (the closest measure of not participating in the activity whether they have visited the site or not).

The following questions and statements constituted the questionnaire given to the respondents:

1. How often do you come here?
2. There are ancestor spirits in this area
3. I come here to clear my head and get fresh air
4. I connect with my ancestors in this place
5. This is where I collect wood.
6. This is where I collect medicinal plants (*amayeza*)
7. This is where livestock graze
8. I relax/play. This is my recreation spot.

9. I come here to hunt animals

10. This is where rituals are carried out.

11. I fear wild animals in this area.

12. I fear crime in this area

13. I fear evil spirits in this area

Data analysis

The mean ± SD scores of men and women of each question was tabulated according to the four vegetation types to see if there were differences relating to gender. The sites were related to the vegetation sampling sites as well as the four vegetation categories (Figure 2.2).

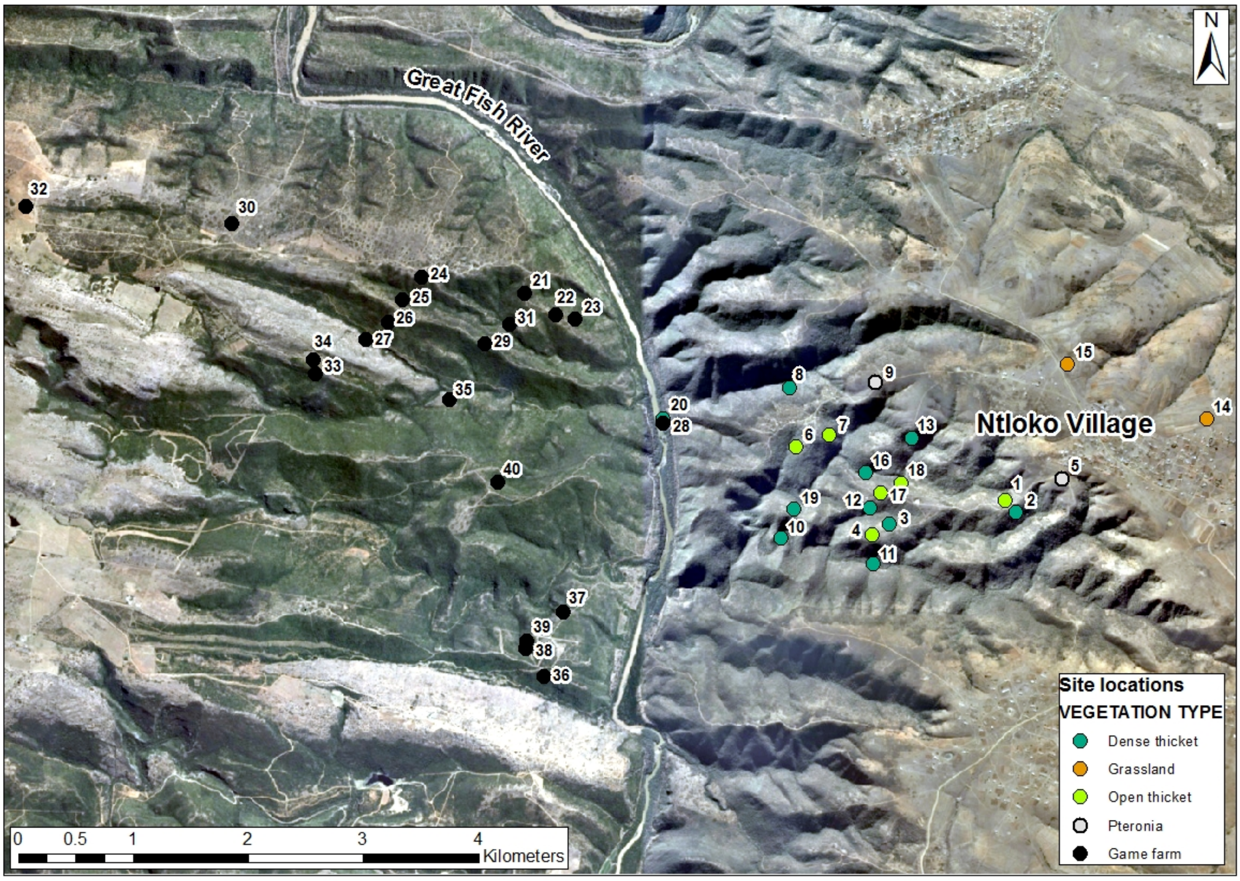

Figure 2.2. Study area showing sites according to the four vegetation types in Ntloko.

Results

The general impression during the semi-structured interviews was that the vegetation types corresponded to the disturbance gradient with distance from the village, where anything with tall trees and bushy clumps was classified as as a "forest" (*ihlatana* and *ihlathi* denoting shorter/open and taller/dense thicket, respectively), open grasslands, including formerly cultivated fields were classified as grassland (*ithafa*), and the *Pteronia incana*-dominated patches surrounding the village as *ibhobosi* sites. Grazing grounds were identified within the forest as open patches of grass among dense thicket stands covered with dry or fresh cow dung. These patches are created by grazing cattle when they rest and ruminate and defecate, thus creating open space. Additional information was always brought up during the interviews such as the elders' childhood memories recalling how their livelihood and lifestyle has changed with the times. Although they missed their way of living in the past they were grateful to the current developments such as improved infrastructure including schools, clinics and clean running water and electrification

When asked about respondents' perceptions about the transformation of the vegetation, the majority of respondents responded by saying that they had noticed changes in vegetation structure over the decades. The general perception was linked to village expansion, where clearing of woody vegetation was a result of house and road development. Independent Men and women who work and live in towns and cities but originally come Ntloko moved from their family homes and built their own homes for their families. They also mentioned that proper wood and good quality medicine were found down in the forest because the vegetation has been cleared close to the village and that they no longer cultivate in what now is used as grazing plots because the large homesteads provide enough space to create their own gardens. However, they appreciated having electricity and water, which meant they no longer had to go down to the forest to collect wood and water from dams and valley streams. In some households, when finances are tight, men and women go down to the forest to collect firewood for cooking and heating water. Women go in pairs or groups to collect wood in the forest and they only go as far as the open areas (*ihlathana*). They fear that if a woman goes alone she might get raped or be at risk of being attacked by an animal (snakes and warthog),therefore they prefer going in pairs/groups. Only men go as far as the river as they not only cut wood during their trips but they also use the time for hunting. It was clear that most of the respondents were only familiar with places quite close to the village and only a few huntsmen knew their ways around the deep forest and all the way to the river.

In the questionnaire walks, there were slight differences in the responses of men and women regarding the activities, feelings and provision between the four different vegetation types. This is mainly caused by differences in beliefs relating to gender and age (Table 2.5). The characteristics of the four vegetation types described by the respondents is summarised in Table 2.4.

Men had a higher score for visitation frequency in the *Pteronia* and grassland vegetation as they believe that they connect with their ancestors in these areas. This is mainly because these areas (site 5,9,14 and 15) are used for rituals such as initiation schools. They are used as sacred grounds where boys are taken and taught about manhood – and as such areas that are restricted to women. Next to these areas are previously cultivated fields (grassland) which some households still use to cultivate maize and greens as well as grazing grounds for livestock. Both men and women visit these areas but more so men than women because of the above mentioned activities that are carried out in these areas.

Men visit open and dense thicket areas more frequently than women do. Women hardly come to areas further away from the village than the *Pteronia* sites because they fear to go down remote areas such as the forest alone. Men come down to the thicket areas to hunt, collect building material and look for their wandering livestock. The majority of sites in the open and dense thicket were considered places where traditional healers performed rituals. Many of the young respondents based their answers on what they have been taught by their elders, as some of them mentioned that they had never gone beyond a certain point in the forest. There was a great deal of excitement to have reached the Great Fish River and back, and some participants collected bundles of firewood and ‘natural cosmetics’ such as bracken fungus that grows on *Ptaeroxylon obliquum* and *Schotia afra* trees. Wild animals feared by both men and women in the thicket were warthogs, snakes and baboons. Ghosts were also feared in some parts of these areas, especially areas which are believed to be cursed and where witchcraft is believed to be practised.

Table 2.4: Descriptive characteristics of the four vegetation types.

Vegetation type	Local name	Location	Description	Associations	Sites
Pteronia	*Ibhobhosi*	Upper slope – near the village	Transformed thicket, predominantly *Pteronia incana* with scattered *Aloe ferox*	Cultural	5, 9
Grassland	*Ithafa*	Plateau – near the village	Open grassland quite close to former cultivated land	Grazing area	14 and 15
Open thicket	*Ihlathana*	Ridge and north facing upper slopes – further from the village	Semi transformed with lots of open clearings. A mixture of thicket vegetation and herbaceous and grassy ground layer	Wood collecting, cultural and spiritual	1, 4, 6, 7, 17 and 18,
Dense thicket	*Ihlathi*	Valley bottom, middle and lower south facing slopes – very far from the village	True thicket forest	Wood collecting, spiritual, cultural and hunting	2, 3, 8, 10, 11, 12, 13, 16, 19 and 20

Table 2.5: The mean (±SD) scores given in response to questions by men and women across the different vegetation types. Question 1 was scored between 0 and 3, where 0 – never been to the site, 1- Once or twice a year and 3 – Regularly comes to the site. The rest of the questions were scored between 0 and 4, where 1– strongly disagrees and 5 – strongly agrees.

		Pteronia		**Grassland**		**Open thicket**		**Dense thicket**	
	Question	Men	Women	Men	Women	Men	Women	Men	Women
1	How often?	1.4 ± 0.2	1.2±0.1	1.8±0.1	0.6±0.1	2.1±0.5	0.9±0.4	1.7±0.8	0.8±0.5
2	Ancestors?	3.9±0.8	3.7±0.3	3.3±0.1	3.4±0.3	3.8±0.5	3.7±0.4	3.3±0.5	3.4±0.5
3	Clear head?	3.3±0.5	4.7±3.8	3.3±0.1	2.3±0.2	3.2±0.5	2.9±2.0	3.3±1.3	2.3±0.4
4	Connection with ancestors?	4.1±0.4	3.3±0.2	3.0±0.1	3.4±0.4	3.4±0.7	3.3±0.2	3.2±0.6	3.2±0.3
5	Collect wood?	2.9±0.6	2.6±1.5	3.4±0.4	3.7±0.1	3.3±0.7	3.1±0.9	3.1±1.0	3.2±0.6
6	Collect medicine?	3.3±0.4	2.6±0.4	3.0±0.2	2.1±0.3	3.1±0.8	2.3±0.3	2.9±0.6	2.3±0.6
7	Livestock grazing	4.4±0.1	4.4±0.2	4.7±1.0	3.8±0.1	4.2±0.3	3.9±0.5	4.1±0.2	3.8±0.5
8	Relax/play?	3.1±0.2	1.7±0.1	3.0±0.1	2.5±0.5	3.0±0.2	2.2±0.3	2.8±0.6	2.1±0.4
9	Hunt animals?	3.8±0.3	1.5±0.7	3.3±0.4	1.0±0	3.6±0.4	1.2±0.2	3.3±1.0	1.2±0.3
10	Rituals?	3.6±0.3	3.6±1.1	3.2±0.3	3.2±0.1	3.3±0.5	2.9±0.3	3.0±0.7	3.0±0.4
11	Fear of wild animals?	3.7±0.1	3.9±0.3	3.8±0.2	3.9±0.2	3.3±0.3	3.8±0.2	3.4±0.5	3.9±0.4
12	Fear of crime?	3.4±0.3	3.7±0.6	3.0±0.1	4.3±0.4	3.2±0.3	3.9±0.2	2.8±0.5	3.9±0.4
13	Fear of evil spirits?	3.9±0.2	3.6±0.4	3.6±0.1	4.1±0.5	3.7±0.3	3.7±0.5	3.4±0.9	3.8±0.5

Discussion

Men and women had different perceptions about the type of provision the land provides. Women would not go down to thicket areas alone because they feared wild animals and crime, while men went down to the forest with vigilance. Although the village has a low crime rate, there are thought to be high chances of a woman to be raped in a remote area such as the forest. Hunting in Ntloko is not a popular sport amongst men, only a few men are recognised as hunters and are grooming the curious young boys about hunting; bringing them along to their hunting trips. The local people utilise as much of the land as possible, but more so in areas close to the village such as the *Pteronia* and grassland areas. These vegetation types are the most easily accessible sites in the village. The first two were easily distinguished from the rest because of the dominating species namely *Pteronia incana* and *Digitaria monodactyla*; the respondents identified them as *ibhobhosi* and *ithafa*.

The open thicket was considered a type of forest (*ihlathana*), but the openness separated it from what respondents considered a ‘true forest’ (*ihlathi*) which is the dense thicket (Situngu, 2012). Each vegetation type was identified by its vegetation composition and structure. Sites in the dense thicket were considered sacred because they represented an intact thicket forest. There was a great sense of appreciation for the closed vegetation as it represented a home for their ancestral spirits and a ‘clean’ environment. Access to electricity and the housing developments have minimised the need for fuelwood and building material therefore people spend less time in nature (McAlister, 2012). However, recent developments have not changed the people’s perception about the ecosystem services relating to plant usefulness (see chapter 4) as they still use the natural resources but at a lower rate than before.

Information about the environment and vegetation change is passed from older to younger generations, and plays an important role in managing the local environment (Cross & Barker, 1991; Gadgil et al., 1993; Lykke et al., 1999). Knowledge is transferred through educational institutions and within families (Müller, 2005) and thus encourages the idea of incorporating local knowledge into management strategies in protected areas. If local knowledge is integrated in management strategies, emphasis will have to be on species and vegetation types that the local people find most valuable (Lykke, 2000). By so doing, successful outcomes can be expected if local priority is applied rather than forced by external decision makers (Lykke, 2000). Natural resources that are perceived as culturally important by local people are usually beneficial for their well-being and are the most used (Byers et al., 2001). However, in some instances the dense vegetation is considered the most sacred and never used as it is perceived as an area of ancestral residence. The younger generation had some knowledge about the cultural activities and ecosystem services provided by the landscape and they learnt these from the older generations (parents and other family members).

There were differences in how the respondents connected with nature, although the majority viewed it on cultural grounds, while only a few respondents appreciated the tranquillity and beauty of nature. Such differences were mainly based on religion, as a minority of respondents did not believe in the traditional customs. Most people in Ntloko practise both Christianity and traditional customs, but members of certain churches have dissociated themselves from traditional religious practices that include reverence for ancestral spirits (McAlister,2012). However, unity and support was reported to be shown amongst the villagers, who respect each other's beliefs and attend each other's religious rituals even when they don't practice these themselves.

Various disciplines are engaging in cultural ecosystem services and apply different research approaches (Milcu et al., 2013). It is a dynamic and diverse field with different aspects but lacks a common terminology and understanding across the different disciplines. Therefore, quantifying cultural ecosystem services is in its infancy and at this stage, even conceptualising them needs more work (Milcu et al., 2013). This study has revealed a range of cultural values rural men and women across a range of ages, attribute to nature. It has also illustrated the links between the cultural and religious values of nature, how these link with rituals, livelihood and recreational activities, and how they differ with age and gender, in some cases via concerns such as those about crime.

CHAPTER 3 – THE EFFECT OF LAND USE AND TOPOGRAPHY ON PLANT SPECIES RICHNESS AND COMPOSITION

Introduction

Land degradation is considered the main cause of biodiversity loss in southern Africa, (Rutherford & Powrie, 2010; 2013) with continuous overgrazing by livestock and subsistence land use as driving forces (Fabricius et al., 2002). Heavy grazing in communal areas has been identified as contributing factor to decreasing biodiversity compared to commercially farmed or protected areas (Hoffman & Ashwell, 2001;Rutherford & Powrie, 2013;). This has been attributed to the fact that communal areas are not owned by anyone, but rather operate under "open access", thus resulting in poor management strategies, a situation characterised as "the tragedy of the commons" (Hardin 1968; Ward et al.,1998). The decrease in biodiversity in communal areas has been linked to the foraging behaviour of goats and sheep which results in a change in vegetation composition and structure between land uses (Evans et al., 1997, Birch et al., 1999). Land use activities have direct effects on ecosystems and it is important to understand them to better manage and prevent biodiversity loss (Birch et al., 1999).

Other human activities such as unsustainable harvesting of firewood in communal areas has resulted in reduced biodiversity (Fabricius et al, 2002). The exploitation of natural resources was exacerbated by the betterment planning schemes where people were concentrated into villages which has since increased in rural population numbers (Shackleton, 1993). According to Mapaure & Ndeinoma (2011) inherent sustainable use of natural resources was practised by the local people for centuries but because of poor management strategies and the accumulation of population numbers have led to land degradation. Studies have shown that communal areas are biologically impoverished compared to commercial/protected areas especially in plant abundance (Fabricius & Burger 1997). This is mainly caused by various economic and cultural practises where certain plant species are harvested and sold as building material and medicinal purposes. Therefore, there is a high need for sustainable use of natural resources in areas where fuelwood is still the primary source of energy

Soil moisture content plays a significant role in determining patterns and cover in water- limited ecosystems (Grayson et al., 2006). These arid and semi-arid systems contain soil moisture for only a limited time period following rainfall (Grayson et al., 2006). Unlike wetter environments, they have limited hydraulic conductivity which is important in plant growth. Increased vegetation cover is normally found in areas with high infiltration capacity on hillslopes, which enhances water storage supporting vegetation growth between rainfall events (Grayson et al., 2006). Species composition along a topographic gradient is affected by soil moisture, which is dependent on seasonal patterns that affect infiltration and runoff in response to precipitation, evapotranspiration and uptake by vegetation (Lookingbill &Urban, 2004). In such arid and semi-arid rangelands, rainfall has often been found to be the driving factor for vegetation productivity, composition and structure, with minor long term effects by grazing (Ellis & Swift, 1988; Ward et al.,1998; Fernandez-Gimenez & Allen-Diaz, 1999; Rutherford & Powrie, 2013). The most common pattern observed in these areas is the compositional shift from perennials to annuals, geophytes and less unpalatable species because of selective grazing pressures as observed in the Succulent Karoo (Anderson & Hoffman, 2007).

In the southern hemisphere, south-facing slopes receive less insolation than north-facing slopes. The magnitude of this affect is caused by latitude which determines the solar angle, which in turn affects the local slope, landscape context, creating topographical shading (Lookingbill & Urban, 2004). Therefore, slope and aspect are expected to influence soil moisture, where drier north-facing slopes and ridge tops are expected to have less soil moisture and lower vegetation cover and wetter south-facing slopes and valleys are expected to have more soil moisture content and denser vegetation cover. Plant composition and diversity thus varies with slope position, and in some cases slope is considered a better predictor of vegetation composition than grazing intensity (Venter et al., 1989; Michunas & Lauenroth, 1993). Soil type has been identified as an important factor in determining the effects of topography on plant diversity (Gibson & Hulbert, 1986). According to Irl et al., (2015) a variety in slope position and aspect across a landscape increases habitat diversity and allows for increased plant diversity. Topographic complexity not only creates high habitat diversity, which increases niche space, but creates micro refugia during environmental disturbances (Irl et al., 2015).

To successfully maintain a landscape, plant communities that characterise the area need to be properly managed and produce enough biomass and to support the local people and livestock (Birch et al., 1999). This is can be achieved by understanding the effects and relative importance of environmental factors and land use on vegetation patterns (Evans et al., 1997; Birch et al., 1999;). The mid-Fish River valley is divided into commercial farms west of the Fish River and communal rangelands to the east (Birch et al., 1999; see Chapter 2). Heavy utilisation by cattle, goats and sheep in the communal rangelands east of the Fish river contrasts with low densities of wildlife on the western side. The region is also topographically diverse, offering an opportunity to examine the relative contribution of land use and topography in determining plant composition and richness.

The aim of this chapter is to look at how the patterns of plant composition and richness are affected by land use and environmental factors. This is achieved by investigating plant richness and composition on different parts of the landscape in Ntloko and the neighbouring game farms which represent largely undisturbed thicket.

Since Ntloko is part of the communal area one would expect to find significant differences in plant composition and richness compared to the game farms. In Ntloko, I expected areas closest to the village to be most heavily impacted by human activities, while areas further from the village would be similar to topographically similar areas on the game farms. These patterns would be a result of the grazing prevalence by livestock, which are expected to concentrate in the flatter areas surrounding and the village, where they are kraaled at night, a pattern commonly found in rural villages (Evans et al., 1997). Anthropogenic disturbances through land use – notably the collection of fuelwood and medicinal plants - may also result in an increasing gradient in plant richness from the accessible areas close to the village to steep, inaccessible areas (rivers and valleys). Overall vegetation patterns are expected to reflect topographic position (with a strong influence of soil moisture on plant species richness and composition), overlain by the effects of land use, with evidence of grazing and human activity gradients with distance from the village. Overall, highest species richness is expected in steep and south-facing valleys on both sides of the Fish River, due to their high moisture availability and inaccessibility. On gentler and more accessible slopes, plant species diversity is predicted to be higher on the lightly stocked game farms than the heavily utilised areas surrounding Ntloko village.

Methods

Data collection

Sampling was done in two land use types: Ntloko village and its surrounding communal rangeland, and two game farms opposite the village across the Great Fish river. Twenty sites were sampled on each land use type (hereafter referred to as Ntloko and game farms), which covered a wide range of topographic positions (slope and aspect).

A 15 x 6 m plot (90 m^2) was laid out at each site and divided into ten 3 x 3 m quadrats. The percentage aerial cover of all plant species was recorded in each 3 x 3 m quadrat on a scale of 1 – 3, where 3 represents > 10 % cover, 2 represents 1 – 10 % cover and 1 represents < 1 % cover. Crown cover of species rooted inside the sampled quadrat but extended to the outside was excluded and the crown cover of species rooted outside transects that extended into the sampled quadrat was included (Schmutz et al., 1982). Categorising the percentage cover allowed me to distinguish between rare and common species in a 90 m^2 plot, where percentage cover was a challenge to measure. Plant species were identified in the Schonland Herbarium in Grahamstown. Data thus included species and their abundance at each of the ten 3 x 3 m quadrats, with a total score of between 0 and 30 for each species at each of the forty 90 m^2 plots.

A species lists was compiled for the communal area and the game farms, including unique and shared species as well as useful species. The species list was compared to a species list for the Great Fish Thicket vegetation type (Mucina & Rutherford 2006) supplied by the South African National Biodiversity Institute (SANBI). For all plant species identified at the study site, known uses by Xhosa people were recorded in four categories, namely fuel, forage, medicinal and other (cultural, consumable or crafts; Tony Dold, unpublished data).

Selection and location of sampling sites

The main aim of this study was to assess the effects of land use and topo-edaphic factors on thicket vegetation. To do this, 20 sites were identified within each land use type. Due to the varied and deeply dissected topography at the study site, a range of slope and aspect conditions were represented on each side, and sample sites were selected with the aim of representing a similar range of habitat conditions at each site. Areas with high moisture content such as riparian zones and south facing slopes have a different composition than dry north-facing areas. *Portulacaria afra* is the local dominant species in the Great Fish thicket, but its dominance changes due to the effects of soil moisture and land use. *Euphorbia tetragona, E. triangularis* and other woody species dominate the steep slopes along river valleys supporting small, medium and tall trees and shrubs, while typical dominant species at more arid sites include *E. bothae* and a lower density of *P. afra* (Mucina & Rutherford, 2006). Sites at similar topo-edaphic conditions (slope, aspect, slope position) were assumed to have similar vegetation before land use impacts, given that vegetation in this biome is water limited.

Geographical Information System (ArcGIS 10.4) was used to create a map of the study area, where sites at various slope and aspect were chosen for sampling. Twenty study sites were selected per study area (forty in total), representing different landforms, slope and aspect (Figure 3.1). The aim was to ensure that sampling covered the entire landscape, and to select comparable sites in each land use.

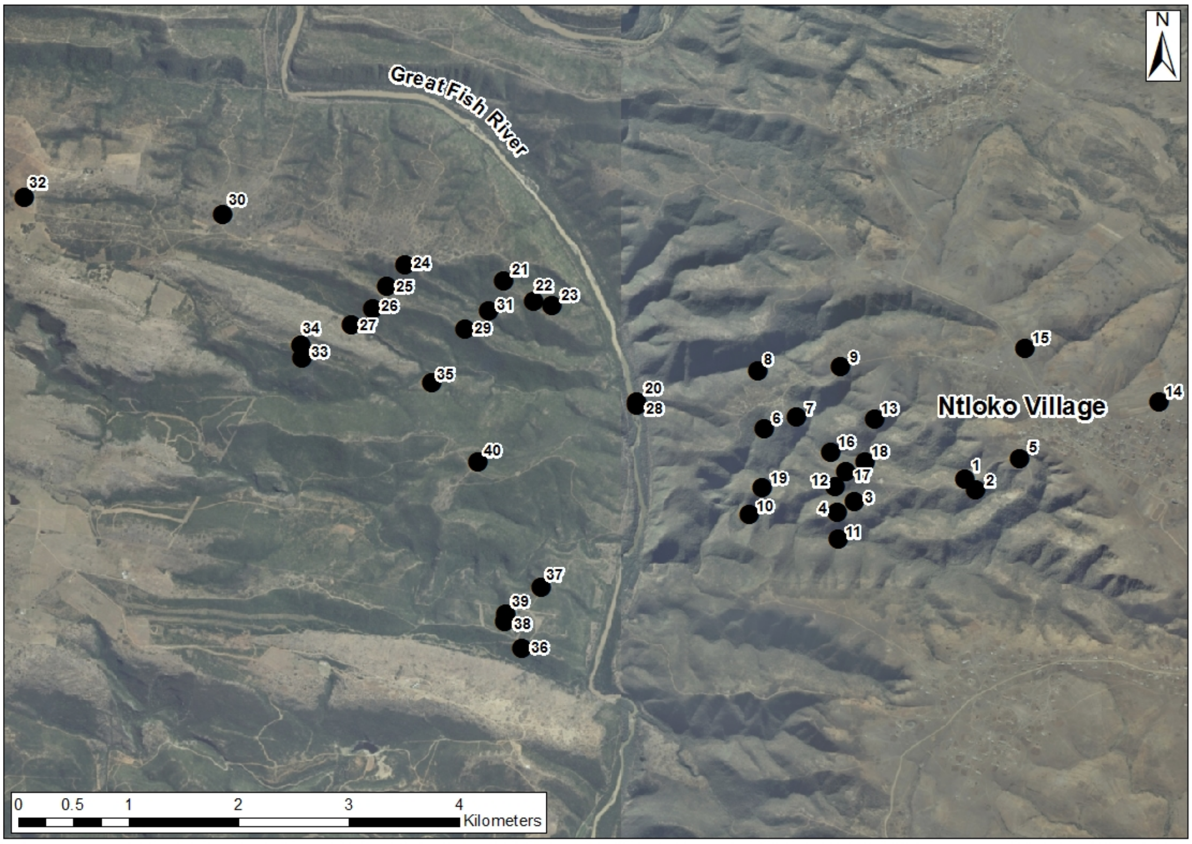

Figure 3.1. Aerial photograph showing the map of the study area and sampling sites on the game farms (west of the Great Fish River) and in the communal grazing lands of Ntloko village (east of the Great Fish River). Source of background image: Google Earth

The study sites were then grouped according to the Topographic Relative Moisture Index (TRMI). TRMI quantifies the relative available moisture that is controlled by topographic features. It attempts to quantify topographic complexities between sites based only on environmental parameters (Parker, 1982). TRMI was calculated using four slope parameters (topographic position, slope steepness, slope configuration and slope aspect; see Table 3.1). To get the TRMI values, all four parameters had to be summed up using the allocated values which are shown in Table 3.2. TRMI values range between 0 (xeric) to 60 (mesic). The study sites were grouped into five TRMI classes to allow comparisons of vegetation under similar growing conditions between the two land use types. Table 3.2 shows a summary of the TRMI size classes. This grouping was used for comparing species richness and composition (see chapter 3) and woody density and composition (see chapter 4).

Table 3.1. Determination of Topographic Relative Moisture Index value. The four slope parameter values (in bold) are summed up to determine the TRMI scores depending on the location and configuration of slope.

Topographic position		Slope steepness (degrees)	
valley bottom	**20**	< 3.0	**10**
lower slope	**15**	3.0 to 5.9	**9**
middle slope	**10**	6.0 to 8.9	**8**
upper slope	**5**	9.0 to 11.9	**7**
ridge top	**0**	12.0 to 14.9	**6**
		15.0 to 17.9	**5**
Slope configuration		18.0 to 20.9	**4**
Concave	**10**	21.0 to 23.9	**3**
Concave/straight	**8**	24.0 to 26.9	**2**
Straight	**5**	27.0 to 29.9	**1**
Convex/straight	**2**	> 30.0	**0**
convex	**0**		

Slope aspects (degrees azimuth):					
19 – 26	**20**	81 – 89; 316 – 324	**13**	144 – 152; 253 – 261	**6**
27 – 35; 10 – 18	**19**	90 – 98; 307 – 315	**12**	153 – 161; 244 – 252	**5**
36 – 44; 1 – 9	**18**	99 – 107; 298 – 306	**11**	162 – 170; 235 – 243	**4**
45 – 53; 352 – 360	**17**	108 – 116; 289 – 297	**10**	171 – 179; 226 – 234	**3**
54 – 62; 343 – 351	**16**	117 – 125; 280 – 288	**9**	180 – 188; 217 – 225	**2**
63 – 71; 334 – 342	**15**	126 – 134; 271 – 279	**8**	189 – 197; 208 – 216	**1**
72 – 80; 325 – 333	**14**	135 – 143; 262 – 270	**7**	198 – 207	**0**

Table 3.2. TRMI classes used in comparisons of vegetation between land use types. Sites grouped as "A" represent the driest sites, while class "E" represents the sites with the highest available soil moisture.

Symbol	TRMI class
A	20 – 25
B	26 – 30
C	31 – 35
D	36 – 39
E	>40

Data analysis

Quantification of species richness

I used the EstimateS 9 software package (Colwell, 2013) to estimate species richness at each site and for each land use overall. EstimateS estimates asymptotic species richness for a site using the richness of reference samples of biodiversity data (Colwell, 2013). Species richness was calculated using the richness estimator, which uses data from the ten sub-samples in each 90 m^2 plot to estimate the overall (asymptotic) species richness at each sample site (Chao 2). The species accumulation curve was used from the ten adjacent 9 m^2 quadrats, totalling 90 m^2 using a type IIB species accumulation curve (Scheiner, 2003) to estimate species richness using Chao 2 mean ± upper and lower bounds (Colwell, 2013). In addition, a single species accumulation curve for each land use was plotted using each of the twenty 90 m^2 plots as subsamples, for a total area of 1800 m^2 per land use.

Chao 2 values and their confidence intervals were compared for each site and for the combined data for each land use. A non-overlap of 95 % confidence interval (mean ± 1.96 SE) represents a statistically significant difference in means at $p <$ or $= 0.05$, but this state is very conservative (Colwell 2013). The Chao 2 estimator is generally accepted to give the lower bounds of actual species richness. Any sample size can be used, provided the Chao 2 has a reasonably accurate estimation of actual species richness (Colwell, 2013). A sufficient sample for the Chao 2 estimator is for the estimated sample completeness to be approximately 50 %, that is $Q1/M < 50$ %, where M is the total number of incidences and Q1 is the frequency of uniques (Colwell, 2013). This criterion was met by the data at each sampling site and for the combined sites under each land use type.

Sample sites were grouped according to their environmental similarity to allow for comparison of species richness where vegetation was expected to be similar under undisturbed conditions.

Topographic Relative Moisture Index (TRMI) was used as the grouping factor. This index calculates the accumulation of water in a topographic landscape (Archibald et al., 2005). The sites were grouped according to the following TRMI classes: 20 – 25, 26 – 30, 31 – 35, 36 – 39 and > 40.

Best model selection

Best model selection using Akaike's information criterion (AIC) was used to determine which factors best predicted species richness. The dependent variable was estimated species richness (Chao 2), and the independent variables were land use, distance from village, TRMI, slope and aspect.

The best-subset for model building was selected using the Akaike Information Criterion (AIC). A multiple linear regression analysis was carried out using the variables comprising the best model thus identified. The relative importance of each independent variable in predicting species richness was calculated by summing up the Akaike weights (w_i) for all the models in which the variable appears (Burnham & Anderson, 2002).

The TRMI was calculated using topographic position, slope steepness, slope configuration and slope aspect. ArcGIS 10.4 was used to calculate the mean values for slope and aspect (in degrees) using a digital elevation model. The GPS coordinates from the all forty sample sites were used to create a polygon to mask the study area. The polygon was then used to *extract by mask* the area of the DEM which was relevant to the study area. The DEM was then projected to a local area projection which is the Transverse Mercator, central meridian 27 degrees East, WGS84. The slope and aspect tools were used to generate a slope map and aspect map from the DEM. The *extract values points* tool was then used to extract the *slope per site* and the *aspect per site*. The GIS analyses were performed by Gillian McGregor, Geography Department, Rhodes University.

The distance from the village was determined using a 1 to 5 scale where 1 represents vegetation areas quite close to the village and 5 are areas far beyond the Great Fish River, i.e the game farms (Table 3.3). The score for each site was based on walk-through interviews (see Chapter 2) across the Ntloko forest and the vegetation criterion was based on eye observation. The asterisk denotes the intensity of activity across each land use where (***) indicates high, (**) medium and (*) low. The scores given by the respondents to the questionnaires determined the intensity of activities and the evidence shown in each vegetation type e.g. pastures and tree bark damaged by harvesters. For details of how intensity was classified see the "Description" column in Table 3.3.

Table 3.3: Distance scores from the village showing the common types of and their relative intensity (where * is least intense and *** is most intense and no asterisk means the activity does not take place at all). A distance score of 1 indicates areas very close to the village and a score of 5 indicates areas where local people do not have any access

Distance score:	Approximate distance (m)	Grazing / browsing	Wood collection	Medicinal plants	Description
1	0-1000	***	***	***	*Pteronia incana*-dominated and grassland sites very close to the village. These areas are accessible to everyone in the village and show signs of heavy utilisation.
2	1000-2000	***	**	**	Sites located in the relatively open thicket. Many people can access these sites, and grazing livestock access them easily, but some people, including the elderly, find them difficult to reach.
3	> 2000 (accessible via paths)	**	*	**	Sites in the thicket with small trees and dense shrubland. These sites are normally only accessed by 2 in 5 who regularly collect natural resources.
4	> 2000 (difficult to access, steep, dense and often no clear path)	*		*	These sites are in the dense woody thicket, which includes steep slopes and valley sites. Most people find these areas too remote for wood collection and difficult to access. Very few people come to these parts of the forest, only livestock pass through on their way to the Fish River and medicinal collectors reach this far.
5	NA				These are all sites located in the game farms. Activities such as wood and medicinal collection does not occur in these parts as access is prohibited.

Plant species composition

Multivariate analyses were done to evaluate the similarities of sites in subtropical thicket vegetation in different TRMI classes across the two land use types. Riverine and grassland sites were left out because of their distinct vegetation types. Bray-Curtis similarity indices were used to create a dendrogram using group-average linkage. Non-metric multi-dimensional scaling (NMDS) ordination plots were also based on Bray-Curtis similarity. A two – way (ANOSIM) was used to test for significant differences in species composition by TRMI classes and land use. A similarity percentage (SIMPER) analysis was done to look at which plant species contribute most to similarity within sites clustering together at about 40 % Bray-Curtis similarity. The vegetation data was square root transformed except for the SIMPER analysis, of which untransformed abundance values were used. All multivariate analyses were performed on PRIMER v.6 software (Clarke & Gorley, 2005).

Results

Summary of species life form sampled and usefulness

A total of 386 species were recorded from the 40 sites, with 292 species found in Ntloko and 265 in the game farms. Of the species sampled, 121 and 94 were recorded only in Ntloko and only on the game farms, respectively, while 171 species were shared. Fourteen bulbous and two unknown species were unidentified due to their unrecognisable state (loss of distinguishable features) of the specimens by the time it reached the herbarium. Table 3.4 summarises the unique and shared species of the two land use types by life form.Thirty-six per cent of species recorded were herbaceous plant species (from herb to herbaceous succulent). The slightly higher number of species recorded at Ntloko are largely accounted for by a higher number of herbaceous species recorded there (Table 3.4). Apart from the greater number of herbaceous species in Ntloko, the number of species in each life form was very similar between the two areas. Each of the more common life forms had a substantial number of species unique to each of the two land use types. A total of 110 species were identified as useful species which were used for fuel, medicinal purposes, forage for livestock, cultural purposes or as edibles by the local people (Table 3.5). Eighty-three useful plants species were recorded in Ntloko and 63 in the game farms. The majority of useful species sampled were not locally abundant, contributing < 1 % cover on average across the plot at each site (Appendix 1).

Table 3.4 Plant species life forms sampled at Ntloko and the game farms in the Great Fish Thicket (AT 11) (Mucina and Rutherford 2006). The rows "Ntloko" and "Game" refer to species found only at Ntloko, and the game farms, respectively. Key to life forms (classified according to Mucina & Rutherford vegmap data supplied by SANBI): Herb – Herb, Ep herb - Epiphytic herb, Geo herb – Geophytic herb, Succ herb – Succulent herb, M herb – Mega herb, Par herb – Parasitic herb, Herb climb – Herbaceous climber, Herb succ climb – Herbaceous succulent climber, L shrub – Low shrub, Tall shrub, Tall succ – Tall succulent shrub, Succ shrub – Succulent shrub, Semi Ep shrub – Semiparasitic epiphytic shrub, Sm tree – Small tree, Tall tree, Succ tree – Succulent tree, W climber – Woody climber, W succ climber – Woody succulent climber, Gram – Graminoid, Unid life form – unidentified life form.

	Herb	Ep herb	Geo Herb	Succ herb	M herb	Par herb	Herb climb	Herb succ climb	L shrub	Tall shrub	Tall succ	Succ shrub	Semi Ep shrub	Sm tree	Tall tree	Succ tree	W climber	W succ climber	Gram	Total
Ntloko	29	0	10	5	0	1	3	1	21	11	0	8	1	9	2	1	8	2	9	121
Game	12	0	10	3	0	0	5	0	12	12	0	15	0	14	0	2	3	0	6	94
Shared	25	1	16	8	1	0	9	1	26	24	1	12	1	17	1	0	10	2	16	171
Total	66	1	36	16	1	1	17	2	59	47	1	35	2	40	3	3	21	4	31	386
% Total	17.1	0.3	9.3	4.1	0.3	0.3	4.4	0.5	15.3	12.2	0.3	9.1	0.5	10.4	0.8	0.8	5.4	1.0	8.0	

Table 3.5 Useful plants used by local people in Ntloko village. The number of plants do not add up to the total (for both study sites) because some species were used for more than one purpose.

Use	Ntloko	Game
Fuel	20	18
Forage	12	4
Medicinal	38	31
Other	16	13
Total	**86**	**66**
Total of useful plants		**110**

Species richness

There was no significant difference estimated in species richness (Chao 2) between Ntloko and the game farms in any of the TRMI classes (Figure 3.2). The most notable differences are at sites with TRMI 31 – 35 (Figure 3.2 d) and in the grassland habitat (Figure 3.2 f), which had the highest and lowest variation in species richness respectively. The rest of the classes have a similar range in mean species richness, lying between 55 and 121.

The overall species richness estimated for Ntloko and the game farms was significantly different. Figure 3.3 shows that the game farms had a higher estimated total species richness of 386 compared to 305 for Ntloko. Although the total number of species sampled in the two areas had minimal differences with slightly higher value in Ntloko (292) than in the game farms (265), the species accumulation curve for Ntloko saturates at a lower total area than that for the game farms (Figure 3.4). Thus, additional sampling at the game farms would produce more species as the species accumulation curve continues to increase at the total number of sites sampled, while at Ntloko, the number of species sampled (292) is close to the estimated species of 305. The extrapolated species richness for all forty sites combined is 691, a considerably higher value than the total number of species samples. This is explained by the steep species-accumulation curve for the two land use types combined, with each of the land use types contributing a substantial number of unique species (Figures 3.3 and 3.4).

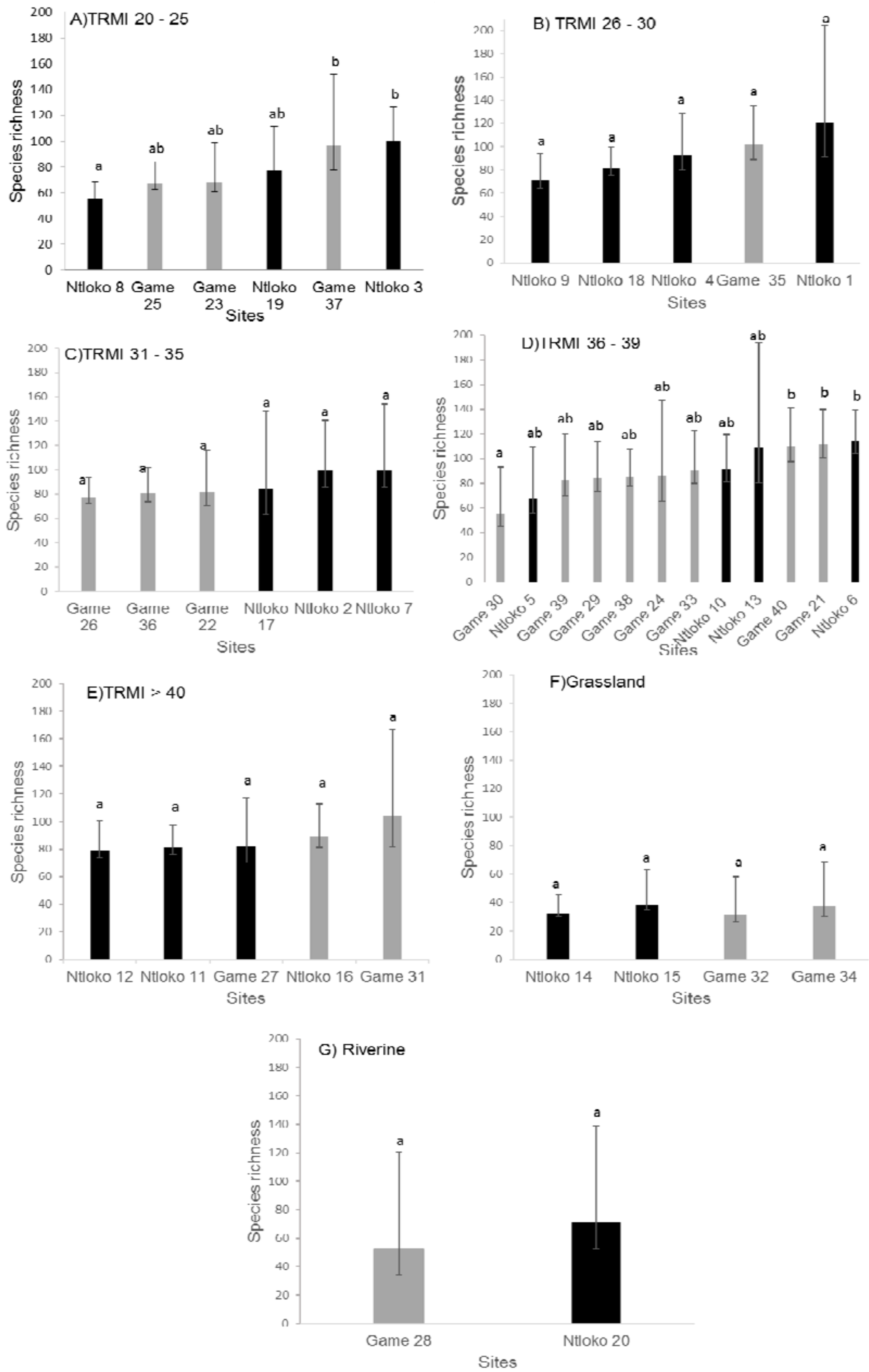

Figure 3. 2. Estimated mean species richness ± 95 % confidence interval for thicket vegetation at sites with TRMI a) 20 – 25 b) 26 – 30 c) 31 – 35 d) 36 – 39 e) > 40, as well as f) grassland and g) riverine vegetation. Grey bars show sites on game farms and black bars show the communal site.

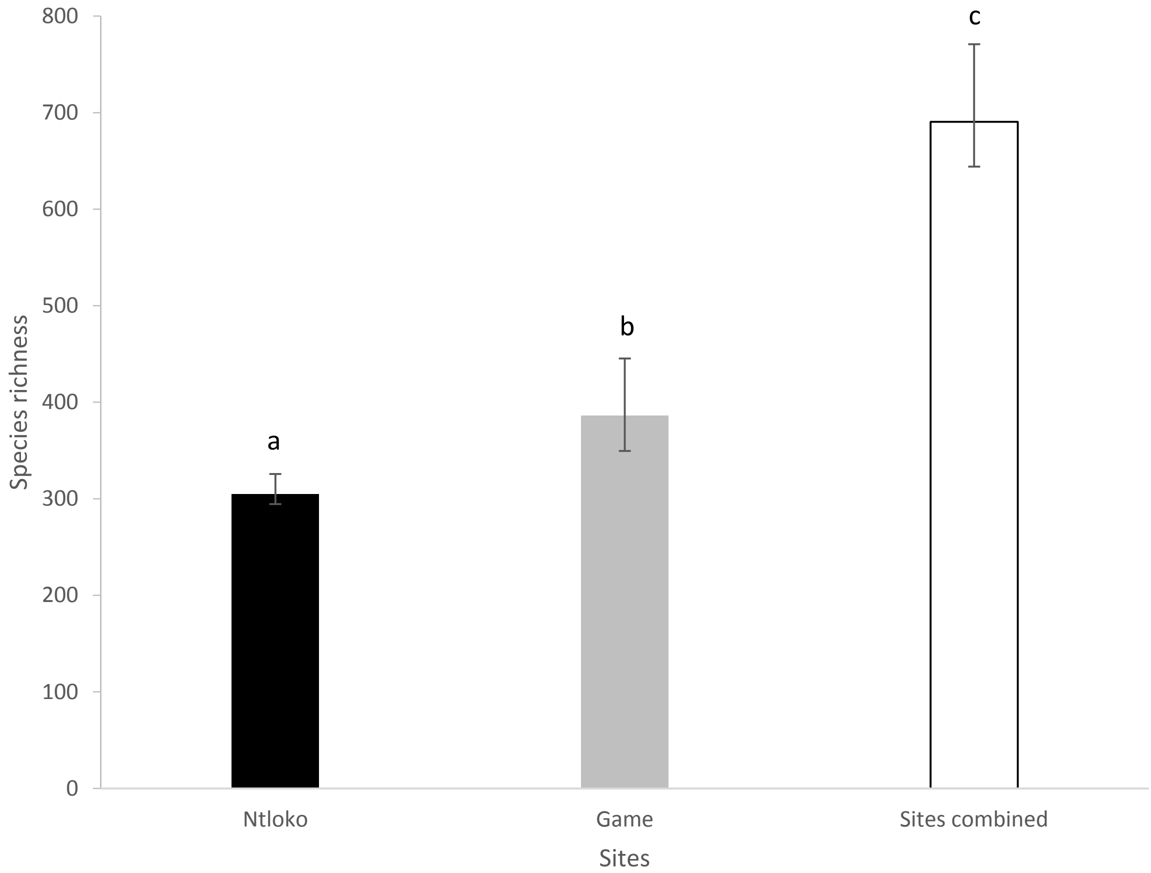

Figure 3.3. Overall extrapolated species richness in Ntloko and the game farms based on the twenty sites. The last bar denotes the overall species richness for both areas based on all forty sites combined. The bars show estimated richness and the error bars denote 95 % confidence interval. Grey bars show sites on game farms, black bars show the communal site and open bars shows all sites for Ntloko and the game farms combined.

Slope, TRMI, land use and aspect did not significantly predict species richness at the sampling sites. The relative importance of the independent variables in explaining estimated species richness is shown in Table 3.6, but none of the variables (alone or in combination) significantly explained estimated species richness. The model selection was run with and without the variable “distance from village”. Including this variable led to even poorer prediction of estimated species richness.

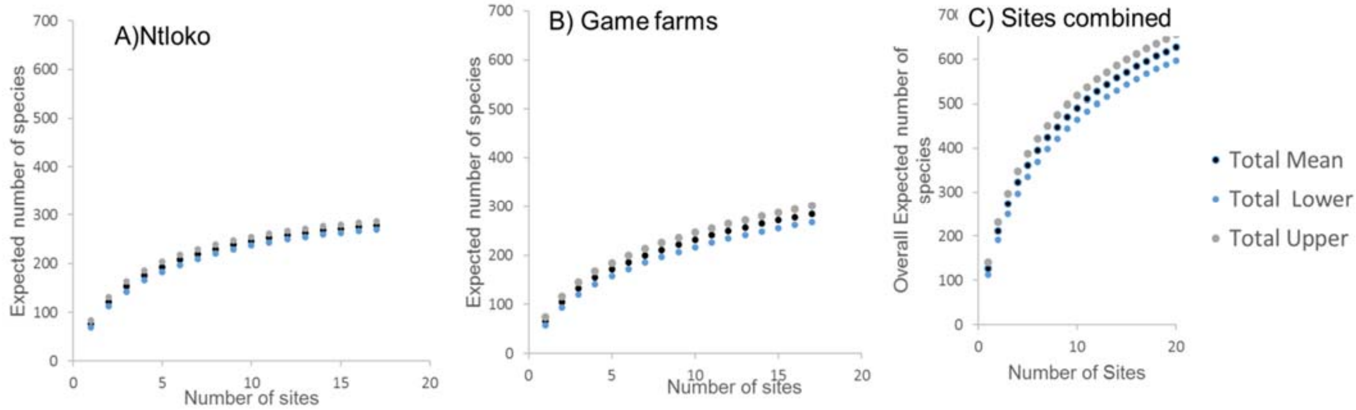

Figure 3.4. Species area curves for expected number of species for a) Ntloko and the b) game farms and c) overall species richness for all forty sites combined.

Table 3.6 Predictor variables for species richness in the multiple linear regression based on the sums of Akaike weights (w_i). Values are from the best model selection done with the four variables, excluding distance from the village.

Predictors	**Σw_i for dependent variables**	**R^2**	**p**
Slope	0.612825	0.02	0.16
TRMI	0.511339	0.07	0.27
Land Use	0.351945	0.02	0.62
Aspect	0.267899	-0.07	0.41

Species composition

Four groups of sites and a single site clustered at or above 40 % Bray-Curtis similarity (Figure 3.5). Each cluster comprises only game farms or only communal sites. The first major group comprised of 14 sites on the game farms divided into two clusters of seven sites each (Game 1 a & b). The second major group comprised of 13 sites in Ntloko, divided into three clusters of three, three and seven sites (Ntloko 1 a, b & c). Two smaller groups (Game 2, two sites) and Ntloko 2 (four sites) and a single game farm site are split by the 40 % similarity cut-off. Like the cluster analysis, the ordination plot shows that the plant species composition at Ntloko is distinct from that of the game farms (Figure 3.6). The split between game 1 a & b is mainly by topographic position and resultant soil moisture availability, into drier (TRMI > 20) and wetter sites (TRMI < 50). Similarly, the split between Ntloko 1 a, b and c is divided into sites into the same TRMI classes, > 20 and < 45. The smaller groups, Game 2 and Ntloko 2 have sites with > 25 and < 40 (Figures 3.5 and 3.6).

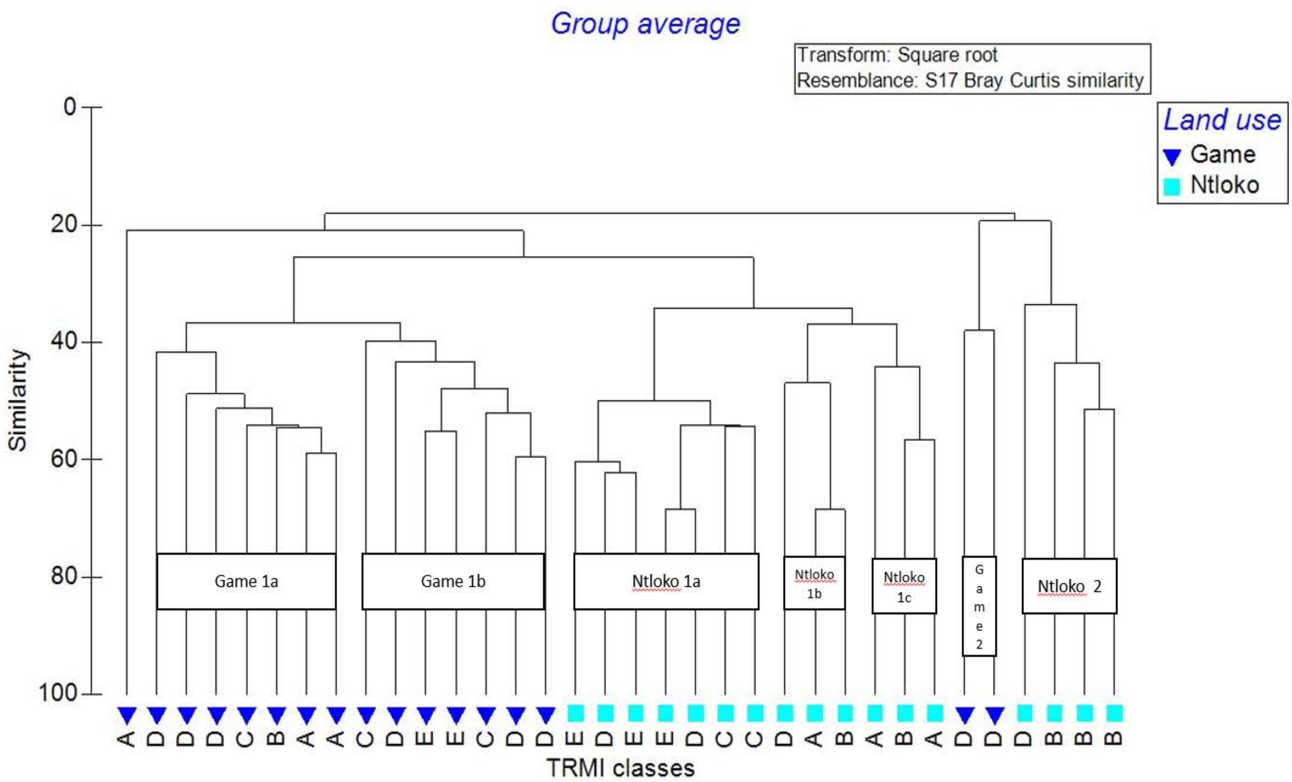

Figure 3.5 Hierarchical clustering dendrogram with group average linkage for sampling sites in Ntloko village and on game farms. Bray-Curtis similarities were calculated using square root transformed abundance data. The TRMI classes are grouped as follows: A = 20 – 25, B= 26 – 30, C = 31 – 35, D = 36 – 39 and E > 40 and categorised as game 1a & b for the two game clusters and Ntloko 1a, b and c for the three communal clusters and game 2 and Ntloko 2 for the last groups.

The two-way ANOSIM showed that there was a significant effect of land use on plant composition ($p = 0.001$; $R = 0.63$). Even though the effect of TRMI on plant composition was not statistically different overall ($p = 0.255$; $R = 0.075$), species composition at the wettest sites with TRMI > 40 (class E) was significantly different from species composition at the drier sites with TRMI < 35 (A, B and C) (Table 3.7). As illustrated by the cluster and ordination analyses (Figures 3.5 and 3.6) land use and soil water availability both had a significant influence on plant composition, but the effect of land use was more pronounced.

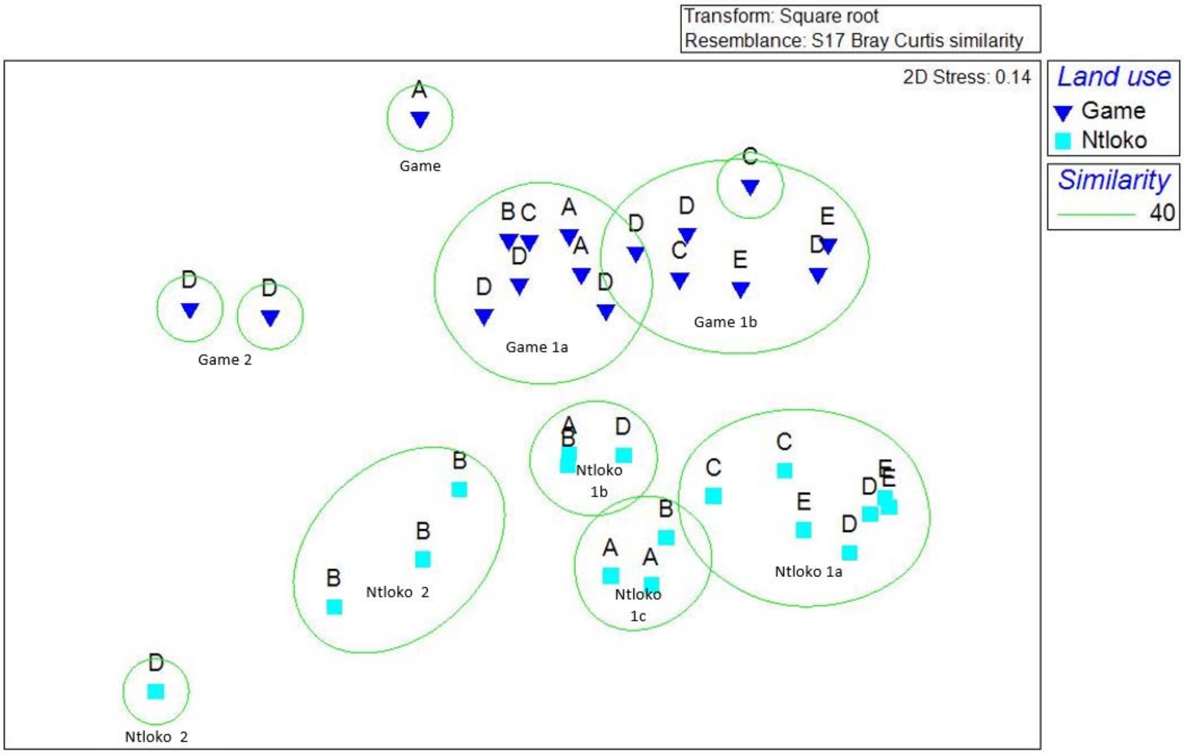

Figure 3.6 NMDS ordination plots showing the relationship between Ntloko and the game farms. The similarities were calculated on square root transformed abundance data. The TRMI classes are grouped as follows: A = 20 – 25, B = 26 – 30, C = 31 – 35, D = 36 – 39 and E > 40 and categorised as game 1a & b for the two game clusters and Ntloko 1a, b and c for the three communal clusters and game 2 and Ntloko 2 for the last groups.

The plant species contributing most to the similarity between sites clustered in the dendrogram are summarised in Table 3.8. Clusters Game 1 a and b are characterised by *Curio radicans*, *Jasminum sp., Grewia robusta, Plumbago auriculata* and *Barleria obtusa*, which are all either shrubby or herbaceous species (see Appendix 1). Species clustered in these two groups normally cover the ground layer in thicket vegetation predominantly occupying south-facing and valley sites (personal observation). Clusters Ntloko 1a, b and c are characterised by *Scutia myrtina*, *Grewia occidentalis, Allophylus decipiens, Delosperma calcinia, Barleria obtusa, Pteronia incana*, *Panicum maximum* and *Schotia afra, which* are mostly tall or succulent shrubs that are characteristic of thicket vegetation. *Panicum maximum* amongst other perennial grasses is normally widespread in these dense vegetation clumps occupying the ground layer.

Table 3.7. The Analysis of similarities between sites in different TRMI classes showing the R-values and significance level. Significant differences ($p < 0.05$) are highlighted. TRMI classes are as follows: A = 20 – 25, B = 26 – 30, C = 31 – 35, D = 36 – 39 and E > 40

TRMI classes	*R-value*	p
B, C	0.374	0.071
B, A	0.245	0.125
B, D	0.044	0.402
B, E	**0.894**	**0.006**
C, A	0.221	0.12
C, D	-0.197	0.879
C, E	**0.667**	**0.04**
A, D	0.008	0.431
A, E	**0.712**	**0.03**
D, E	-0.018	0.47

Sites in the cluster Ntloko 1 a were found in south-facing slopes, in Ntloko 1 b and 1 c were found in ridge and north-facing slopes. The two sites comprising the cluster Game 2 were dominated by *Ptaeroxylon obliquum, Delosperma calcinia, Brachylaena ilicifolia*, and located at upper south-facing slopes. At Ntloko, sites on a similar topographic position near the top edge of the Fish River valley and on ridges were strongly dominated by *Pteronia incana*, along with *Delosperma calcinia* and *Eragrostis obtusa*. These relatively accessible and heavily impacted sites near Ntloko village made up the cluster Ntloko 2. Within land use types, there was a clear influence of mean TRMI values and aspect on the composition of thicket vegetation occupying south-facing and valley sites.

Table 3.8: Summary of mean species abundance (on a scale of 0-30) and their percent contribution to within-group similarity in each of the groupings identified by the cluster analysis. Average similarity is the mean Bray-Curtis similarity of plant composition of sites within a cluster. Similarity values are based on untransformed data.

Land Use	**Average within-group similarity**	**Contributing species**	**Life form**	**Mean species abundance**	**% contribution to within group similarity**	**Mean TRMI (±SD)**
Game 1a	49.02	*Curio radicans*	Succulent herb	19.57	8.87	
		Jasminum sp.	Woody climber	14.71	6.60	31.00 ±
		Grewia robusta	Tall shrub	15.00	5.48	6.56
Game 1b	37.06	*Curio radicans*	Succulent herb	20.86	9.60	38.43 ±
		Plumbago auriculata	Woody climber	16.57	8.59	5.03
		Barleria obtusa	Low shrub	23.86	8.23	
Ntloko 1a	42.00	*Scutia myrtina*	Tall shrub	24.71	10.17	38.57 ±
		Grewia occidentalis	Tall shrub	17.00	5.67	5.53
		Allophylus decipiens	Tall shrub	14.00	5.50	
Ntloko 1b	41.21	*Delosperma calcinia*	Succulent	21.67	6.91	29.67 ±
		Barleria obtusa	shrub	17.33	4.56	6.03
		Pteronia incana	Low shrub	16.33	3.59	
			Low shrub			
Ntloko 1c	44.69	*Barleria obtusa*	Low shrub	23.67	11.97	25.33 ±
		Panicum maximum	Graminoid	21.00	9.50	3.21
		Schotia afra	Small tree	15.33	8.36	
Game 2	37.28	*Ptaeroxylon obliquum*	Small tree	30.00	32.97	36.50 ±
		Delosperma calcinia	Succulent	16.50	14.29	2.12
			shrub	15.00	8.79	
		Brachylaena ilicifolia	Small tree			
Ntloko 2	36.40	*Pteronia incana*	Low shrub	30.00	21.87	30.8 ±
		Delosperma calcinia	Succulent	23.50	9.20	5.0
			shrub			
		Eragrostis obtusa	Graminoid	16.50	8.46	

Discussion

Effect of land use and topography on species richness

Heavy grazing and intense wood collection have been identified as major causes of low biodiversity in communal areas (Fabricius et al., 2002). In the Albany Thicket Biome, these activities lead to decreases in bush clumps, giving way to herbaceous species and karroid dwarf shrubs that thrive in more arid or disturbed areas (Evans et al. 1997, Fabricius et al. 2002, Vlok et al. 2003). In many rural and peri-urban areas of the former Ciskei, uncontrolled grazing and browsing by domestic livestock has transformed Thicket to an open karroid dwarf shrubland; this transformation was accompanied by the loss of many woody and succulent species, which re-establish with great difficulty in the hotter and more arid micro-climate that results from this transformation (Evans et al., 1997). Such patterns not only decrease vegetation cover but also pose a threat to the natural resource base (Fabricius et al., 2002).

Plant species richness was fairly similar between Ntloko and the game farms. Alpha diversity did not differ between the two land use types, as shown in the species richness estimates at the plot scale, but the game farms had a higher beta diversity as evidenced by the species accumulation curve and resultant species richness estimate for the entire sites. The Albany Thicket Biome has a floristically high alpha diversity and low beta diversity (Evans et al., 1997) and so in this case I expected a high beta diversity because of the topographic variation. The lower beta diversity could be because areas close to the village contribute fewer species than equivalent areas in the game farms. The soil moisture conditions across the two land use types had similar effects on species richness, which suggests that Ntloko is not degraded but less diverse than the game farms as shown by the overall species richness. The accumulation curve shows that Ntloko levels off much earlier, indicating that with more sampling sites few additional species would turn up. In comparison, that of the game farms is steeper and more sampling sites are predicted to add a substantially greater number of species to the total. This is supported by current studies which suggest that the accumulation curve is useful in comparing species richness on different scales and sample sites (Rutherford & Powrie, 2013) and thus holds true as the significant portion of the species in Ntloko were herbaceous.

The high number of herbaceous species in Ntloko may be a result of human activity in sites closer to the village which are *Pteronia* and grass dominated. These human disturbances are caused by intense grazing and fuelwood collection which leads to land degradation and the recolonization of spontaneous species. Degradation reduces plant cover and has direct effects on composition and functioning of an ecosystem (Maestre et al., 2001), thus species composition was able to tell us which species are present and how similar the species pool is at the different sites.

Species composition

There were clear, significant differences in species composition between Ntloko and the game farms. The compositional patterns found within each land use type were related to slope and aspect, as reported in other studies in this vegetation type (Birch et al., 1999). The drier, more exposed sites (TRMI < 35) had different plant composition to wetter sites near the bottom of steep valleys (TRMI > 40). Sites with high TRMI values were dominated by species adapted to mesic conditions and sites with low TRMI values were characterised by succulents, dwarf shrubs and grassland type species, as expected. Although TRMI did not have a significant overall effect on species composition across all sites, it showed significant differences in species composition between the moister valley sites and the relatively dry sites that were identified as being close to the village.

Twenty-seven percent of the total species recorded were unique to Ntloko and more than 24% were restricted to the game farms. The unique species for each land use type had a relatively low abundance (< 1 %) compared to the shared species, which had a relatively higher abundance (≥ 10 %). This suggests that many of the "unique" species occur at low density and may have been missed during sampling. Nevertheless, the species-area curves suggest that while many of the species apparently unique to Ntloko are likely to be found with additional sampling at the game farms; whereas the species accumulation curve for Ntloko suggests that the species unique to the game farms may actually be absent from Ntloko, since the total estimated richness is very similar to that found in the 20 sites sampled. Finding unique species on both land use types is a common pattern in all similar studies (Fabricius & Burger, 1997; Evans et al., 1997), but previous studies have also found a higher abundance of unique species on protected land than on commercial or communal farming areas.

Species composition at Ntloko was significantly different from that at the game farms, and utilisation by people and livestock foraging are the most plausible explanation. The degree of vegetation transformation was visibly affected by accessibility from the village to the river, with areas of thicket vegetation in distance classes 1 and 2 having sparser and lower woody cover, and an abundance of dwarf shrubs and grasses. Pote et al. (2006) found areas in the forest, further away from the village to be highly vegetated by thicket vegetation. Most striking is the band of *Pteronia incana*-dominated vegetation on the upper edge of the Fish River valley, which can be observed all along the Eastern side of the Fish River. These sites formed a distinct cluster in the dendrogram and NMDS. The distance scores for each site (Table 3.3.1) show that the activities of local people currently only extend about halfway from the village to the Fish River. Beyond that, anthropogenic disturbances have limited effect on the vegetation because very few people nowadays access these areas due to cultural and safety issues (see Chapter 2).

In contrast to the findings of Fabricius & Burger (1997) what would have been expected in an area where people harvest natural resources, useful plants were not found to be less represented in Ntloko. Neither the number of useful species nor the abundance of useful species were lower in Ntloko than at the game farms. This suggests that while land use has had an impact on vegetation composition and overall species richness in the communal area, there has been no catastrophic decline in plant diversity or the availability of useful plants.

It is important when interpreting these data to keep in mind that vegetation reflects not only current land-use but also the land-use history of an area. This is particularly true for vegetation dominated by long-lived perennial species (Evans et al., 1997; Wigley et al., 2009; Vetter et al, 2006). A study of the relationship of Ntloko residents with their surrounding thicket (McAlister 2012) suggested that more people used to access and utilise thicket areas in the past and that reliance on natural resources and people's willingness to walk far into the thicket has declined in recent decades. It is thus likely that human impacts on thicket vegetation in Ntloko extended further into the Fish River Valley. Similarly, the game farms had in the past been used for livestock farming, and while details of their land use history were unavailable, there may have been substantial impacts, including bush clearing, in the past.

Overall, while plant composition differed between the two land use types, the difference in species richness (especially at the plot scale) was small, the representation of different life forms in the species pool was similar at both sites, and with the exception of the thicket sites closest to the village, the species composition in the communal landscape did not show obvious signs of obvious transformation from thicket to a degraded vegetation. Similar patterns were found in several studies in southern Africa. In comparing the effects of grazing in communal and commercial areas. Todd & Hoffman (1999) and Anderson & Hoffman (2007) found species composition to be affected by land use and not so much on species richness in Namaqualand and Kamiesberg mountain range Succulent Karroo. Todd et al., (1998) also, found no differences in species richness of plants and invertebrates between a communal and commercial area in Paulshoek Namaqualand while Shackleton (2000) found higher species richness in intensely used communal lands than protected areas at plot and point-scale in a study in the Bushbuckridge lowveld savanna. Similarly, Smart et al. (2005) and Fabricius et al. (2003) reported higher reptile species richness and diversity in disturbed communal lands than protected areas disturbed areas. This suggests that human impact in rural areas does not necessarily reduce plant species richness and diversity compared to less impacted areas, although compositional changes often occur. In such cases, a mosaic of heavily and lightly utilised areas is likely to conserve the greatest diversity overall, since different suites of species thrive under different land use intensities.

The common finding that protected areas maintain substantially higher biodiversity than unprotected areas, and particularly communal rangelands, did not apply in this study. From the satellite view (Google Earth) the game farms are relatively abundant in vegetation cover compared to Ntloko but species composition in Ntloko still resembles a relatively stable thicket vegetation regardless of the high percentage of herbaceous species. Some of this may be due to relatively inaccessible terrain of the Fish River valley, with its steep slopes and dense vegetation. Human impact appears to be concentrated close to the village and along the easily accessible ridges at the top of the Fish River Valley.

Other work by Rutherford et al., (2012) has shown communal land use to affect vegetation structure more strongly than composition. Woody plant species provide essential needs for people in rural areas, thus with poor management these natural resources can be overused. Rutherford et al., (2012) found that the structural transformation in the communal land was a result of either an increase or decrease of an individual species affected the cover of the next species. However, the most important factor that determined each species cover was its life history trait, how it responded under a stressful environment and whether it was able to recover following disturbance. Similar results were also found in a study done in the southern Kruger Park (Mathieu et al., 2009) where they found that communal residence use a large portion of wood for fuelwood. In addition to the findings, many studies related to above mentioned recognised overgrazing and overuse by people as the major drivers of vegetation structure and composition. The following chapter looks at the woody structure and composition between the two study sites.

CHAPTER 4 – THE EFFECTS OF LAND USE ON WOODY STRUCTURE AND COMPOSITION

Introduction

Land use practices exert different pressures on thicket vegetation (Fabricius & Burger, 1997). Rural communities are dependent on a variety of woody plant species, which provide a wide range of goods and services such as timber, fuelwood, medicine, fruit and other usable resources (Higgins et al., 1999; Pote et al., 2006). These biological products have direct use to the household and are sometimes sold at local markets (Koziell & Saunders, 2001) to add to the low income received by the local people (Shackleton, 2004). Fuel wood harvesting and browsing by goats have been recognised as the most important factors reducing woody plant cover in the subtropical thicket biome, especially in areas surrounding human settlements (Puttick et al., 2014). Harvesting of natural resources has raised concern about biodiversity loss especially in dry systems, which only recently received attention in understanding the forces responsible for change in vegetation structure and functioning (Pote et al., 2006).

Despite electrification and other developments in the rural areas, fuelwood is still a primary source of energy in many rural communities (Shackleton,2004; Berry et al., 2005; Madubansi & Shackleton, 2007). This is evident around thicket coastal vegetation, where there is typically an open patch of grassland close to the villages and denser, more pristine vegetation is observed further away from the village (Berry et al., 2005). Plants are used for different reasons, including woodcutting for fuelwood, medicine, kraal material and woodpiles (McAlister, 2012). These products are needed by all social classes as mentioned in a report by Shackleton & Shackleton (2006) that the poor and the wealthy still use natural resources for household needs especially non timber products (NTFPs) such as traditional medicine, wild fruits and vegetables. Wealthier households use their disposable income to purchase NTFPs from their neighbours and vendors, thus suggesting natural resources play an important role in the local economy of rural areas (Cocks et al, 2008). Human disturbances have changed the life form composition from tall woody species to smaller shrubby layers (Berry et al., 2005). The increasing demand on economic development which includes vegetation clearing and industrial projects have significant impacts on the vegetation structure and functioning.

The change in abundance and composition of woody species because of domestic and wild herbivores is well documented (Stuart-Hill, 1992; Barnes et al., 1994; Loffell, 1999). Although subtropical thicket vegetation is relatively resilient to browsing by indigenous herbivores, goats have had devastating effects (Stuart-Hill, 1992; Sigwela et al., 2009). Uncontrolled grazing and browsing due to poor management strategies has often led to a reduction of palatable species which are replaced by unpalatable invaders (Evans et al., 1997). The subtropical thicket has been documented to have been transformed through heavy grazing by goats changing a closed canopy thicket vegetation into a pseudo-savanna with scattered trees and ephemeral grasses and forbs (Lechmere-Oertel et al., 2005) or karroid vegetation more characteristic of arid areas (Birch et al., 1999). Canopy species in the arid zone of the subtropical thicket are unable to recover spontaneously following degradation by browsing (Lechmere-Oertel et al., 2005; Van Luijk et al., 2013). Browsing by goats has a negative effect on some thicket species (notably the highly palatable *Portulacaria afra*) as they remove the canopy "skirt" that extends down to the ground, changing the microclimate beneath the canopy, as well as reducing the organic mulch that gathers below the plant (Sigwela et al., 2009). Perennial, woody thicket vegetation is usually replaced by a sparse layer of ephemeral weedy species and/or dwarf shrubs that leaves the soil vulnerable to soil erosion and cannot provide sufficient fodder for herbivores (Stuart-Hill, 1992).

Overgrazing by domestic and wild herbivores and over-use by local people have been recognised as major drivers of the change in woody structure and composition in the thicket. However, the effects of land use often have a stronger effect on vegetation structure than on species diversity and composition (Rutherford et al., 2012; see chapter 3). Degradation has negative effects on vegetation cover and structure, replacing perennials with annual species and favouring less palatable species (Rutherford et al., 2014). Recent studies in Mopane savanna showed similarities in plant species composition and diversity between a high utilisation (communal land) and low utilisation area (game farm). The outcomes supported the intermediate disturbance hypothesis suggesting that the similarities between the two areas was caused by competitive exclusion in the low utilisation area and by continuous disturbance in the high utilisation area. Both probable causes limited the species numbers. The parity found in species diversity was due to only a small fraction of species which were able to tolerate disturbance caused by heavy grazing (Rutherford et al., 2012). In another study, three biome rangelands in Grassland, Nama-Karoo and Mopane savanna showed similarities in species composition with heavy grazing. The results showed that palatable species become replaced by less palatable species (Rutherford & Powrie, 2013).

Vulnerable species are more likely to go extinct in the semi-arid region due to drought coupled with heavy grazing (Rutherford & Powrie, 2010). The loss of species may not necessarily have a strong effect on how the systems functions but in the longer term it may be virtually impossible to re-establish (Aucamp,1976). Structural changes in vegetation may result in reduced height due to grazing, which leads to decreases in reproductive output (Rutherford & Powrie, 2010). A reduction in utilisation pressure may thus be required to increase the chances of recovery.

This chapter will be focusing at the effects of land use on structure and composition of woody plant species between the two land use types. The aim of this chapter is to assess the effects of land use on woody structure and composition by measuring woody plant composition in different parts of the landscapes and comparing it between the two land use types. Woody thicket species were assessed in two size classes: those that are less than 2 m in height (which includes new recruits as well as stunted individuals) and those > 2 m in height, which include reproductively mature thicket trees and shrubs with a portion of leaves and branches above browse height. Larger plants are targeted for wood harvesting, and browsers reduce the growth of plants leaving them in a stunted form, therefore woody plants > 2 m were expected to have a lower density in Ntloko than on the game farms. This may result in a) lower density of woody plants > 2 m and b) a difference in the composition of woody plants > 2m with unpalatable species and those not preferred for firewood and building being dominant over the palatable species in that size class. Most thicket plants resprout after browsing and one would expect to have a higher density of smaller individuals (< 2 m) in Ntloko. *Portulacaria afra* and other non-spinescent, palatable species that are sensitive to browsing by goats are expected to be found at lower densities in both size classes in Ntloko.

Methods

Data collection

The point-centered quarter method (PCQ) was used as it is effective at describing woody plant composition, tree density, and vegetation structure (Trollope *et al*., 2006). Two transects were laid out parallel to each other, each 100 m long, and 25 m apart. Eleven points were recorded at 10 m intervals on the transect line giving a total of 22 points at each site. The distance (in metres) from the recording point to the closest rooted tree or shrub was recorded at each recording site in all four quadrants, and the species name was identified. In the first two quadrants of each recording point, the nearest tree or shrub < 2 m in height was measured and if no trees or shrubs of that size class were recorded within the 10 m range, zero plants were recorded. Unlike many other studies, no minimum size limit was set which allowed the inclusion of the smallest juvenile thicket plants. In the third and fourth quadrant of each recording point, the distance to the nearest tree or shrub with height > 2 m was measured. In the absence of trees or shrubs > 2 m within 10 m of recording point, a zero plant was recorded (Trollope *et al*. 2006).. Dwarf shrubs and succulents characteristic of karroid vegetation were excluded from sampling.

Species were separated into the two size classes in order to capture the wide range of woody size classes of trees and shrubs that represented thicket vegetation. Species < 2 m tend to be denser, and combining them with > 2 m would lead to under-representation of the larger size classes. The size class of < 2 m height represents juvenile and heavily browsed thicket plants, while the > 2 m height class incorporates mature thicket individuals, which have grown beyond the browse height of goats.

The mean sampling point-tree distance at each site was used to calculate the mean density per site (density (stems.ha^{-1}) = mean distance*10000/mean distance^2). The total tree density was multiplied by the proportion of stems recorded made up by each species (total tree density*(count/100)). An error of about 100 plants. ha^{-1} is created when a zero is recorded at any of the four quadrats within the 10 m point because the density is calculated on the assumption that 10 m as 10000m ^{2}/10m ^{2} = 100 plants/ hectare (Trollope *et al*., 2006). Such errors would only have occurred in non-thicket sites, which were omitted from this analysis.

Data analysis

Factors determining woody plant density in the different size classes

The best subset for model building was selected using the Akaike Information Criterion (AIC). A General Linear Model analysis was carried out using the variables comprising the best model thus identified. The dependent variable was woody density (< 2m and > 2m, analysed separately) and the independent variables were TRMI, land use and slope. The methods for quantifying independent variables are described in Chapter 3 in the section "best model selection: independent variables". The relative importance of each dependent variable in predicting woody plant composition in each size class was calculated by summing up the Akaike weights (w_i) for all the models in which the variable appears (Burnham & Anderson, 2002).

Effect of available soil moisture and land use on the abundance of palatable and unpalatable woody species

All species were categorised into three palatability classes, namely palatable, slightly palatable and unpalatable (Trollope et al. 2006, A. R. Palmer, pers comm). I performed regression analyses of woody plant densities (in the three palatability classes and total woody density) against TRMI separately for the communal area and the game farms to explore the relationship between woody density and available soil moisture under the two different land uses. I also calculated the percentage of palatable, slightly palatable and unpalatable species at each site. I then divided sites into relatively drier and wetter sites (TRMI ≤ 35 and TRMI > 35) and compared the density and percentage of woody plants in each of the three palatability classes, as well as total density, between the communal site and the game farms. Since the data did not meet the assumptions for ANOVA, I used Mann-Whitney U tests to compare density or percentage between the communal sites and the game farms separately for each soil moisture class.

Plant species composition

I used multivariate analyses to evaluate the similarities of the subtropical thicket woody vegetation in different TRMI classes and between the two land uses. Bray-Curtis similarity indices were calculated between all sampling sites and used to create a dendrogram using hierarchical clustering by group average linkage. Non-metric multi-dimensional scaling (NMDS) ordination plots were also based on Bray-Curtis similarity. An analysis of similarity (ANOSIM) was used to test for significant differences in species composition by TRMI classes and the two localities. A similarity percentage (SIMPER) analysis was done to look at which plant species contribute most to similarity among sites clustering together at 40 % Bray Curtis similarity. The vegetation data was square root transformed, except for the SIMPER analysis where untransformed values were used for greater ease of interpreting the abundance values. All multivariate analyses were performed with PRIMER v.6 software (Clarke &Gorley, 2006). Separate comparisons were done for > 2 m and < 2 m data.

Results

Woody plant density in the > 2m size class.

Ntloko and the game farms had similar densities of taller woody plants at the drier (TRMI < 35) and wetter (TRMI > 40) sites (Figure 4.2). Both study sites had relatively low densities, more so for the drier sites, which had densities below 1000 stems.ha^{-1} (Figures 4.1 and 4.3). Land use had no effect on the density of woody plant species but TRMI and slope significantly predicted woody density in the > 2m size class. The relative importance of the independent variables in explaining woody density is shown in Table 4.1.

Table 4.1 Predictor variables for woody plant composition in the multiple linear regression based on the sums of Akaike weights (w_i) Values are from the best model selection done with three variables, excluding aspect.

Predictors	**Σw_i for dependent variables**	**R^2**	**p**
TRMI	0.999999	0.27	0.0033
Slope	0.999962	0.27	0.0038
Land use	0.980494	0.05	0.11

Woody plant density in the < 2m size class.

There were no differences in woody plant density < 2 m height between Ntloko and the game farms (Figures 4.2 and 4.4). This size class had higher densities than the > 2 m size class, with most sites exceeding 5000 stems ha $^{-1}$, except for a few sites (shown in Figure 4.2). The same sites had the lowest densities in the > 2 m size class. None of the models significantly predicted woody composition in the < 2 m size class. Table 4.2 is a summary of the relative importance of the independent variables in explaining woody composition, but none of the variables (alone or in combination) significantly explained the woody composition suggesting that land use and TRMI had no effect on the < 2 m size class .

Table 4.2 Predictor variables for woody plant composition in the multiple linear regression based on the sums of Akaike weights (w_i) Values are from the best model selection done with three variables, excluding aspect.

Predictors	**Σw_i for dependent variables**	**R^2**	**p**
TRMI	0.876057	0.05	0.11
Land use	0.669916	0.0033	0.30
Slope	0.607546	0.0039	0.32

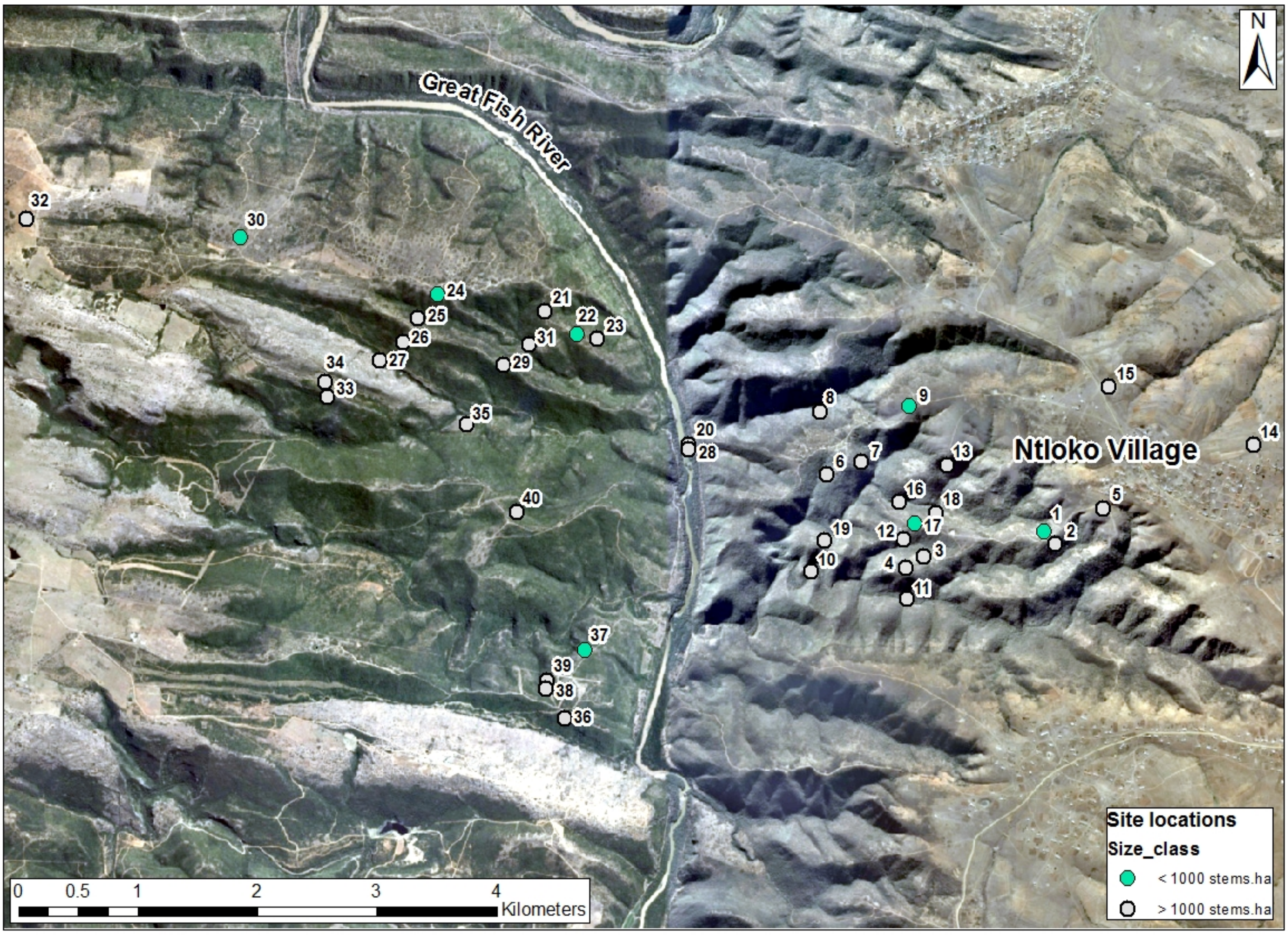

Figure 4.1. Map showing sites with lower densities in the > 2 m size class. Green symbols indicate sites with densities below 1000 stems. ha^{-1}. Sites 14,15,20,28,32, and 34 were excluded from the analyses.

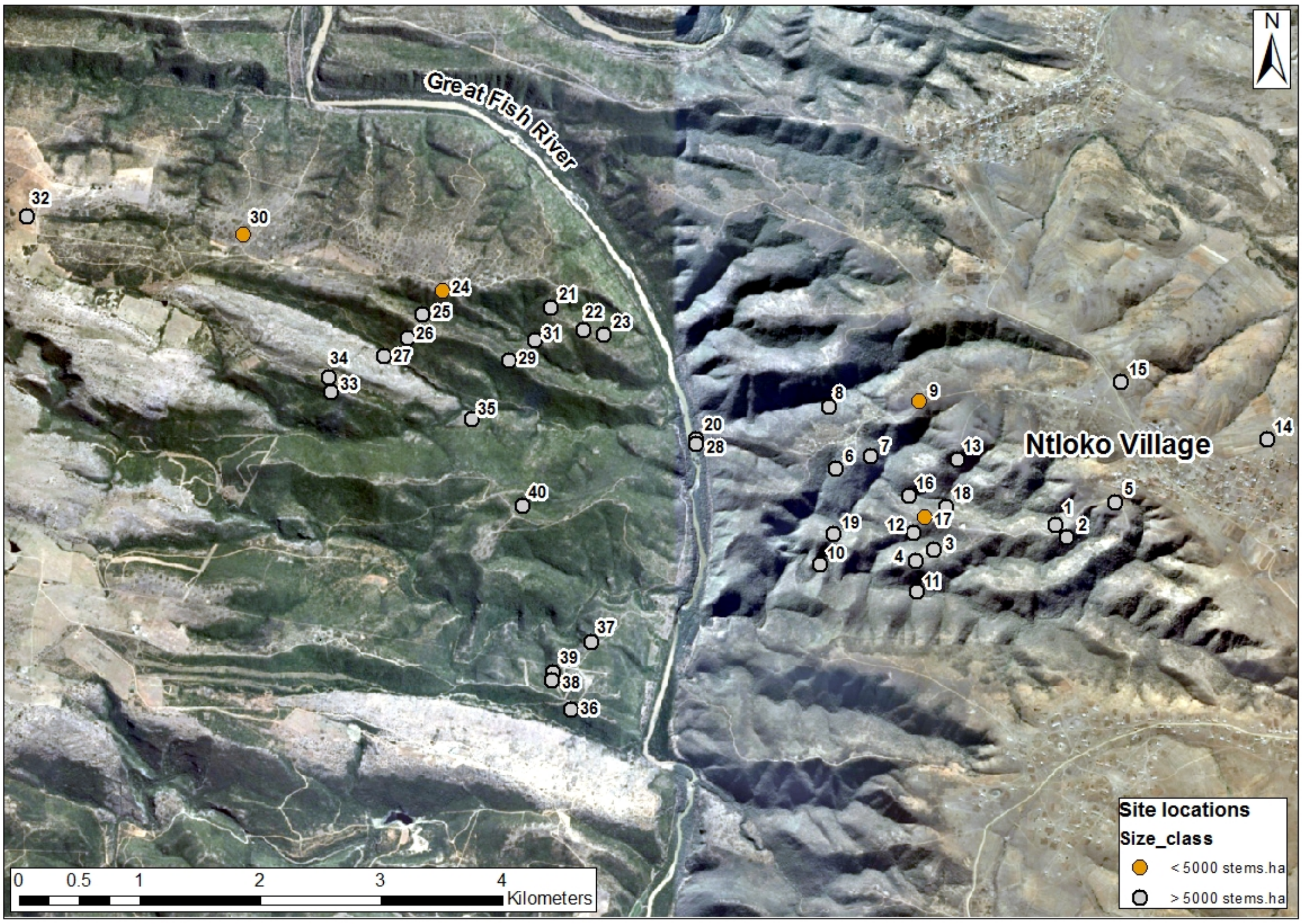

Figure 4.2 Map showing sites with lower densities of woody plants in the < 2 m size class. Orange shaded sites are sites with densities below 5000 stems. ha^{-1} Sites 14,15,20,28,32, and 34 were excluded from the analyses.

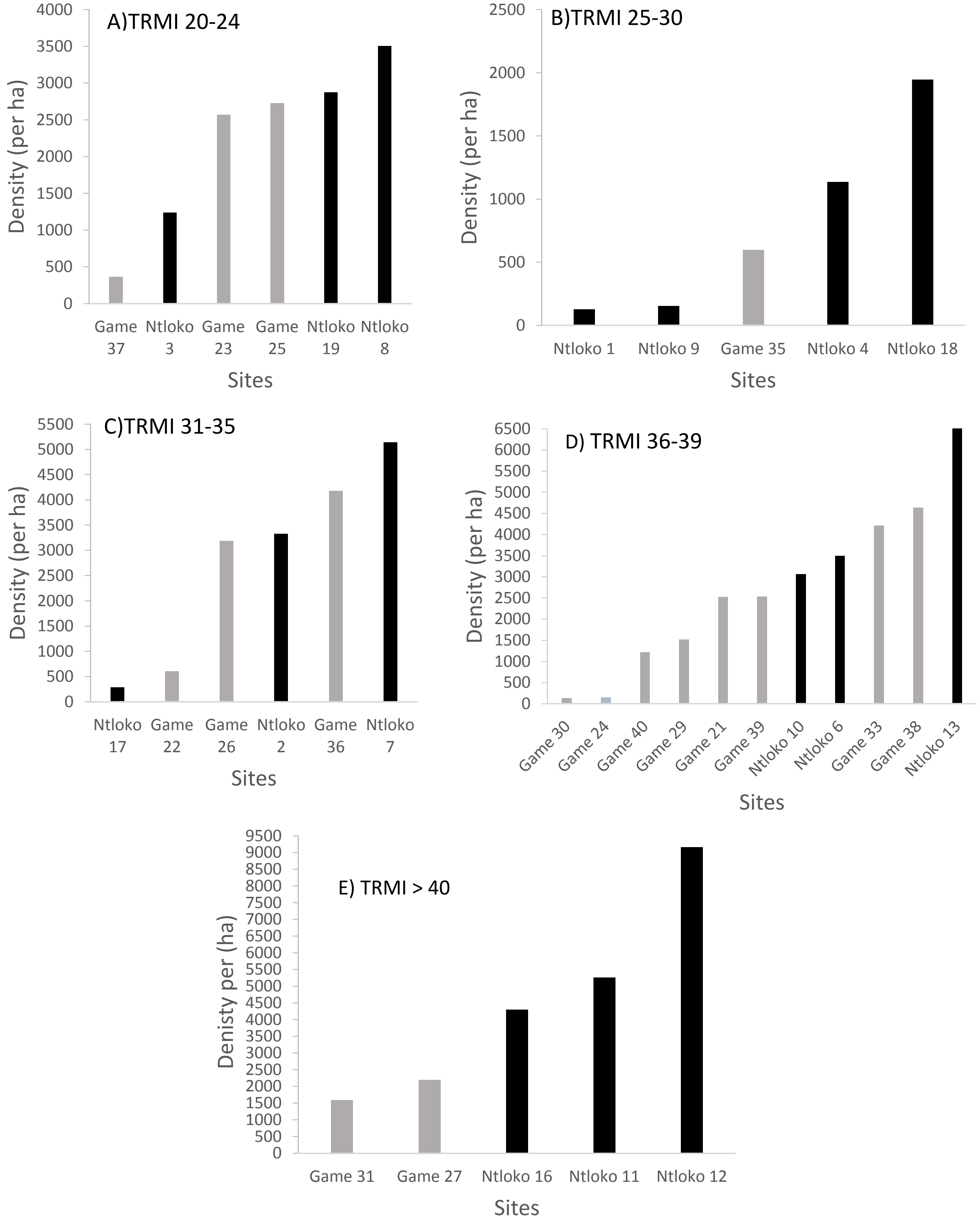

Fig. 4.3: A comparison of woody plant density between Ntloko and the game farms in the > 2m size class. Grey bars show sites on game farms and black bars show the communal sites

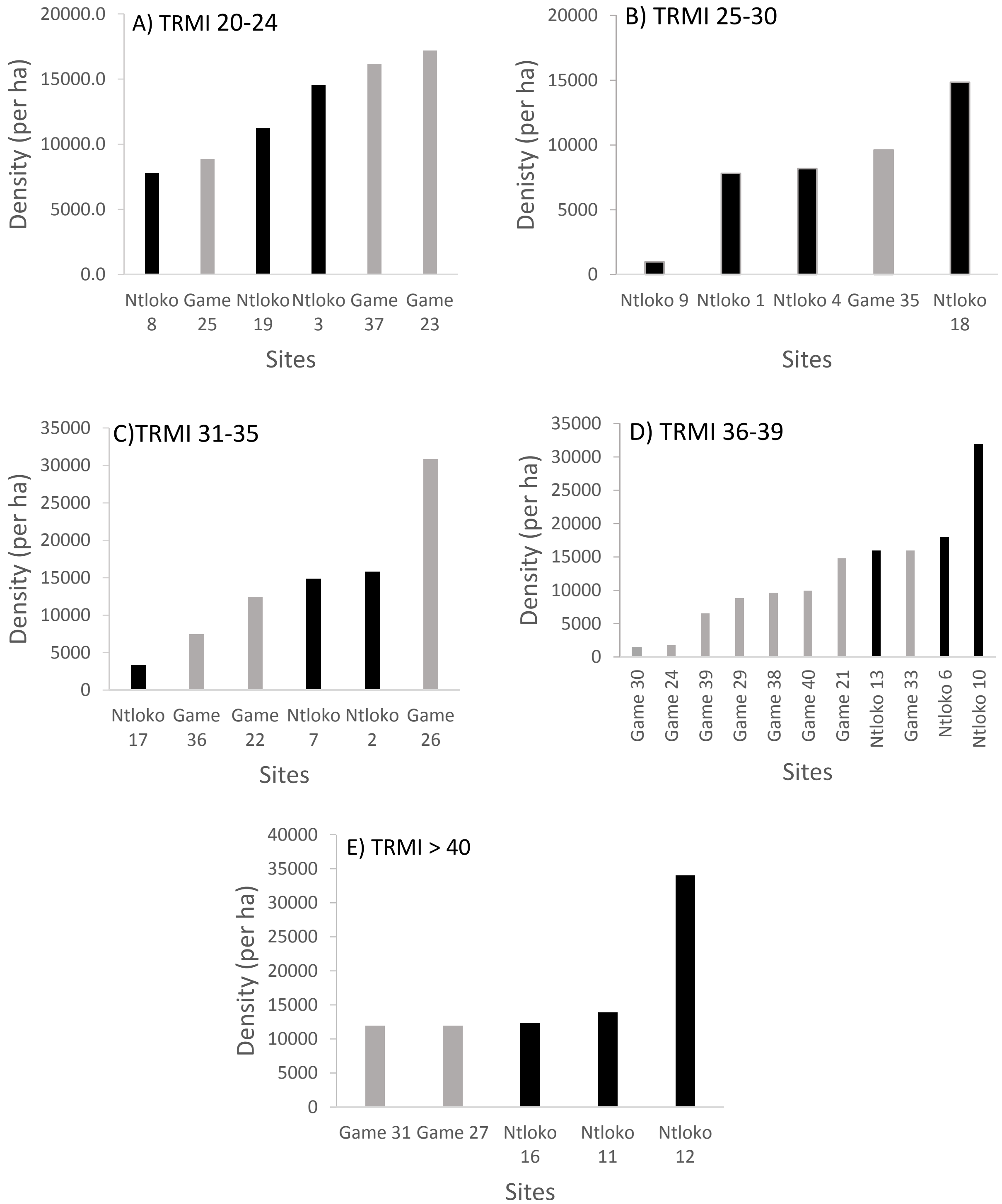

Fig. 4.4: A comparison of woody plant density between Ntloko and the game farms in for the < 2m size class. Grey bars show sites on game farms and black bars show the communal sites.

Abundance of palatable and unpalatable woody species

There was a significant positive relationship between TRMI and woody density (of < 2 m and > 2 m size classes combined) in Ntloko for each of the palatability classes as well as total woody density. In contrast, woody plant density (total and in each palatability class) was not significantly correlated with TRMI on the game farms (Figure 4.5). Woody density at Ntloko and all the game farms was similar at drier sites, but at wetter sites it was significantly higher in Ntloko (Figure 4.6).

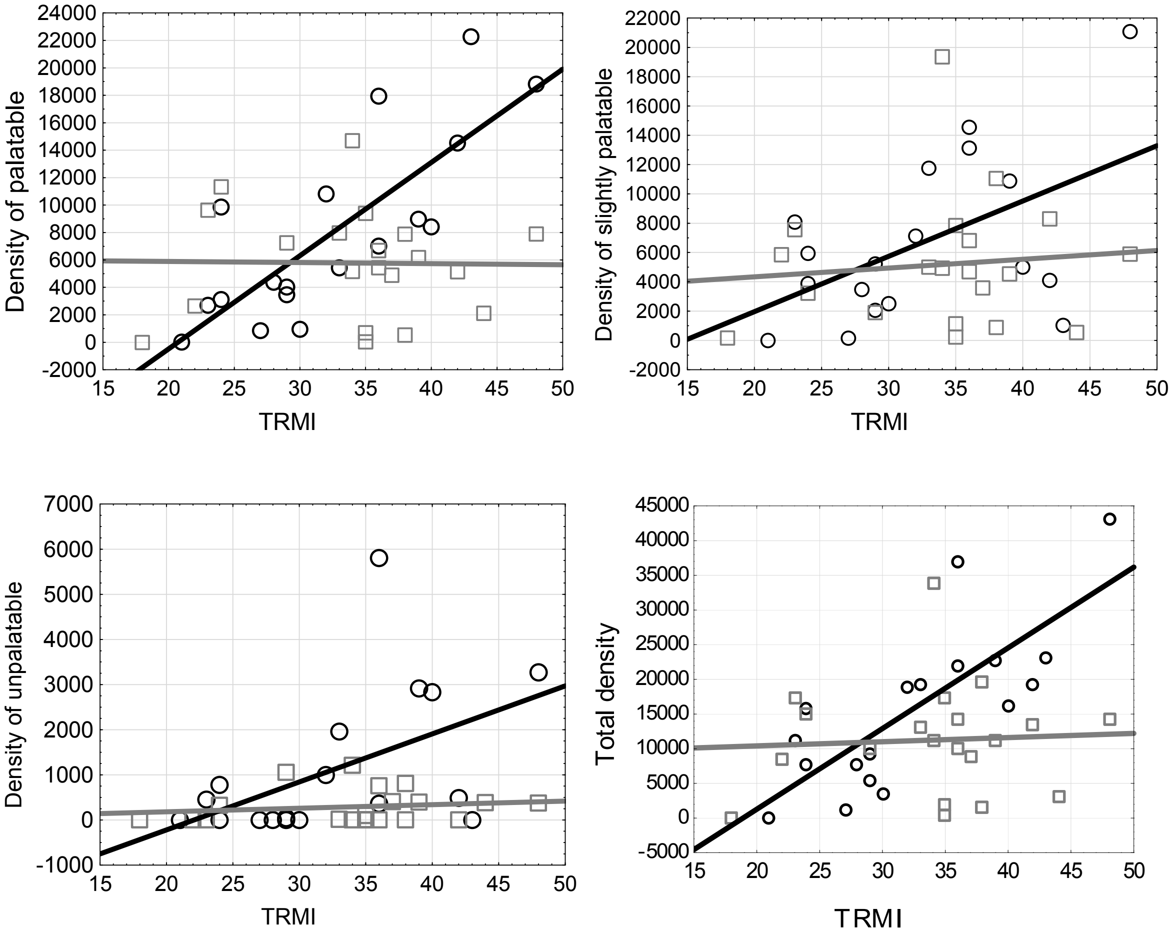

Figure 4.5. Relationship between TRMI and density for the different palatability classes and total woody plant density in Ntloko (black circles) and the game farms (grey squares). Density of palatable: communal (R^2 = 0.663, p < 0.001), game (n.s.); density of slightly palatable: communal (R^2 = 0.265, p < 0.05), game (n.s.); density of unpalatable: communal (R^2 = 0.255, p < 0.05), game (n.s.); and total density: communal (R^2 = 0.600, p < 0.001) game (n.s.).

The percentage of unpalatable species was low throughout (but somewhat higher and more variable in Ntloko at higher TRMI), whereas the percentage of slightly palatable species was slightly lower in Ntloko at higher TRMI, and the percentage palatable, at around 50 %, was very similar across soil moisture status and land use (Figure 4.7). Overall, the absolute and relative abundance of palatable woody species did not differ with land use, and overall woody density (including all classes of palatability) was higher in Ntloko at sites with higher moisture availability.

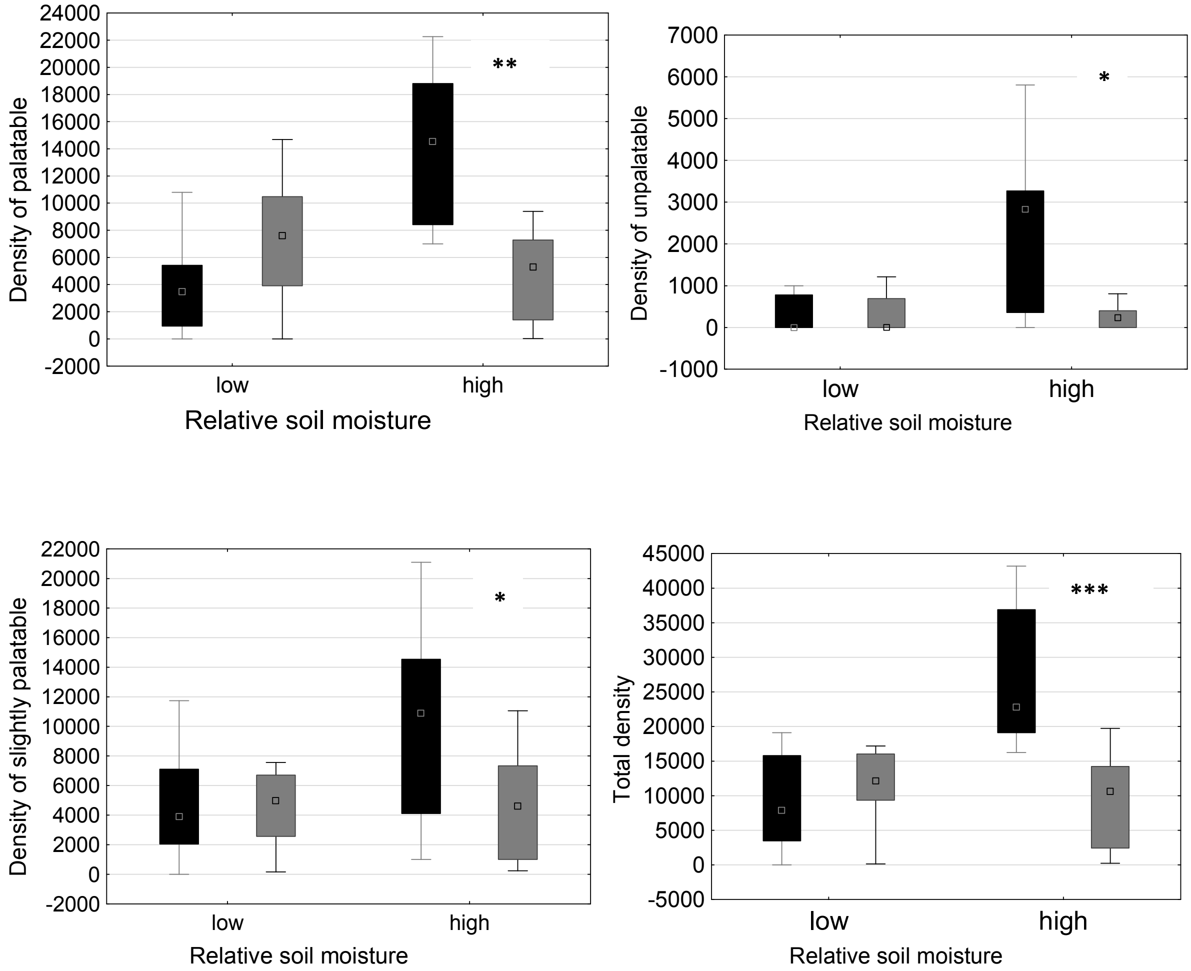

*Figure 4.6. Comparison of woody density in the different palatability classes and total density between Ntloko (black bars) and the game farms (grey bars) at high and low TRMI (TRMI of <= 35 and > 35 respectively). Pairwise comparisons (game farms vs. communal) of each variable were done separately for low and high TRMI and significant differences are reported as * p < 0.05, ** p < 0.01, *** p < 0.001 and no significant difference on unmarked graphs.*

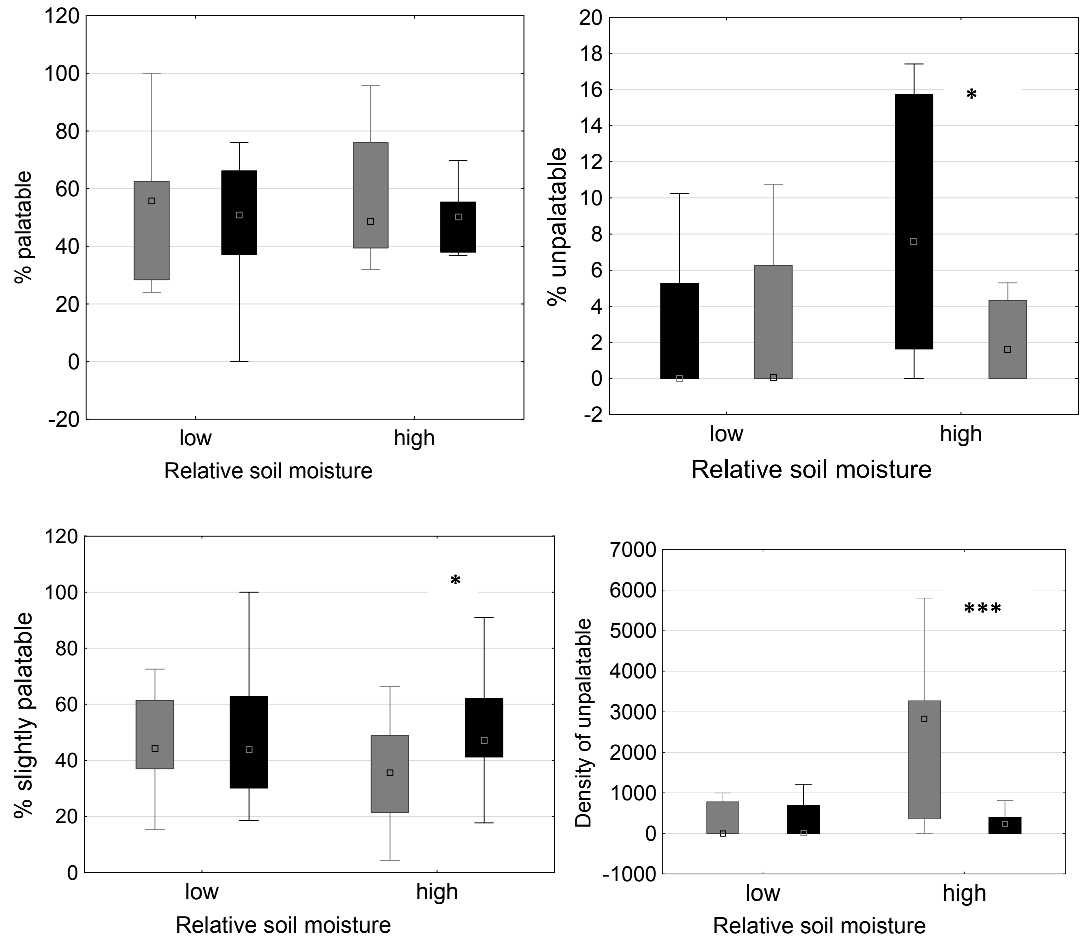

*Figure 4.7. Comparison of the percentage of total woody plants in each of the three palatability classes between Ntloko (black bars) and the game farms (grey bars) at high and low TRMI (TRMI of <= 35 and > 35 respectively). Pairwise comparisons (game farms vs. communal) of each variable were done separately for low and high TRMI and significant differences are reported as * p < 0.05, ** p < 0.01, *** p < 0.001 and no significant difference on unmarked graphs.*

The highly palatable *Portulacaria afra* was very abundant at the game farms, but was found at very low density at the drier sites at Ntloko. The next most abundant of palatable species are *G.robusta* and *Searsia* species which have a low density in Ntloko compared to the game farms. As in the > 2m size class, the density of species in the wetter sites is higher in Ntloko than the game farms with slightly palatable *E. triangularis* & *E. grandidens* and palatable *G. occidentalis* & *A.glabrata* as the dominating species (Appendix 2).

Woody composition of thicket vegetation in the > 2 m height class

Four major groups of sites clustered at or above 30 % Bray-Curtis similarity (Figure 4.8). Some clusters are a combination of communal and game farm sites, and only group 1 comprises of communal sites only. The first major group is comprised of 18 sites divided into three clusters of four, twelve and six (Group 1a, b & c). Group 1a has four Ntloko sites, Group 1b consists of three sites from Ntloko and nine game farms sites and group 1c has a combination of four Ntloko sites and two game farms sites. The second major group comprised of 7 sites (group 2) three from Ntloko and four from the game farms. Group 3 is comprised of four sites, two from Ntloko and the game farms respectively.

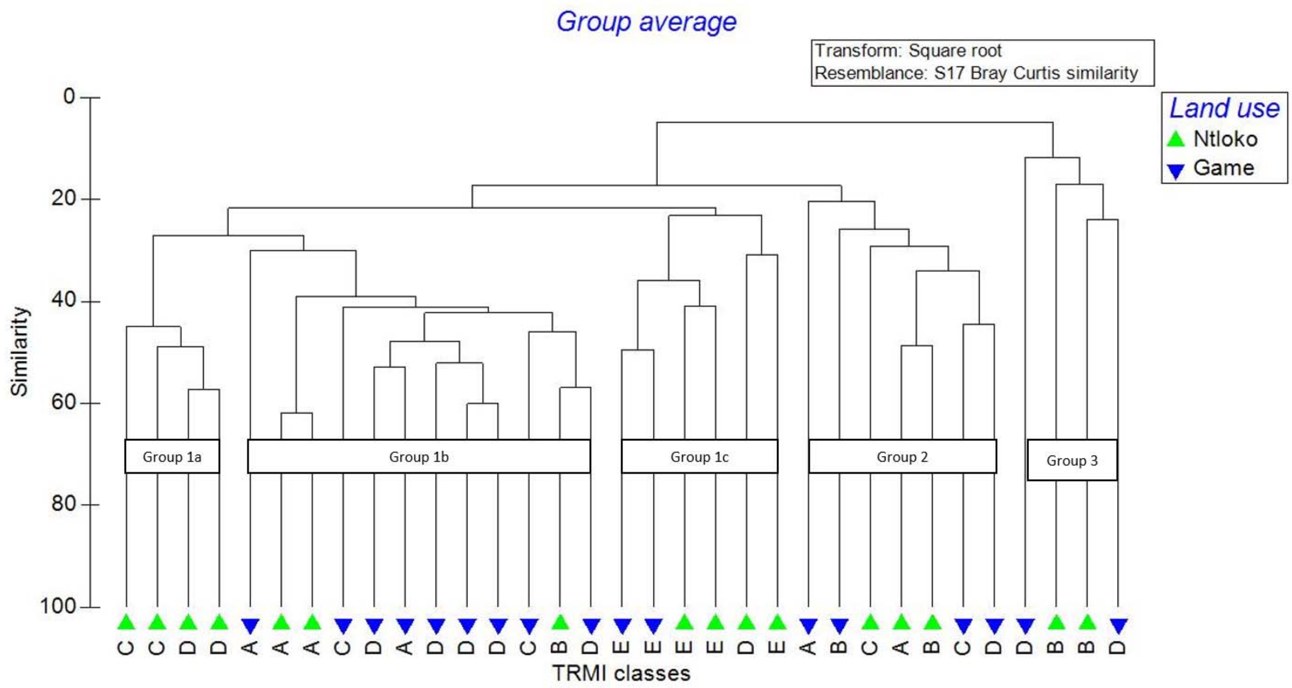

Figure 4.8 Hierarchical clustering dendrogram based on woody species > 2 m height with group average linkage for sampling sites in Ntloko village and on game farms. Bray-Curtis similarities were calculated using square root transformed abundance data. The TRMI classes were grouped as follows: A = 20 – 25, B = 26 – 30, C = 31 – 35, D = 36 – 39 and E > 40 and categorised as group 1 a,b and c forming the big cluster, group 2 second largest cluster and group 3 is the last group with two sites from the two land us types.

Like the cluster analysis, the ordination plot shows that the woody composition between the two land use types is to some extent similar (Figure 4.9). The split between clusters Game 1a, b and c is caused by differences in topographic position and subsequent soil moisture availability into sites with TRMI of < 50 including sites > 20. Likewise, sites found in Group 2 and 3 range between > 24 and < 40.

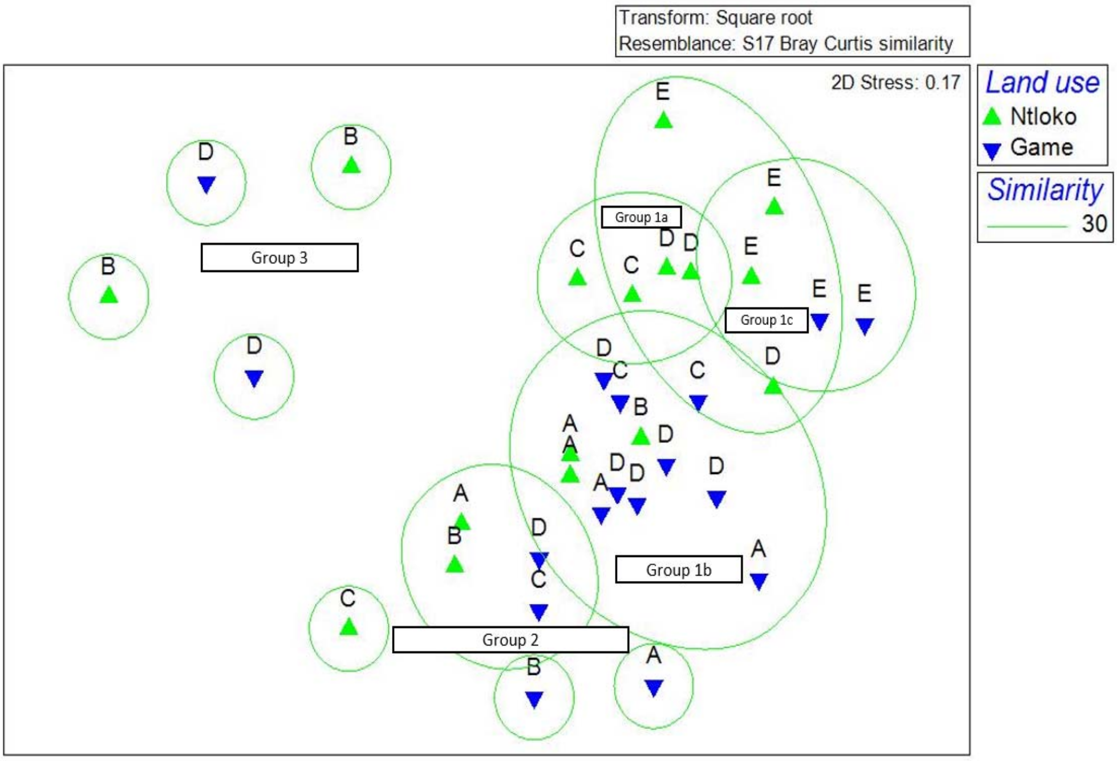

Figure 4.9 NMDS ordination plots of woody species composition > 2 m showing the relationship between Ntloko and the game farms. The similarities were calculated on square root transformed abundance data. The TRMI classes were grouped as follows A = 20 – 25, B = 26 – 30, C = 31 – 35, D = 36 – 39 and E > 40 and categorised as group 1 a,b and c forming the big cluster, group 2 second largest cluster and group 3 is the last group with two sites from the two land us types.

The two-way ANOSIM showed that land use ($p = 0.114$; $R = 0.17$) and TRMI ($p = 0.167$; $R = 0.124$) did not have any significant effect on the woody composition of plants > 2 m (Table 4.3). However, the effect of TRMI class on the woody plant composition at the wetter sites with TRMI > 40 (class E) was significantly different from woody plant composition at drier sites with TRMI < 35 (A, B and C). Similarly, the cluster and ordination analyses also show that relative soil moisture had a significant influence on plant composition (Figure 4.8 and 4.9).

Woody species that contributed most to the similarity between sites clustered in the dendrogram are summarised in Table 4.4. Clusters of group 1a has the highest within-group similarity of (> 40 %) and Group 3 has the lowest within-group similarity value (4.17%). Group 1a is characterised by G. *occidentalis, S. myrtina* and *S. refracta* with *G. occidentalis* contributing more to within-group similarity and mean species abundance. Species found in group 1a & c were mostly sampled on wetter south facing and valley sites while species on group 1b is comprised of species sampled on various slopes from north to south, east and ridge sites. Group 1b, c and group 2 have a relatively high *Euphorbia* density compared to other groups dominating mean species abundance and within group similarity. *Grewia occidentalis* in Group 1c, however, has the highest mean species abundance.

Table 4.3. Analysis of Similarities (ANOSIM) comparing sites with different relative soil moisture, based on woody species composition > 2 m. The table shows R-values and significance level. Significant differences ($p < 0.05$) are in bold. TRMI classes are as follows: A = 20 – 25, B = 26 – 30, C = 31 – 35, D = 36 – 39 and E > 40.

TRMI classes	R-value	p
B,C	0.123	0.264
B,A	0.055	0.343
B,D	0.176	0.238
B,E	**0.486**	**0.038**
C,A	0.167	0.23
C,D	-0.131	0.715
C,E	**0.51**	**0.01**
A,D	0.027	0.358
A,E	**0.901**	**0.01**
D,E	0.218	0.222

Group 2 species were sampled on drier north facing and ridge sites, hence the low mean TRMI value compared to other groups. Group 3 is characterised by *G. nemorosa* and *A. ferox*. They were sampled on the *Pteronia* sites and one north facing slope. *Gymnosporia nemorosa* had the highest within group similarity and *A. ferox* the highest mean species abundance.

Effect of available soil moisture and land use on the abundance of palatable and unpalatable woody species in > 2 m size class.

The density of species in the drier sites was much lower in Ntloko than at the game farms. *Euphorbia triangularis* and *E. grandidens* which are slightly palatable species were abundant in Ntloko but found at low density in the game farms. Similarly, *G. occidentalis,* a palatable species, had a higher density in the game farms with low density in Ntloko. The wetter sites were dominated by a variety of slightly palatable species such as *E.triangularis, P. auriculata* etc. and palatable *A. glabrata, G. occidentalis* in Ntloko with very low density in the game farms (Appendix 2).

Table 4.4: Summary of mean species abundance (on a scale of 0-30) and their mean contribution to within-group similarity in each of the groupings identified by the cluster analysis. Average similarity is the mean Bray-Curtis similarity of plant composition of sites within a cluster. Similarity values are based on untransformed data.

Clustered groups	**Average within-group similarity**	**Contributing species**	**Life form**	**Mean species abundance**	**% contribution to within group similarity**	**Mean TRMI (±SD)**
Group 1a	41.87	*Grewia occidentalis*	Tall shrub	675.10	24.19	35.0 ± 3.2
		Scutia myrtina	Tall shrub	402.68	14.23	
		Searsia refracta	Tall shrub	315.69	14.07	
Group 1b	32.19	*Euphorbia grandidens*	Succulent tree	232.83	14.37	30.9 ± 6.3
		Schotia afra	Small tree	211.63	12.75	
		Euphorbia triangularis	Succulent tree	485.83	12.31	
Group 1c	23.62	Euphorbia grandidens	Succulent tree	1394.09	16.87	42.7 ± 4.7
		Grewia occidentalis	Tall shrub	1638.80	15.49	
		Suregada africana	Tall shrub	875.58	8.39	
Group 2	27.26	*Euphorbia triangularis*	Succulent tree	199.76	33.34	29.7 ± 5.2
		Gymnosporia capitata	Tall shrub	81.76	20.86	
		Euclea undulata	Tall shrub	29.05	13.76	
Group 3	4.17	*Gymnosporia nemorosa*	Tall shrub	5.82	79.55	32.0 ± 5.4
		Aloe ferox	Succulent tree	20.56	20.45	

Woody composition of thicket vegetation in the < 2m size class

Three major groups of sites and a single site were clustered at or above 30 % Bray-Curtis similarity (Figure 4.10). Each cluster is a combination of Ntloko and game farms sites. The first major group consisted of 17 sites divided into three clusters of four, four and nine sites which are evenly distributed amongst the clusters (Group 2a, b & c). The second major group comprised of 12 sites divided into two clusters of seven and five sites. Group 3a comprised of six sites from Ntloko and one from the game farms and Group 3b comprised of two sites from Ntloko and three from the game farms. Group 1, which is the smallest consisted of the three clusters comprised of 3 sites (two game and one Ntloko) and a single game farm site were split by the 30 % similarity cut-off.

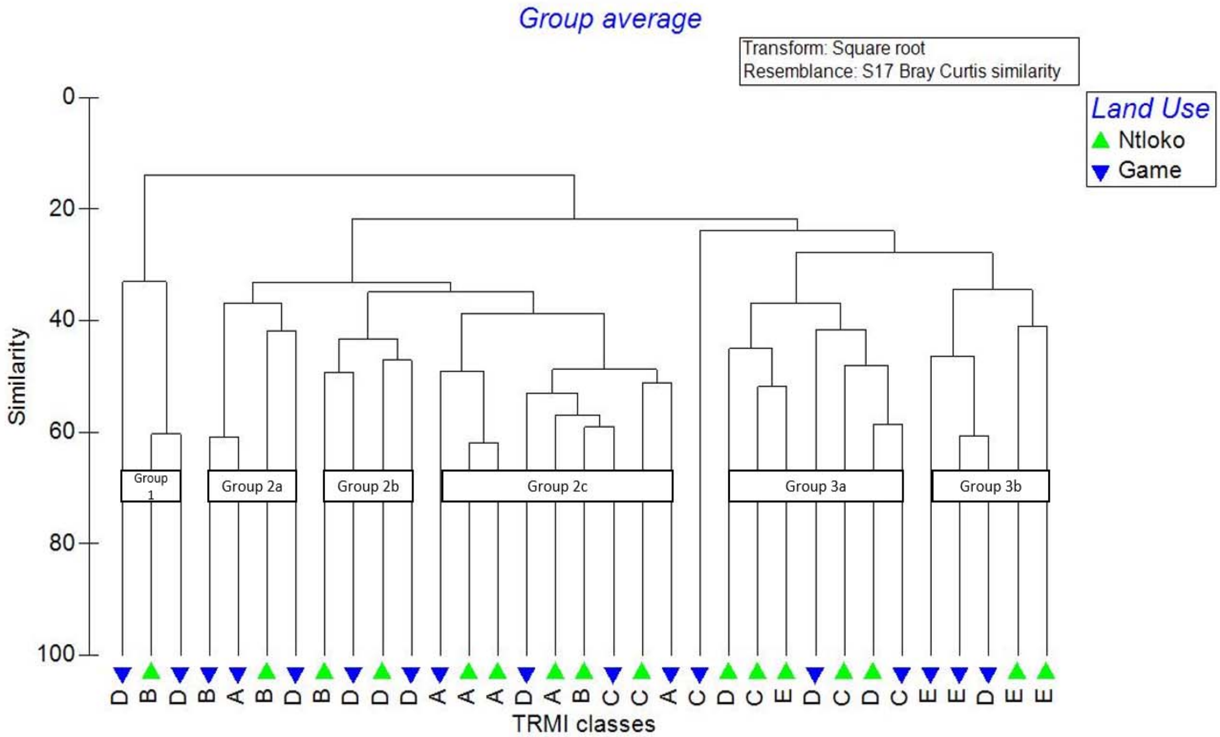

Figure 4.10 Hierarchical clustering dendrogram with group average linkage for sampling sites in Ntloko village and on game farms. Bray-Curtis similarities were calculated using square root transformed abundance data of woody plants < 2 m in height. The TRMI classes were grouped as follows: A = 20 – 25, B = 26 – 30, C = 31 – 35, D = 36 – 39 and E > 40 and categorised as group 1 for the first two sites from the game farms and one from Ntloko, group 2 a,b and c for the first big cluster, group 3 a & b form part of the second large cluster.

Like the cluster analysis, the ordination plot shows that the woody composition of communal sites and the game farms are not distinct (Figure 4.11). The cluster between Group 2 a, b & c, which are relatively dry sites is mainly by topographic position and soil moisture availability into sites with TRMI < 39 including sites with TRMI > 20. Group 3 a & b had a relatively higher TRMI range of wet south facing and valley sites which fall under TRMI < 45 which in this case included sites with TRMI > 30. Group 1 are all *Pteronia*-dominated sites sampled on a south facing slope with TRMI > 25 and < 40.

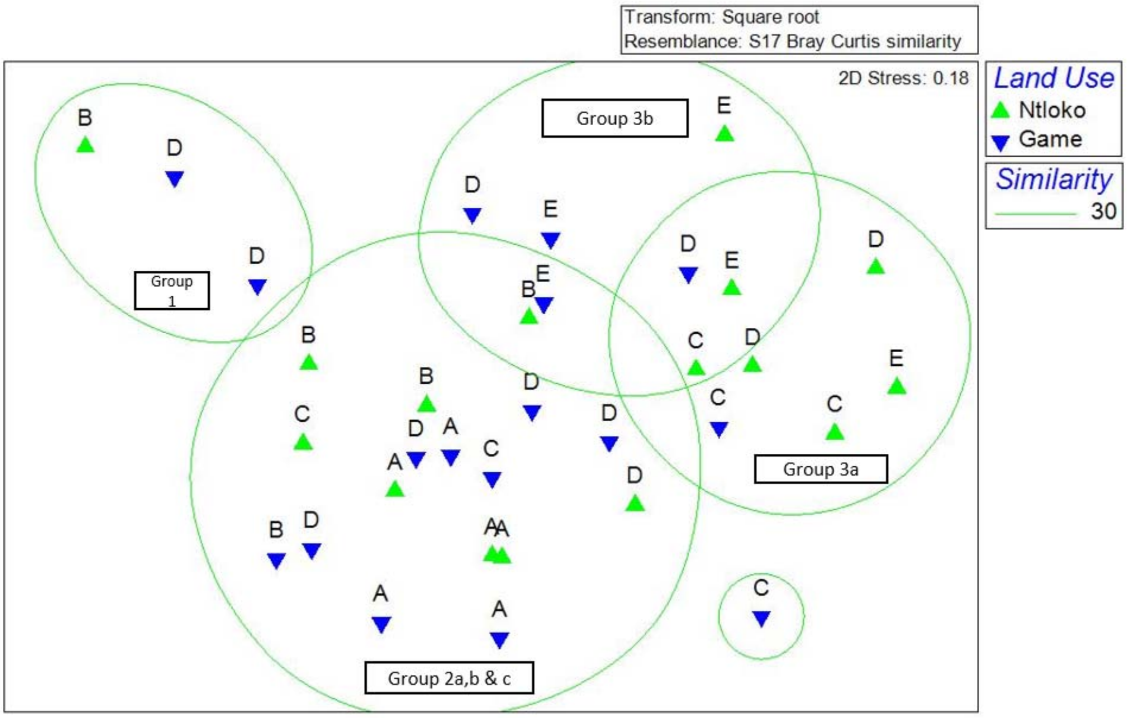

Figure 4.11 NMDS ordination plots showing composition of woody plants < 2 m in height at Ntloko and the game farms. The similarities were calculated on square root transformed abundance data. The TRMI classes were grouped as follows: A = 20 – 25, B = 26 – 30, C = 31 – 35, D = 36 – 39 and E > 40 and categorised as group 1 for the first two sites from the game farms and one from Ntloko, group 2 a,b and c for the first big cluster, group 3 a & b form part of the second large cluster.

The two-way ANOSIM showed that there was no significant effect of land use on the composition of woody plants < 2 m, $p = 0.137$; $R = 0.146$ (Table 4.5). The effect of TRMI class on woody plant composition was not statistically different overall ($p = 0.252$; $R = 0.072$), but species composition at the wettest sites with TRMI > 40 (class E) was significantly different from species composition at the drier sites with TRMI < 35 (A and B). As illustrated by the cluster and ordination analyses (Figure 4.10 and 4.11) soil water availability had a significant influence on plant composition in the < 2 m size class.

Table 4.5. Analysis of Similarities (ANOSIM) comparing sites with different relative soil moisture, based on woody species composition > 2 m. The table showsR-values and significance level. Significant differences (p < 0.05) are in bold. TRMI classes are as follows: A = 20 – 25, B = 25 – 30, C = 30 – 35, D = 35 – 39 and E > 40

TRMI classes	R-value	p
B, C	0.221	0.171
B, A	-0.077	0.621
B, D	0.166	0.222
B, E	**0.63**	**0.029**
C, A	0.167	0.22
C, D	-0.008	0.474
C, E	0.133	0.24
A, D	-0.036	0.352
A, E	**0.9**	**0.001**
D, E	-0.244	0.878

The woody plant species contributing most to similarity between sites clustered in the dendrogram are summarised in Table 4.6. Clusters of group 2b and 3b had the highest within-group similarities of (> 40 %) and *J. capensis* was the common species appearing multiples times across the groups. Group 1 is characterised by low shrubs (*Lycium cinereum* and *J. capensis)* and *Aloe ferox* (Table 4.6). *Aloe ferox* contributed more to within-group similarity and highest mean abundance. Group 2a is characterised by different shrubs, which consist of *G. robusta, J.capensis* and *P. afra*. *Grewia robusta* had the highest within-group similarity and mean abundance and were all sampled on north facing slopes. Group 2b is characterised by *F. verrucosa, Plumbago auriculata* and *J. capensis* which were sampled on the two west facing and south facing slopes.

Table 4.6: Summary of mean species abundance (on a scale of 0-30) of woody plants < 2 m and their percent contribution to within-group similarity in each of the groups identified by the cluster analysis. Average similarity is the mean Bray-Curtis similarity of plant composition of sites within a cluster and similarity values were based on untransformed data. UN=unpalatable, MP=moderately palatable and VP=Very palatable.

Clustered groups	Average within-group similarity	Contributing species	Life form	Mean species abundance	% contribution to within group similarity	Mean TRMI (±SD)
Group 1	33.50	*Aloe ferox (VP)* *Lycium cinereum (MP)* *Jatropha capensis (MP)*	Succulent tree Low shrub Low shrub	375.20 144.48 53.94	39.94 31.49 12.60	33.3 ± 5.7
Group 2a	41.79	*Grewia robusta (VP)* *Jatropha capensis (MP)* *Portulacaria afra (VP)*	Tall shrub Low shrub Succulent shrub	1858.62 827.99 1473.21	24.91 17.90 16.28	30.0 ± 6.4
Group 2b	31.98	*Flueggea verrucosa (VP)* *Plumbago auriculata (MP)* *Jatropha capensis (MP)*	Tall shrub Woody climber Low shrub	1202.68 1105.11 637.36	22.87 20.45 12.40	34.0 ± 3.4
Group 2c	32.84	*Jatropha capensis (MP)* *Euphorbia triangularis (MP)* *Lycium cinereum (MP)*	Low shrub Succulent tree Low shrub	1113.07 1495.68 796.48	21.71 16.65 14.94	27.1 ± 5.1
Group 3a	33.92	*Grewia occidentalis (VP)* *Allophylus decipiens (UP)* *Scutia myrtina (MP)*	Tall shrub Tall shrub Tall shrub	1952.08 1554.75 1446.92	21.66 16.80 12.42	37.1 ± 5.4
Group 3b	42.66	*Euphorbia grandidens (MP)* *Acalypha glabrata (VP)* *Grewia occidentalis (VP)*	Succulent tree Tall shrub Tall shrub	1777.40 903.48 786.93	24.29 19.99 12.60	41.8 ± 4.0

Group 2c is characterised by *J capensis, E. triangularis* and *Lycium cinereum*. *Jatropha capensis* had the highest within-group similarity and *E. triangularis* had the highest mean species abundance for this group with sites mainly sampled on ridge, east and north facing slopes. This group had the lowest mean TRMI value which is characteristic of drier sites. Group 3a is characterised by tall shrub which comprised of *G. occidentalis, A. decipiens* and *S. myrtina. Grewia occidentalis* had the highest within-group similarity and mean species abundance for this group with sites mainly sampled on south facing slopes. Group 3b mainly composed of valley and one south facing site is characterised by tall shrubs namely *Acalypha glabrata, Grewia occidentalis* and a succulent tree Euphorbia *grandidens* which had the highest within-group similarity and mean species abundance. Sites in group 3a & b had the highest relative soil moisture.

Discussion

The overall woody plant density of species of both size classes was similar in both Ntloko and the game farms, but with significantly higher density of both palatable and unpalatable species at higher moisture sites in Ntloko. Interestingly the density did not change with TRMI on the game farms while there was a strong significant positive relationship between TRMI and woody density at Ntloko. This suggests that factors affecting woody density actually are different between the two sites, although the relative abundance of palatable and unpalatable species is mostly unaffected. A notable exception is the high abundance of *P. afra* at drier (flat north facing) sites on the game farms whereas it has been mostly lost under similar conditions at Ntloko. This may be a result of resilience to browsing, with the exception of *P. afra*, which has been much reduced in abundance in Ntloko.

Although none of the variables significantly predicted woody density in the < 2m size class, TRMI and slope best explained the woody density in > 2 m size class thus showing the importance and influence of slope position on woody density and biomass. Slope position has been documented to be a key predictor of vegetation diversity, structure and composition (Venter et al.,1989; Milchunas & Lauenroth, 1993; Vetter et al., 2006). Venter et al. (1989) reported similar results where slope influenced grass species richness and diversity than land use in a study comparing two land use types in a savanna biome in KwaZulu Natal. Similarly, Milchunas & Laueronth (1993) found slope position best explains vegetation structure and composition in grazing lands across the globe. Similar findings were also reported by Irl et al (2015) when they found topographical variables including slope in predicting species diversity and endemism in high elevation island in La Palma in the Canary islands in the Atlantic ocean. Similarly, in this study, results showed high plant density in valleys and south facing slopes, which had high TRMI values. High soil moisture content in arid systems has been documented to only last a short while after rainfall and only retain soil moisture after high rainfall intensity (Grayson et al., 2006). This suggests that hydraulic conductivity in these areas decreases rapidly as the soil dries up after low rainfall leaving insufficient water supply especially in exposed dry areas, while the wetter areas are able to maintain enough moisture for vegetation growth.

The effects that TRMI and slope have on woody composition support the hypotheses that TRMI has a direct effect on woody density in the communal sites but also that the drier and generally more accessible sites have had their woody density reduced by goat browsing and other land use impacts. The lack of a correlation between TRMI and woody density at the game farms, and the much lower woody density at high TRMI on the game farms when compared to the communal sites is intriguing. This may be that game are better at utilising the dense bush while livestock tend to concentrate closer to the village; it may also reflect past efforts as reported by Mucina & Rutherford (2006) that game farms open up bush by mechanical means to facilitate livestock utilization, since the game farms were previously used for livestock farming.

The high woody density at Ntloko reflects a high density of smaller trees indicating differences in impact, but from a potential recovery point of view there was no shortage of individuals and species in Ntloko. Therefore, the main concern were the drier areas closer to the village where woody species (and especially *Portulacaria afra*) have been heavily depleted. This may be a result of high grazing pressure which changes the abundance and composition of vegetation especially in communal areas where they have a long history of grazing and fuelwood harvesting (Wiseman et al., 2004; Higgins et al.,2006).

Sites in Ntloko closer to the village (< 35 TRMI class) had relatively low vegetation density and low infiltration capacity. Such patterns have been identified as a result of unsustainable use of natural resources by the local people through fuelwood extraction, leaving areas quite close to their households clear of woody vegetation (Berry et al., 2005; Kaschula et al., 2005; Pote et al., 2006). The amount of harvesting decreases with distance because the desired species are used and removed from areas that are easily accessible. Species that are used for fuelwood were highly impacted as they are absent in sites closer to the village (TRMI < 35), while they are most dominant in inaccessible steep slopes and further away from the village. This suggests high levels of harvesting of useful species such as *Portulacaria afra*, *Schotia afra* and *Mystroxylon aethopicum*.

Portulacaria afra was very abundant at the game farms, but occurred at very low density in the drier sites at Ntloko. This is most likely an effect of browsing by goats as *P. afra* is quite a key species as it is highly palatable, but also plays an important ecological role as a nurse plant facilitating the establishment of other woody species. It is widely used to rehabilitate degraded thicket, though it needs to be protected from browsing and this may make such an option unfeasible in communal areas. Sites further away from the village (TRMI > 35) were densely vegetated and had a similar structure and composition to sites on the game farms. These sites resembled a proper forest and the pristine impenetrable thicket vegetation and from personal observation there was less human and livestock impacts.

The high density of *Euphorbia* species in the two land use types may be a result of the absence of megaherbivores such as elephant (*Loxodona africana*) and rhinoceros (*Diceros bicornis*) as these animals destroy Euphorbias at a high rate (Heilmann et al., 2006). There was a high percentage of species similarities between Ntloko and the game farms except for *E.gradidens* which is more common in Ntloko and largely in the < 2 m size class. *Euphorbia grandidens* has the lowest population numbers compared to other *Euphorbias* across the coastal and subcoastal belts in the Subtropical thicket (Cowling et al., 2010). Therefore, the higher density in Ntloko may be a result of historical impacts where the existing population of *E. gradidens* survived because they grew on steep rocky slopes that were inaccessible to the megaherbivores as they preferred browsing on gentle slopes (Johnson et al.,1999). It is also important to note that tree euphorbias are relatively short lived (200 – 300 years), cannot resprout after disturbance and produce plenty of seedlings (Midgley & Cowling, 1993) thus explaining the higher density in Ntloko which has had no effects of wild herbivores or disturbances in areas further from the village in a very long time.

Overall these results show that the woody vegetation in Ntloko has not been severely affected by fuelwood collection and grazing as expected, except in areas close to the village. It still maintains quite a similar vegetation structure and composition to the lightly used game farms. The outcome is uncommon in the Albany Thicket Biome considering the wide range of similar studies that produced higher diversity and composition in protected areas/commercial than in communal areas (Fabricius & Burger,1997; Evans et al., 1997; Birch et al., 1999; Fabricius et al., 2002) suggesting feasible conservation planning in communal areas.

CHAPTER 5 – CONCLUSIONS

The study found that the significant role that natural landscapes play in the livelihood of rural people in communal areas still exists. This was demonstrated by the nature-based beliefs that unfolded from the interviews. The ecosystem services are diverse and enjoyed by a large number of people in Ntloko, and vary in a gradient with distance from the village. The social values that people attach to landscapes needs to be quantified in an appropriate cultural method in order to fully understand the importance of cultural ecosystem services. Although, the respondents had a sense of appreciation for the thicket forest, the motivation behind was influenced by the dichotomy between "ancestral worship" and "religion". The thicket forest is no longer perceived as a central place for reverence to ancestral worship by *amaXhosa*, but also a place of peace and tranquillity (McAlister, 2012). The older generation displayed an act of appreciation to the forest and still consider it as a nurturing environment while the younger generation lacked any personal attachment. However, after the walks it was clear that the different areas, and the vegetation types evoked nostalgic moments from what they have been told and learnt from the elders.

This study assessed the nature of ecosystem services (biodiversity, direct use, cultural) in different parts of Ntloko. These ecosystem services were also observed in a spatially explicit manner and as expected, there was a gradient with distance from village and thicket density. Areas close to the village are easily accessible and used for grazing, wood and other plant collection and recreation by many people. A basket of direct use and cultural ecosystem services derived by a large number of people in contrast to the game farms (where the direct use and cultural/recreational benefits are potentially high but derived by a much smaller number of already better-off people). Only a few people accessed the ecosystem services in areas further from the village where the game farms had similar and high biodiversity and cultural ecosystem services. These areas were relatively wet with high TRMI values and had higher species richness, structure and woody composition and were perceived as providing higher levels of multiple ecosystem services. People who do not access these forest areas derive the value of knowing these areas are present, a term called "existence value" (Krutilla, 1967). These intact forests are also important for supporting ecosystem services such as carbon fixation and hydrology (Power, 2010)

Plant species richness and composition differed between Ntloko and the game farms but not as dramatically, as is commonly portrayed. However, as predicted the impact was largely localised near the village. Unlike the work by Fabricius & Burger (1997), there was no evidence that useful plants were less common in the communal area. Woody structure and composition was not very different between Ntloko and the game farms, with the impact again being most pronounced near the village. When looking at forage potential (abundance of palatable species) the main impact was that on *Portulacaria afra* which is significant as reported but otherwise not as dramatic as the work by Evans & Palmer (1997) shows. The results do not overlook the fact that the game farms could potentially have more species. A larger sampling unit could potentially have produced more species in the game farms than in Ntloko.

Implications of findings

There clearly is a spatial gradient in accessibility and this plays an important role. Easily accessible areas near settlements are more affected but the steep terrain and thick bush of the Great Fish River valley has resulted in fairly intact vegetation remaining over a large percent of the rural area (as seen on the maps and aerial photos) and provide more ecosystem services. Changes in resource use due to electrification and modernisation have resulted in less harvesting. Research on fuelwood use suggests it remains important but at reduced volumes taking into account the spatial location of the rural settlement (von Maltitz & Scholes 1995; Pote et al., 2006; Matsika et al., 2013). Research on cultural use (Cocks, 2006; Cocks et al., 2008) shows this remains important.

In summary, these rural areas provide a diverse basket of ecosystem services that are and remain important to the local people. There has been impact, which has been recognised by locals (McAlister thesis) but it is not everywhere. Interventions to ensure better resource management should take into account the different uses, importance and distribution of plant diversity. The effects of land use on the density of wooded species signifies the impacts that land use change has on vegetation patterns. The study supports the relative importance of understanding, implementing and applying management strategies in order to tackle degradation. Management objectives between communal and commercial areas are often different because of the intended goal. Communal farmers are governed by social, cultural and economic factors while commercial are farming is mostly directed by the economy. Sustainable use of resources is at the forefront in most conservation planning. This suggests the involvement of people in communal areas, as they also need to maintain and conserve resources for direct and cultural use. This entails viable harvesting of wood and the introduction of ecologically appropriate and socially feasible grazing management to ensure the continued provision of the ecosystem services people derive and value from their rural landscapes.

Local community's perception of nature and biodiversity is fast being acknowledged for conservation in South Africa. Studies done in rural communal areas on Xhosa people in the

Eastern Cape, South Africa focused on indigenous knowledge and their traditional lifestyles. Nevertheless, minimal focus has been placed on the importance of cultural knowledge in modern conditions of communal areas (Cocks & Wiersum, 2014). Such information is crucial in promoting a better understanding of indigenous knowledge towards conservation. The complex nature of values that people attach to natural landscapes needs to be well understood so that 'culturally sensitive' biological conservation can be identified and applied (Cocks & Wiersum, 2014). This approach needs to be adopted especially in South Africa which has high biodiversity levels and little understanding of the historical knowledge of local people's values and connection to natural landscapes. The similarities in vegetation patterns across the two land use types is indicative of landscapes that may have lost some of its biodiversity but the majority remains intact. A positive relationship between cultural practice and species diversity has been documented (Stepp et al. 2004; Loh & Harmon 2005; Maffi & Woodley 2010). These studies recognised the importance of protecting areas considered sacred by locals, which will lead to high biodiversity. Understanding the relationship between land use and biodiversity is essential in understanding the link people have with the environment. Proper management strategies applied to a land use type can have positive feedback on the projected output, however, the main objective may be detrimental in sustaining ecosystems and the ecosystem services derived from the land (Haines-Young, 2009). Historical land use could be responsible for similarities obtained from Ntloko and the game farms in terms of species richness.

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Appendix 1: *Table A1. Species list for the study area indicating for each species whether it was recorded in Ntloko and/or the game farms (where x = denotes < 1 % aerial cover, xx = 1 – 10 % and xxx = > 10 % aerial cover). Also indicated is whether a species is used as fuelwood, has forage value, is known to be a medicinal plant, and/or has any other uses. Data sources – SANBI for the list of species, families and life forms. Usefulness – Tony Dold (personal communication)*

SPECIES NAME	FAMILY	LIFE FORM	NTLOKO	GAME	FUEL	FORAGE	MEDICINAL	OTHER
Barleria irritans	ACANTHACEAE	Herb	x					
Barleria obtusa	ACANTHACEAE	low Shrub	xxx	xxx				
Blepharis capensis	ACANTHACEAE	Succulent Trees		x				
Chaetacanthus setiger	ACANTHACEAE	Low Shrub	x					
Crabbea hirsuta	ACANTHACEAE	Herb	x					
Ecbolium aristata	ACANTHACEAE	Herb	x					
Ecbolium flanaganii	ACANTHACEAE	Herb		x				
Hypoestes aristata	ACANTHACEAE	Herb	x	x				
Hypoestes forskaolii	ACANTHACEAE	Herb	xxx	xx				
Isoglossa ciliata	ACANTHACEAE	Herb	x	x				
Justicia capensis	ACANTHACEAE	Low shrub	x	x				
Ruellia cordata	ACANTHACEAE	low Shrub	x	x				
Thunbergii capensis	ACANTHACEAE	Herbaceous climber		x				
Acharia tragodes	ACHARIACEAE	Herbaceous climber		x				
Aizoon rigidum	AIZOACEAE	Herb	x	x				
Bergeranthus sp.	AIZOACEAE	Succulent Shrub		x				

SPECIES NAME	FAMILY	LIFE FORM	NTLOKO	GAME	FUEL	FORAGE	MEDICINAL	OTHER
Carpobrotus edulis	AIZOACEAE	Succulent Shrub	**x**					
Ruschia orientalis	AIZOACEAE	Succulent Shrub		**x**				
Trichodiadema sp.	AIZOACEAE	Succulent shrub	**x**	**xx**				*edible
Achyranthes aspera	AMARANTHACEAE	Herb	**x**	**x**				
Amaranthus hybridus	AMARANTHACEAE	Herb	**x**					*edible
Chenopodium carinatum	AMARANTHACEAE	Herb	**x**					
Chenopodium murale	AMARANTHACEAE	Herb	**x**					
Agapanthus praecox	AMARYLLIDACEAE	Geophytic Herb	**x**	**x**			*	
Haemanthus albiflos	AMARYLLIDACEAE	Geophytic herb		**x**			*	
Tulbaghia sp.	AMARYLLIDACEAE	Herb		**x**			*	
Worm bulb	AMARYLLIDACEAE	Geophytic Herb		**x**				
Harpephyllum caffrum	ANACARDIACEAE	Small Tree	**x**	**x**				
Ozoroa mucronata	ANACARDIACEAE	Small Tree	**x**		*			
Searsia longispina	ANACARDIACEAE	Tall shrubs		**x**	*			
Searsia lucida	ANACARDIACEAE	Tall shrubs		**x**	*			
Searsia pallens	ANACARDIACEAE	Tall shrubs		**x**	*			
Searsia refracta	ANACARDIACEAE	Tall shrub	**xx**		*			
Centella asiatica	APIACEAE	Herb	**x**					
Acokanthera oppositifolia	APOCYNACEAE	Tall shrub	**x**					
Carissa bispinosa	APOCYNACEAE	Tall shrub	**xx**	**x**				*edible
Ceropegia carnosa	APOCYNACEAE	Herbaceous succulent	**x**					

SPECIES NAME	FAMILY	LIFE FORM	NTLOKO	GAME	FUEL	FORAGE	MEDICINAL	OTHER
Cynanchum ellipticum	APOCYNACEAE	Herbaceous climber	**x**	**x**				
Cynanchum natalitium	APOCYNACEAE	Herbaceous climber	**x**	**x**				
Fockea capensis	APOCYNACEAE	Herbaceous climber	**x**	**xxx**				
Fockea edulis	APOCYNACEAE	Herbaceous climber	**x**	**xx**				
Pachypodium succulentum	APOCYNACEAE	Succulent	**x**	**x**				
Raphionacme zeyheri	APOCYNACEAE	Geophytic Herb	**x**	**x**				
Sarcostemma viminale	APOCYNACEAE	Woody succulent Climber	**x**	**x**			*	
Secamone alpini	APOCYNACEAE	Woody climber	**x**	**x**				
Secamone filiformis	APOCYNACEAE	Woody climber	**xx**	**xx**				
Secamone gerrardii	APOCYNACEAE	Woody climber	**x**					
Cussonia spicata	ARALIACEAE	Small Tree	**xx**					
Astephanus triflorus	ASCLEPIADACEAE	Herbaceous climber	**x**	**x**				
Raphionacme flanaganii	ASCLEPIADACEAE	Geophytic Herb	**x**	**x**				
Asparagus aethiopicus	ASPARAGACEAE	Woody climbers		**x**				
Asparagus africanus	ASPARAGACEAE	Woody climber	**x**	**x**				
Asparagus asparagoides	ASPARAGACEAE	Woody climber	**x**	**x**				
Asparagus crassicladus	ASPARAGACEAE	Low shrub	**x**	**xx**				
Asparagus densiflorus	ASPARAGACEAE	Dwarf shrub	**x**	**x**			*	
Asparagus falcatus	ASPARAGACEAE	Woody climber	**x**	**xx**				

SPECIES NAME	FAMILY	LIFE FORM	NTLOKO	GAME	FUEL	FORAGE	MEDICINAL	OTHER
Asparagus mucronatus	ASPARAGACEAE	Low Shrub	x	x				
Asparagus multiflorus	ASPARAGACEAE	Woody climber	x					
Asparagus setaceus	ASPARAGACEAE	Tall shrub	xx	x				
Asparagus striatus	ASPARAGACEAE	Low Shrub	x	x				
Asparagus suaveolens	ASPARAGACEAE	Low shrub	xx	x				
Asparagus subulatus	ASPARAGACEAE	Low Shrub	x	x				
Chlorophytum comosum	ASPARAGACEAE	Geophytic Herb	x	x				
Chlorophytum cooperi	ASPARAGACEAE	Geophytic Herb	x					
Eriospermum breviceps	ASPARAGACEAE	Geophytic Herb	x					
Ledebouria cooperi	ASPARAGACEAE	Geophytic Herb	x	xx				
Ornithogalum sp.	ASPARAGACEAE	Geophytic Herb	x	xx				
Sansevieria hyacinthoides	ASPARAGACEAE	Geophytic Herb	x	x			*	
Aloe ciliaris	ASPHODELACEAE	Succulent Shrub		x			*	
Aloe ferox	ASPHODELACEAE	Succulent Tree	x	x			*	
Aloe pluridens	ASPHODELACEAE	Tall shrub		x				
Aloe speciosa	ASPHODELACEAE	succulent tree		x				
Aloe striata	ASPHODELACEAE	Succulent Shrub		x				
Bulbine favosa	ASPHODELACEAE	Geophytic Herb	x					
Bulbine latifolia	ASPHODELACEAE	Geophytic herb		x			*	
Gasteria bicolor	ASPHODELACEAE	Succulent Herb	x				*	
Haworthia cymbiformis	ASPHODELACEAE	Succulent Herb	x				*	
Arctotis arctoides	ASTERACEAE	Herb	x					

SPECIES NAME	FAMILY	LIFE FORM	NTLOKO	GAME	FUEL	FORAGE	MEDICINAL	OTHER
Bidens pilosa	ASTERACEAE	Herb	**x**	**x**				
Brachylaena discolor	ASTERACEAE	Small Tree		**x**				
Brachylaena elliptica	ASTERACEAE	Small tree	**x**	**x**				
Brachylaena ilicifolia	ASTERACEAE	Small Tree		**x**			*	
Conyza bonariensis	ASTERACEAE	Herb	**x**					
Cotula australis	ASTERACEAE	Herb	**x**	**x**				
Cotula sericea	ASTERACEAE	Herb	**x**					
Curio radicans	ASTERACEAE	Succulent herb	**x**	**xxx**				
Felicia echinata	ASTERACEAE	Low Shrub	**x**	**x**				
Felicia filifolia	ASTERACEAE	Low Shrub		**x**				
Felicia muricata	ASTERACEAE	Low Shrub	**x**					
Gazania krebsiana	ASTERACEAE	Herb	**x**	**xx**				
Gerbera ambigua	ASTERACEAE	Herb	**x**					
Haplocarpha lyrata	ASTERACEAE	Herb	**x**					
Helichrysum cymosum	ASTERACEAE	Low Shrub		**x**				
Helichrysum genistifolia	ASTERACEAE	Low shrub	**x**	**x**				
Helichrysum sp.	ASTERACEAE	Herb	**x**	**x**				
Helichrysum zeyheri	ASTERACEAE	Low Shrub	**x**					
Hypochaeris radicata	ASTERACEAE	Herb	**x**	**x**				
Ifloga glomerata	ASTERACEAE	Herb	**x**					
Lactuca capensis	ASTERACEAE	Herb	**x**	**x**				
Nolletia tenuifolia	ASTERACEAE	Low Shrub	**x**					

SPECIES NAME	FAMILY	LIFE FORM	NTLOKO	GAME	FUEL	FORAGE	MEDICINAL	OTHER
Othonna carnosa	ASTERACEAE	Succulent shrub		x				
Phymaspermum parvifolium	ASTERACEAE	Low Shrub	x	x				
Pteronia incana	ASTERACEAE	Low shrub	xxx	x	*			
Senecio angulatus	ASTERACEAE	Herbaceous succulent climber	x	x				
Senecio articulatus	ASTERACEAE	Succulent Shrub		x				
Senecio cylindricus	ASTERACEAE	succulent shrub		x				
Senecio deltoideus	ASTERACEAE	Herb	x					
Senecio inaequidens	ASTERACEAE	Low Shrub	x					
Senecio linifolius	ASTERACEAE	Low Shrub		x				
Senecio pinifolius	ASTERACEAE	Low shrub	x	x				
Senecio quinqueloba	ASTERACEAE	Woody climber	x					
Senecio sp.	ASTERACEAE		x	x				
Senecio tamoides	ASTERACEAE	Herbaceous climber		x				
Taraxacum officinale	ASTERACEAE	Herb	x	x				
Tarchonanthus camphor	ASTERACEAE	Tall shrub	x	x				
Tithonia diversifolia	ASTERACEAE	Herb	x	x				
Vernonia mespilifolia	ASTERACEAE	Herb	x	x			*	
Rhigozum obovatum	BIGNONIACEAE	Low Shrub		x				
Cynoglossum hispidum	BORAGINACEAE	Herb	x					
Ehretia rigida	BORAGINACEAE	Tall shrub	xx	xx	*			
Lepidium africanum	BRASSICACEAE	Herbs	x					

SPECIES NAME	FAMILY	LIFE FORM	NTLOKO	GAME	FUEL	FORAGE	MEDICINAL	OTHER
Lepidium capense	BRASSICACEAE	Herb	x					
Buddleja saligna	BUDDLEJACEAE	Tall shrub		x				
Commiphora harveyi	BURSERACEAE	Small tree	x	x				
Opuntia aurantiaca	CACTACEAE	Tall shrub	x	x				
Opuntia ficus indica	CACTACEAE	Tall succulent shrub	x	x				*edible
Cyphia heterophylla	CAMPANULACEAE	Herbaceous climber		x				
Cyphia salvatica	CAMPANULACEAE	Herbaceous climber	x	x				
Lightfootia nodosa	CAMPANULACEAE	Low Shrub	x					
Lobelia flaccida	CAMPANULACEAE	Herb	x					
Boscia oleoides	CAPPARACEAE	Small tree	x		*			
Capparis sepiaria	CAPPARACEAE	Woody climber	xxx	xx			*	
Maerua racemulosa	CAPPARACEAE	Small Tree	x	x				
Cassine caribea	CELASTRACEAE	Tall shrub		x	*			
Cassine crocea	CELASTRACEAE	Tall shrub	x	x	*			
Cassine peragua	CELASTRACEAE	Tall shrub		x	*			
Elaeodendron croceum	CELASTRACEAE	Small tree	x	x	*			
Gymnosporia buxifolia	CELASTRACEAE	Tall shrub	x		*			
Gymnosporia heterophylla	CELASTRACEAE	Tall shrub	xx	x	*			
Gymnosporia linearis	CELASTRACEAE	Tall shrub		x	*			
Gymnosporia nemorosa	CELASTRACEAE	Tall shrub	xx	xx	*			

SPECIES NAME	FAMILY	LIFE FORM	NTLOKO	GAME	FUEL	FORAGE	MEDICINAL	OTHER
Maytenus capitata	CELASTRACEAE	Tall shrub	**x**		*			
Mystroxylona ethopicum	CELASTRACEAE	Tall shrub	**x**	**x**				*cultural
Pleurostylia capensis	CELASTRACEAE	Tall tree	**x**				*	
Putterlickia pyracantha	CELASTRACEAE	Tall shrub	**x**	**x**	*			
Atriplex nummularia	CHENOPODIACEAE	Low Shrub		**x**				
Atriplex semibaccata	CHENOPODIACEAE	Herb	**x**	**x**				
Chenopodium mucronatum	CHENOPODIACEAE	Herb		**x**				
Exomis microphylla	CHENOPODIACEAE	Low Shrub	**x**	**x**				
Commelina africana	COMMELINACEAE	Small tree	**xxx**	**xx**				
Commelina benghalensis	COMMELINACEAE	Herb	**x**	**x**				
Cyanotis speciosa	COMMELINACEAE	Herb	**xx**	**xx**				
Berkheya carduoides	COMPOSITAE	Herb	**x**					
Convolvulus arvensis	CONVOLVULACEAE	Herb	**x**					
Ipomea cairica	CONVOLVULACEAE	Herbaceous climber	**x**	**x**				
Adromischus sphenophyllus	CRASSULACEAE	Succulent Shrub		**x**				
Anacampseros arachnoides	CRASSULACEAE	Succulent herb	**x**					
Cotyledon orbiculata	CRASSULACEAE	Succulent Shrub	**x**				*	
Cotyledon velutina	CRASSULACEAE	Succulent shrub	**x**	**x**			*	
Crassula arborescens	CRASSULACEAE	Succulent shrub	**x**	**x**				
Crassula capitella	CRASSULACEAE	Succulent Shrub	**x**	**x**				

SPECIES NAME	FAMILY	LIFE FORM	NTLOKO	GAME	FUEL	FORAGE	MEDICINAL	OTHER
Crassula cultrata	CRASSULACEAE	Succulent Shrub		**x**				
Crassula ericoides	CRASSULACEAE	Succulent Shrub		**x**				
Crassula expansa	CRASSULACEAE	Succulent herb	**x**	**x**				
Crassula lactea	CRASSULACEAE	Succulent herb		**x**				
Crassula mesembryanthemoides	CRASSULACEAE	Succulent Shrub	**x**	**xx**				
Crassula multicava	CRASSULACEAE	Succulent herb	**x**					
Crassula muscosa	CRASSULACEAE	Succulent herb	**x**	**x**				
Crassula nemorosa	CRASSULACEAE	Succulent Shrub	**x**					
Crassula orbicularis	CRASSULACEAE	Succulent herb		**x**			*	
Crassula pellucida	CRASSULACEAE	Succulent herb	**x**					
Crassula perfoliata	CRASSULACEAE	Succulent shrub	**x**	**x**				
Crassula tetragona	CRASSULACEAE	Succulent Shrub		**x**				
Kalanchoe rotundifolia	CRASSULACEAE	Succulent Shrub	**x**	**x**				
Kedrostis foetidissima	CUCURBITACEAE	Herbaceous climber	**x**	**x**			*	
Kedrostis nana	CUCURBITACEAE	Herbaceous climber	**x**				*	
Zehneria parviflora	CUCURBITACEAE	Herbaceous climber	**x**					
Zehneria scabra	CUCURBITACEAE	Herbaceous climber	**x**					
Cyperus albostriatus	CYPERACEAE	Graminoid	**x**	**x**				
Cyperus rubicundus	CYPERACEAE	Graminoid	**x**	**x**				
Cyperus sp.	CYPERACEAE	Graminoid	**x**	**x**				

SPECIES NAME	FAMILY	LIFE FORM	NTLOKO	GAME	FUEL	FORAGE	MEDICINAL	OTHER
Ficinia repens	CYPERACEAE	Graminoid	**x**			*		
Dioscorea cotinifolia	DIOSCOREACEAE	Woody climber	**x**				*	
Dioscorea sylvatica	DIOSCOREACEAE	Woody climber	**x**					
Dracena aletriformis	DRACAENACEAE	Megaherb	**x**	**x**				
Diospyros macrophylla	EBENACEAE	Low Shrub		**x**				
Diospyros scabrida	EBENACEAE	Tall shrub	**x**					
Euclea natalensis	EBENACEAE	Tall shrub		**x**	*			
Euclea schimperi	EBENACEAE	tall shrub	**x**		*			
Euclea undulata	EBENACEAE	Tall shrub	**x**		*			
Acalypha glabrata	EUPHORBIACEAE	Tall shrub	**x**	**x**				
Croton rivularis	EUPHORBIACEAE	Tall shrub	**xx**	**xx**				
Euphorbia fimbriata	EUPHORBIACEAE	Succulent shrub	**x**	**x**				
Euphorbia gorgonis	EUPHORBIACEAE	Succulent shrub	**x**				*	
Euphorbia grandidens	EUPHORBIACEAE	Succulent Tree	**xx**					*cultural
Euphorbia kraussiana	EUPHORBIACEAE	Succulent shrub	**x**	**x**				
Euphorbia mauritanica	EUPHORBIACEAE	Small tree		**x**				
Euphorbia rhombifolia	EUPHORBIACEAE	Succulent Shrub		**x**				
Euphorbia sp.	EUPHORBIACEAE			**x**				
Euphorbia triangularis	EUPHORBIACEAE	Succulent Tree	**xxx**					*cultural
Jatropha capensis	EUPHORBIACEAE	Low shrub	**xx**	**x**				
Suregada africana	EUPHORBIACEAE	Tall shrub	**xx**	**x**				
Acacia karroo	FABACEAE	Small Trees	**x**		*			

SPECIES NAME	FAMILY	LIFE FORM	NTLOKO	GAME	FUEL	FORAGE	MEDICINAL	OTHER
Crotalaria capensis	FABACEAE	Tall shrub	x					
Crotalaria obscurum	FABACEAE	Tall shrub	x					
Dolichos hastaeformis	FABACEAE	Herb	x					
Galenia pubescens	FABACEAE	Low shrub	x	x				
Indigofera denudata	FABACEAE	Low Shrub		x				
Indigofera heterophylla	FABACEAE	Low shrub	x					
Indigofera pungens	FABACEAE	Low shrub	x					
Indigofera sessilifolia	FABACEAE	Low Shrub		x				
Indigofera trifoliata	FABACEAE	Low shrub	x					
Schotia afra	FABACEAE	Small trees	xx	x			*	
Schotia latifolia	FABACEAE	Small trees	x	x	*			
Pelargonium alchemilloides	GERANIACEAE	Low shrub	x					
Pelargonium odoratissimum	GERANIACEAE	Low shrub	x	x				
Pelargonium peltatum	GERANIACEAE	Woody succulent Climbers	x					*edible
Pelargonium reniforme	GERANIACEAE	Low shrub	x				*	
Pelargonium zonale	GERANIACEAE	Woody succulent Climbers	x	x				
Drimia anomala	HYACINTHACEAE	Geophytic Herb	x				*	
Drimia elata	HYACINTHACEAE	Geophytic Herb	x				*	
Ornithogalum dubium	HYACINTHACEAE	Geophytic herb		x				
Ornithogalum junceum	HYACINTHACEAE	Geophytic herb		x				

SPECIES NAME	FAMILY	LIFE FORM	NTLOKO	GAME	FUEL	FORAGE	MEDICINAL	OTHER
Ornithogalum tenuifolium	HYACINTHACEAE	Geophytic Herb	x					
Hypoxis hemerocallidea	HYPOXIDACEAE	Geophytic herb		x			*	
Hypoxis sp.	HYPOXIDACEAE	Geophytic herb		x				
Pollichia campestris	ILLECEBRACEAE	Herb	x	x				
Aristea abyssinica	IRIDACEAE	Geophytic Herb	x					
Aristea anceps	IRIDACEAE	Geophytic Herb	x					
Dietes iridioides	IRIDACEAE	Geophytic Herb	x	x				
Freesia laxa	IRIDACEAE	Geophytic Herb	x	xx				
Moraea pallida	IRIDACEAE	Geophytic Herb	x					
Sutera polyantha	IRIDACEAE	Herb	x					
Tritonia securigera	IRIDACEAE	Geophytic herb	x	x				
Leonotis ocymifolia	LAMIACEAE	Low shrub	x				*	
Leucas capensis	LAMIACEAE	Low Shrub	xx	x				
Plectranthus madagascariensis	LAMIACEAE	Succulent herb	x	x				
Plectranthus spicatus	LAMIACEAE	Succulent herb	x	xx				
Plectranthus strigosus	LAMIACEAE	Succulent herb	x	x				
Plectranthus tetensis	LAMIACEAE	Succulent herb	x	x				
Salvia repens	LAMIACEAE	Herbs	xx					
Stachys aethiopica	LAMIACEAE	Herb	x					
Teucrium africanum	LAMIACEAE	Low shrub	x				*	
Calpurnia aurea	LEGUMINOSAE	Tall shrub	x	x			*	

SPECIES NAME	FAMILY	LIFE FORM	NTLOKO	GAME	FUEL	FORAGE	MEDICINAL	OTHER
Dolichos hastaeformis	LEGUMINOSAE	Herb	x					
Lotononis laxa	LEGUMINOSAE	herb		x				
Medicago laciniata	LEGUMINOSAE	Herb	x	x				
Rhynchosia caribaea	LEGUMINOSAE	Herbaceous climber	x	x				
Tephrosia capensis	LEGUMINOSAE	Low Shrub		x				
Abutilon sonneratianum	MALVACEAE	Herbs	xx	xx				
Dombeya tiliacea	MALVACEAE	Small tree	x	x				
Grewia occidentalis	MALVACEAE	Tall shrub	xxx	x	*			
Grewia robusta	MALVACEAE	Tall shrubs	x	xxx				
Hermannia althaeoides	MALVACEAE	Low Shrub	x	x			*	
Hermannia saccifera	MALVACEAE	Low shrub	x	x				
Hibiscus aethiopicus	MALVACEAE	Herb	x	x				
Hibiscus calyphyllus	MALVACEAE	Tall shrub	x	x				
Hibiscus pusillus	MALVACEAE	Herbs	x					
Hibiscus trionum	MALVACEAE	Herb	x	x				
Sida rhombifolia	MALVACEAE	Low shrub	x					
Cissampelos capensis	MENISPERMACEAE	Woody climbers		x			*	
Aptenia cordifolia	MESEMBRYANTHEMACEAE	Succulent shrub	x					
Delosperma calcinia	MESEMBRYANTHEMACEAE	Succulent Shrub	xxx	xxx				
Delosperma ecklonis	MESEMBRYANTHEMACEAE	Succulent Shrub	x					
Lampranthus haworthii	MESEMBRYANTHEMACEAE	Succulent Shrub		x				

SPECIES NAME	FAMILY	LIFE FORM	NTLOKO	GAME	FUEL	FORAGE	MEDICINAL	OTHER
Lampranthus multiradiatus	MESEMBRYANTHEMACEAE	Succulent Shrub		**x**				
Mestoklema elatum	MESEMBRYANTHEMACEAE	Succulent shrub	**x**					
Spalmanthus plenifolius	MESEMBRYANTHEMACEAE	Succulent Shrub		**x**				
Limeum aethopicum	MOLLUGINACEAE	Low Shrubs	**x**					
Ficus natalensis	MORACEAE	Small tree	**x**	**x**				
Eugenia zeyheri	MYRTACEAE	Small trees		**x**				
Ochna arborea	OCHNACEAE	Small trees		**x**				
Ochna serrulata	OCHNACEAE	Small tree	**x**					
Chionanthus foveolatus	OLEACEAE	Tall tree	**x**	**xx**				
Jasminum angulare	OLEACEAE	Woody climber	**x**					
Jasminum multipartitum	OLEACEAE	Woody climber	**x**	**x**				
Jasminum sp.	OLEACEAE	Woody climber	**x**	**xxx**				
Olea africana	OLEACEAE	Tall shrub	**x**	**x**			*	*cultural
Olea capensis	OLEACEAE	Tall shrub		**x**				
Brownleea coerulea	ORCHIDACEAE	Geophytic Herb		**x**				
Mystacidium capense	ORCHIDACEAE	Epiphytic herb	**x**	**x**				
Polystachia sp.	ORCHIDACEAE	Geophytic herb		**x**			*	
Cycnium racemosum	OROBANCHACEAE	Herb		**x**				
Harveya speciosa	OROBANCHACEAE	Parasitic herb	**x**					
Oxalis bifurca	OXALIDACEAE	Geophytic Herb	**x**	**x**				
Oxalis corniculata	OXALIDACEAE	Geophytic Herb	**x**	**x**				*edible

SPECIES NAME	FAMILY	LIFE FORM	NTLOKO	GAME	FUEL	FORAGE	MEDICINAL	OTHER
Oxalis smithiana	OXALIDACEAE	Geophytic Herb	**x**	**x**				*edible
Clutia daphnoides	PERACEAE	Low shrub	**x**				*	
Flueggea verrucosa	PHYLLANTHACEAE	Tall shrubs	**xx**	**x**				
Phyllanthus incurvus	PHYLLANTHACEAE	Low Shrub	**x**					
Plumbago auriculata	PLUMBAGINACEAE	Woody climber	**xx**	**xxx**				*cultural
Aristida congesta	POACEAE	Graminoid	**x**	**x**				
Cymbopogon plurinodis	POACEAE	Graminoid		**x**				thatch
Cynodon dactylon	POACEAE	Graminoid	**xx**	**x**				
Cynodon incompletus	POACEAE	Graminoid	**x**	**x**				
Digitaria eriantha	POACEAE	Graminoid		**x**				
Digitaria monodactyla	POACEAE	Graminoid	**x**			*		
Ehrharta calycina	POACEAE	Graminoid	**x**					
Ehrharta erecta	POACEAE	Graminoid	**x**	**x**				
Enneapogon scaber	POACEAE	Graminoid	**x**	**x**				
Enneapogon scoparius	POACEAE	Graminoid		**x**				
Eragrostis capensis	POACEAE	Graminoid	**x**			*		
Eragrostis ciliaris	POACEAE	Graminoid		**x**				
Eragrostis curvula	POACEAE	Graminoid	**x**			*		
Eragrostis obtusa	POACEAE	Graminoid	**xx**			*		
Eustachys paspaloides	POACEAE	Graminoid		**x**				
Helictotrichon turgidulum	POACEAE	Graminoid	**x**	**x**				
Melica decumbens	POACEAE	Graminoid	**x**	**x**				

SPECIES NAME	FAMILY	LIFE FORM	NTLOKO	GAME	FUEL	FORAGE	MEDICINAL	OTHER
Melinis repens	POACEAE	Graminoid	x			*		
Merxmuellera stricta	POACEAE	Graminoid		x				
Oplismenus hirtellus	POACEAE	Graminoid	x	x				
Panicum aequinerve	POACEAE	Graminoid	x			*		
Panicum deustum	POACEAE	Graminoid	x	xx				
Panicum maximum	POACEAE	Graminoid	xxx	x		*		
Sporobolus africanus	POACEAE	Graminoid	x	x		*		
Sporobolus fimbriatus	POACEAE	Graminoid	x	x		*		
Sporobolus nitens	POACEAE	Graminoid	x	x		*		
Stenotaphrum secundatum	POACEAE	Graminoid	x					
Stipa dregeana	POACEAE	Graminoid	x			*		
Polygala virgata	POLYGALACEAE	Low shrub	x					
Polypodium polypodioides	POLYPODIACEAE	Geophytic Herb	x	x				
Anacampseros telephiastrum	PORTULACACEAE	Succulent herb		x				
Portulaca oleracea	PORTULACACEAE	Succulent herb	x	x				*
Portulacaria afra	PORTULACACEAE	Succulent Shrub	x	x			*	
Ptaeroxylon obliquum	PTAEROXYLACEAE	Small trees	xx	xx	*		*	*cultural
Cheilanthes hirta	PTERIDACEAE	Geophytic Herb	x	x				
Cheilanthes viridis	PTERIDACEAE	Geophytic Herb	x	x				
Scutia myrtina	RHAMNACEAE	Tall shrub	xxx	x				*edible
Pyracantha angustifolia	ROSACEAE	Low shrub	x					

SPECIES NAME	FAMILY	LIFE FORM	NTLOKO	GAME	FUEL	FORAGE	MEDICINAL	OTHER
Anthospermum paniculatum	RUBIACEAE	Low shrub	**x**	**x**				
Canthium inerme	RUBIACEAE	Tall shrub		**x**				
Coddia rudis	RUBIACEAE	Tall shrub	**x**	**x**				
Pavetta lanceolata	RUBIACEAE	Tall shrub	**x**					
Richardia brasiliensis	RUBIACEAE	Herb	**x**					
Clausena anisata	RUTACEAE	Small tree	**x**	**x**			*	
Teclea natalensis	RUTACEAE	Small tree	**x**					
Vepris lanceolata	RUTACEAE	Small tree		**x**				*sticks
Vepris reflexa	RUTACEAE	Small tree	**x**					
Zanthoxylum capense	RUTACEAE	Small tree	**x**	**x**			*	
Dovyalis rhamnoides	SALICACEAE	Small tree	**x**	**x**				
Dovyalis rotundifolia	SALICACEAE	Small tree		**x**				
Scolopia flanaganii	SALICACEAE	Small tree	**x**	**xx**				
Scolopia mundii	SALICACEAE	Tall tree	**x**		*			
Scolopia zeyheri	SALICACEAE	Tall shrub		**x**				
Trimeria trinervis	SALICACEAE	Small tree	**x**					
Azima tetracantha	SALVADORACEAE	Tall shrub	**xx**	**x**			*	
Osyridicarpos schrimperianus	SANTALACEAE	Woody climber	**x**					
Viscum rotundifolium	SANTALACEAE	Semiparasitic epiphytic shrub	**x**	**x**				
Allophylus decipiens	SAPINDACEAE	Tall shrub	**xx**	**x**				
Hippobromus pauciflorus	SAPINDACEAE	Tall Shrub	**x**				*	

SPECIES NAME	FAMILY	LIFE FORM	NTLOKO	GAME	FUEL	FORAGE	MEDICINAL	OTHER
Pappea capensis	SAPINDACEAE	Small tree	**xx**	**x**	*			*edible
Sideroxylon inerme	SAPOTACEAE	Small tree	**x**	**xx**				
Anastrabe integerrima	SCROPHULARIACEAE	Small tree	**x**	**x**				
Chaenostoma campanulatum	SCROPHULARIACEAE	Herb	**x**	**x**				
Chaenostoma glanduliferum	SCROPHULARIACEAE	Herb	**x**	**x**				
Selago coroymbosa	SCROPHULARIACEAE	Low shrub	**x**					
Selago corymbosa	SCROPHULARIACEAE	Low shrub	**x**	**x**				
Selago saxatilis	SCROPHULARIACEAE	Low Shrub		**x**				
Sutera microphylla	SCROPHULARIACEAE	Herb		**x**				
Walafrida geniculata	SCROPHULARIACEAE	Low Shrub	**x**	**x**				
Datura stramonium	SOLANACEAE	Herb	**x**				*	
Lycium cinereum	SOLANACEAE	Low shrub	**xx**					
Solanum hermannii	SOLANACEAE	Low Shrub		**x**				
Solanum retroflexum	SOLANACEAE	Herb	**x**				*	
Solanum rigescens	SOLANACEAE	Low shrub	**x**	**x**				
Solanum tomentosum	SOLANACEAE	Low shrub	**x**					
Strelitzia reginae	STRELITZIACEAE	Geophytic herb		**x**				
Gnidia capitata	THYMELAEACEAE	Low Shrub		**x**			*	
Chaetacme aristata	ULMACEAE	Tall shrub	**xx**	**x**				
Urtica dioica	URTICACEAE	Herb	**x**					*edible

SPECIES NAME	FAMILY	LIFE FORM	NTLOKO	GAME	FUEL	FORAGE	MEDICINAL	OTHER
Lantana rugosa	VERBENACEAE	Low shrub	x	x				
Priva meyeri	VERBENACEAE	Herb	x	x				
Viscum obscurum	VISCACEAE	Semiparasitic epiphytic shrub	x					
Cyphostemma cirrhosum	VITACEAE	Herbaceous climber		x				
Cyphostemma quinatum	VITACEAE	Woody succulent climber	x					
Rhoicissus tomentosa	VITACEAE	Woody climbers		x			*	
Rhoicissus digitata	VITACEAE	Woody climber	x				*	
Rhoicissus tridentata	VITACEAE	Woody climber	x	x			*	
Aloe tenuior	XANTHORRHOEACEA	Succulent shrub	x				*	
Bulbine frutescens	XANTHORRHOEACEA	Succulent shrub	x	x				
Bulbine narcissifolia	XANTHORRHOEACEA	Geophytic Herb	x					

Appendix 2: *Species density for > and < 2m height in Ntloko and the game farms.*

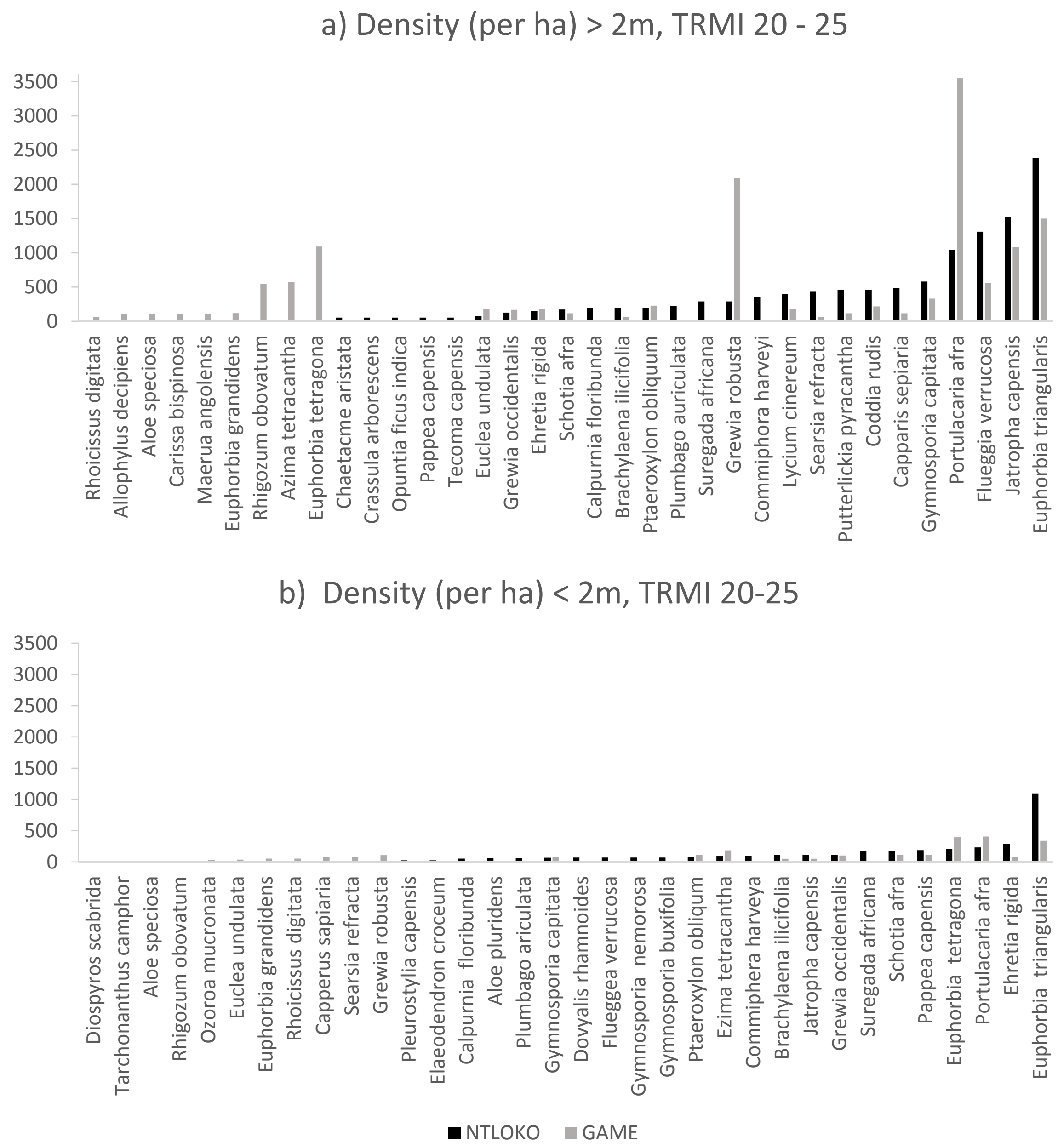


Figure 4.12. A comparison of woody species density between Ntloko and the game farms within the TRMI 20-25 size class. a) Density of species >2 m and b) density of species < 2m. Grey bars show sites on game farms and black bars show the communal site.

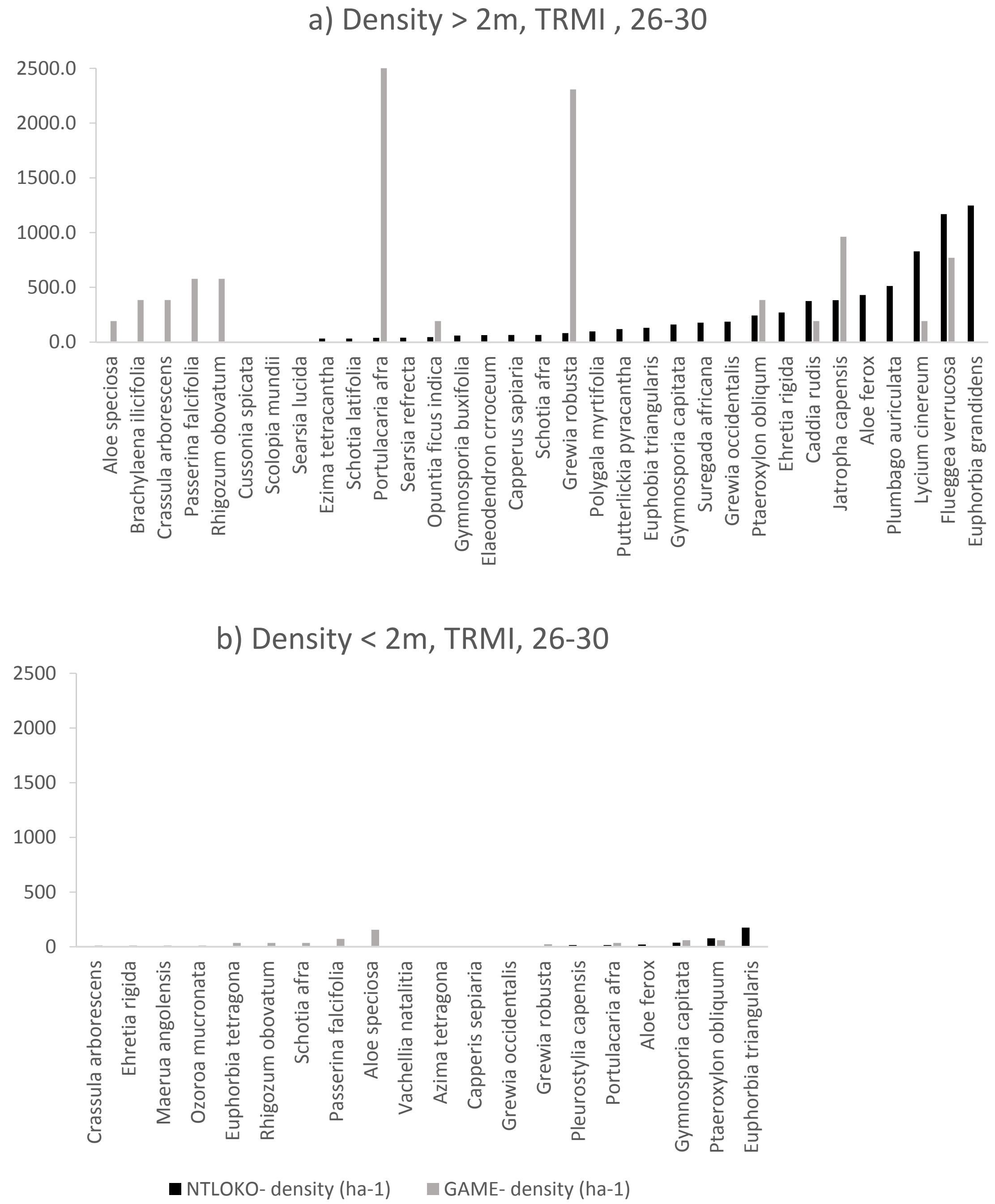


Figure 4.13. A comparison of woody species density between Ntloko and the game farms within the TRMI 26-30 size class. a) Density of species >2 m and b) density of species < 2m. Grey bars show sites on game farms and black bars show the communal site.

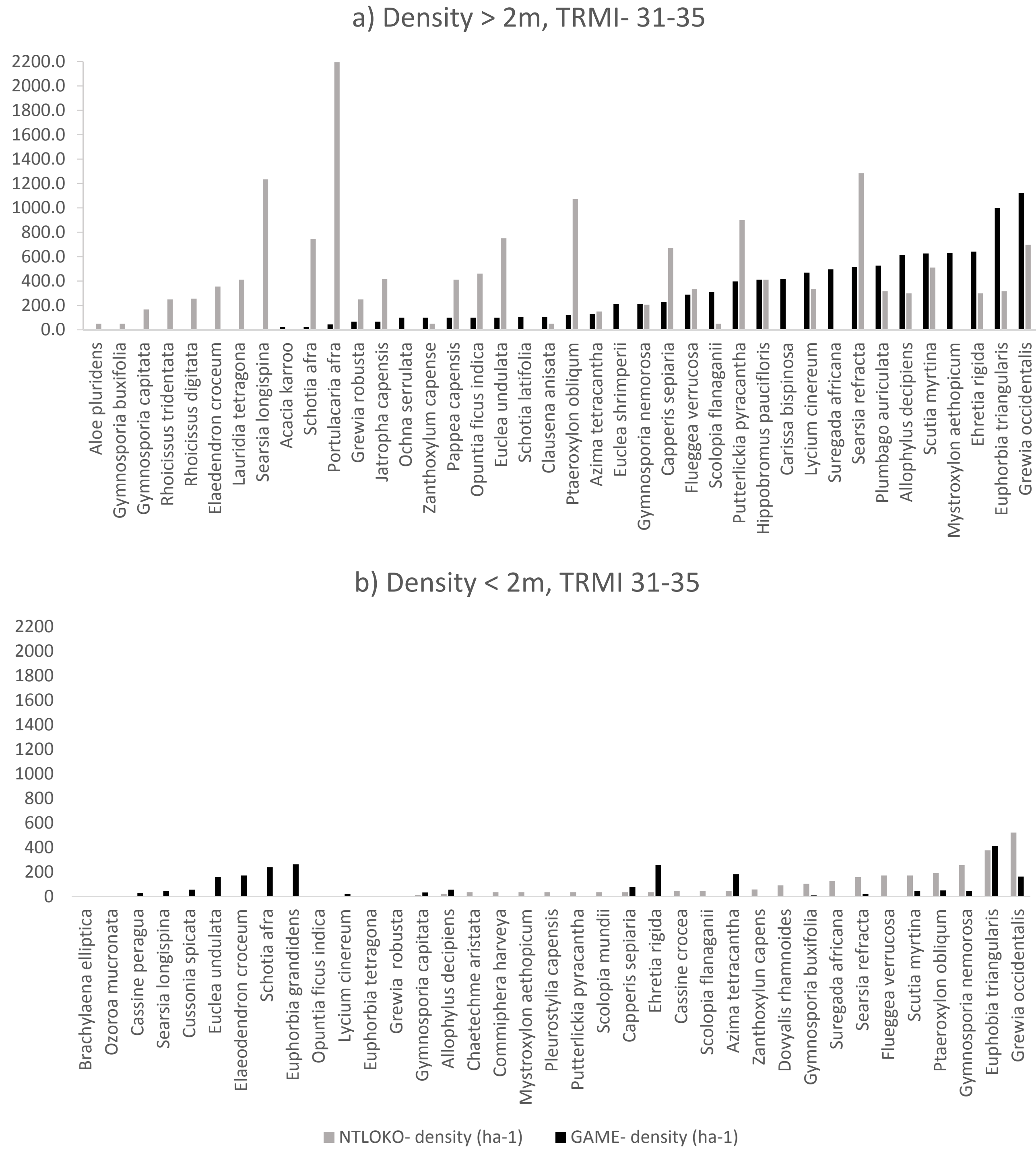
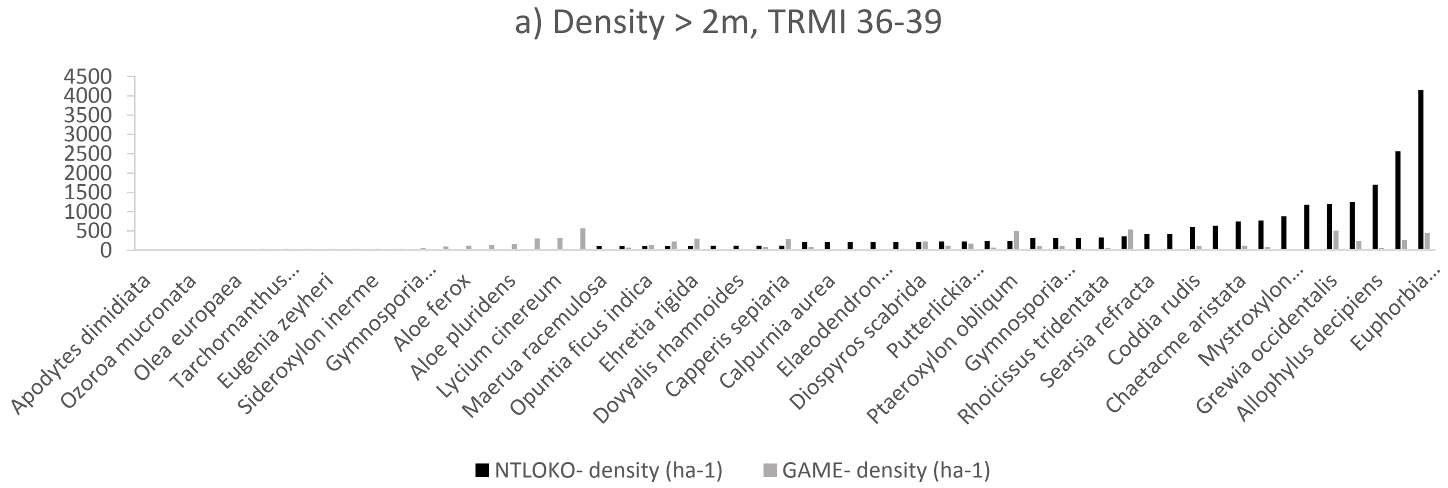
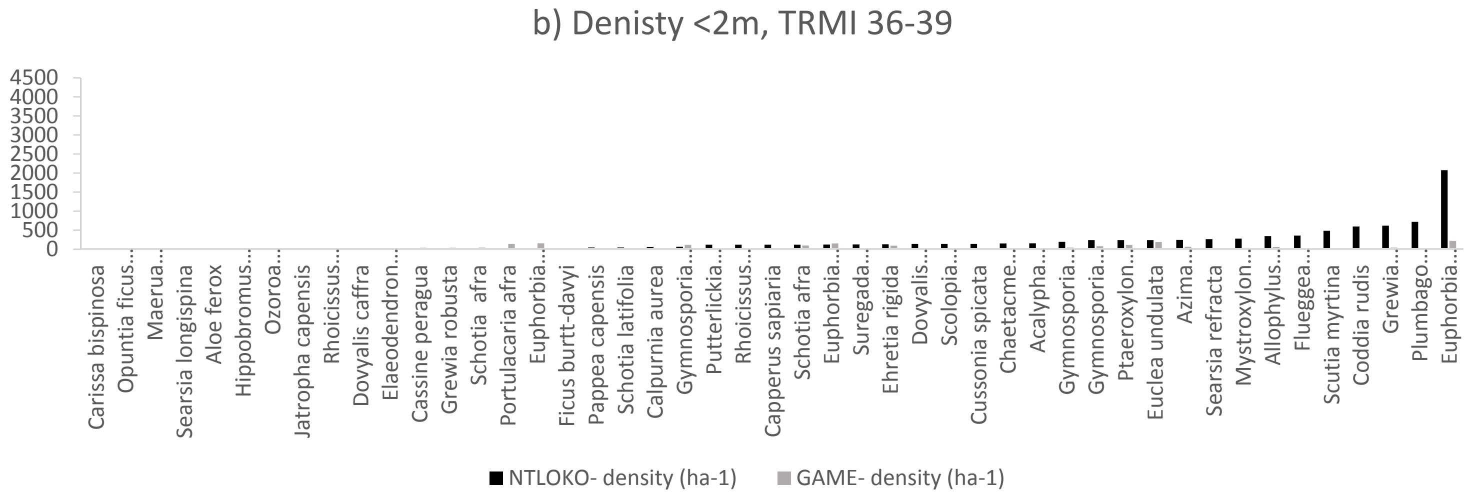


Figure 4.14. A comparison of woody species density between Ntloko and the game farms within the TRMI 31-35 size class. a) Density of species >2 m and b) density of species < 2m. Grey bars show sites on game farms and black bars show the communal site.



a) Density > 2m, TRMI 36-39
NTLOKO- density (ha-1)
GAME- density (ha-1)



b) Denisty <2m, TRMI 36-39
NTLOKO- density (ha-1)
GAME- density (ha-1)

Figure 4.15. A comparison of woody species density between Ntloko and the game farms within the TRMI 36-39 size class. a) Density of species >2 m and b) density of species < 2m. Grey bars show sites on game farms and black bars show the communal site.

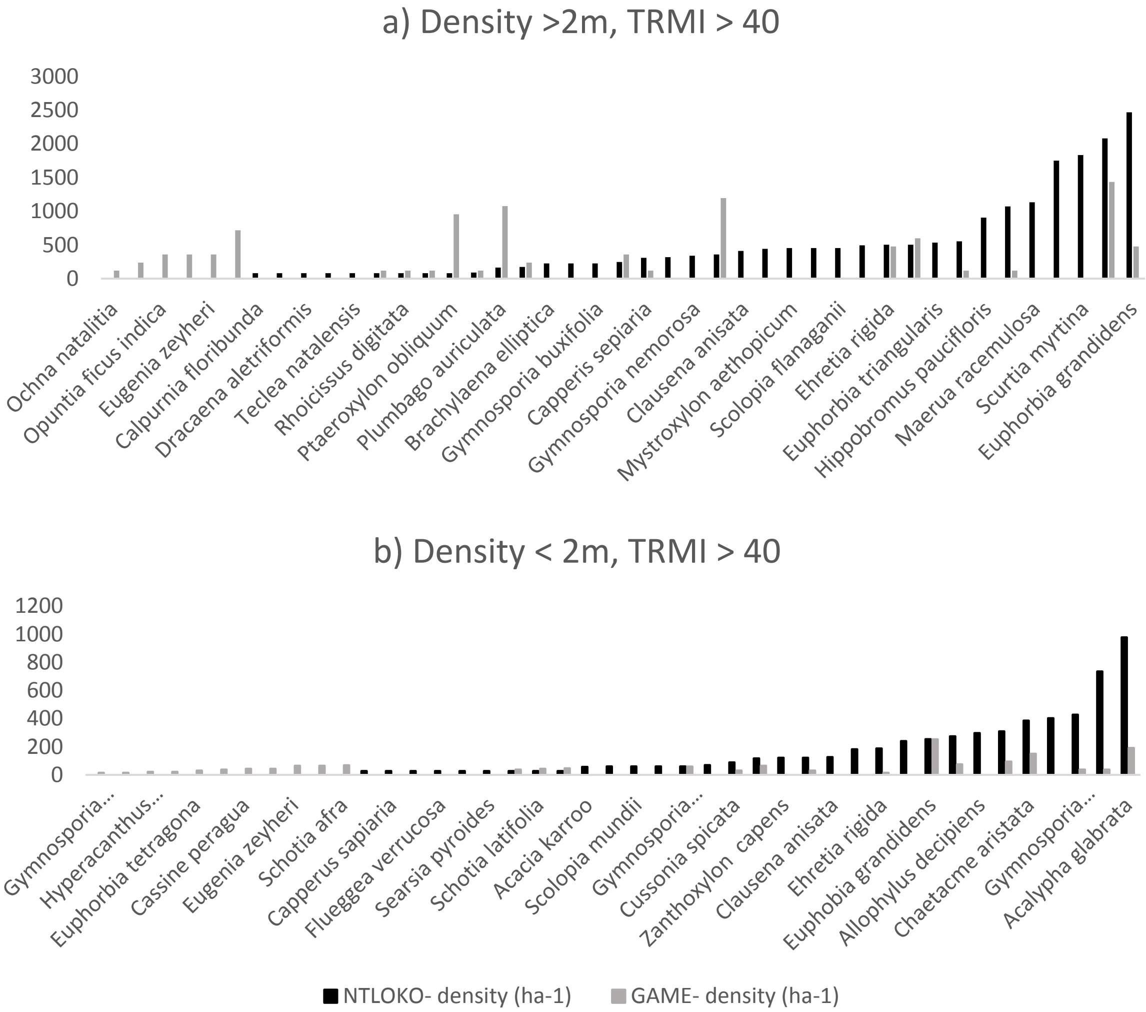


Figure 4.16. A comparison of woody species density between Ntloko and the game farms within the TRMI >40 size class. a) Density of species >2 m and b) density of species < 2m. Grey bars show sites on game farms and black bars show the communal site.