A VEGETATION SURVEY AND MAPPING OF THE WOODBUSH GRANITE GRASSLAND IN THE LIMPOPO PROVINCE, SOUTH AFRICA

BY

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[redacted]

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DECLARATION

I, Mapula Rose Matjie, declare that **'A VEGETATION SURVEY AND MAPPING OF THE WOODBUSH GRANITE GRASSLAND IN THE LIMPOPO PROVINCE, SOUTH AFRICA'** is my own work, and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete references.

This dissertation, submitted for the degree of Master of Science in Botany, in the Faculty of Science and Agriculture of the University of Limpopo, represents original research conducted by the author. I have not previously, in its entirety, or in part submitted it at any other university.

MAPULA ROSE MATJIE

10-October-2018

Signature **Date**

DEDICATION

I dedicate this dissertation to my family. I express my gratitude to my family for their undying love and support throughout the time I have spent at University.

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ABSTRACT

The Woodbush Granite Grassland (WGG) is the most threatened vegetation type in Limpopo Province of South Africa. However, it has a high conservation value, because few examples of this vegetation type remain in southern Africa. Unfortunately, a large part of it is not formally conserved, making this the vegetation type most urgently in need of conservation.

The study aimed at mapping transformation of the WGG, identifying species of conservation importance, and providing a management plan required for maintenance of the WGG. The objectives of the study included compiling a transformation map for the WGG, which also involved describing the remaining patches of the WGG that are in a natural or near-natural state. It also provides information on species of conservation importance, medicinal plants and threats to the WGG.

On the four main study sites (Iron Crown Grassland, Haenertsburg Grassland, Ebenezer Dam Nature Reserve Grassland, and Ebenezer Dam Perimeter Grassland), quadratic plots were randomly set with a size of 25 x 25 m, and subplots of 1 x 1 m. Vegetation mapping was done during summer and winter. At each plot data was collected on all plant species occurring within the quadrat. A cover score was assigned to each plant species. A modified Braun-Blanquet data collection sheet was employed to obtain baseline data. For transformation mapping GeoTerra Image (GTI), land cover data were extracted for the WGG, using the modelled boundary as a mask, with 5 categories of transformation defined.

Of the surveyed sites, the Ebenezer Dam Nature Reserve Grassland has the highest number of species, while the Haenertsburg Grassland contained the most endemic species of conservation importance. Rare species such as the *Aloe zebrina*, which does not occur in any formally protected area, and medicinal plants such as *Athrixia phylicoides,* occur on the WGG. All sites have importance with regard to WGG conservation. Identified threats include the spread of alien invasive plants, uncontrolled collection of medicinal plants, urban development, and poorly timed anthropogenic fire.

The WGG underwent transformation to other land classes. Grassland clearing for plantations and cultivation were the main causal factors behind the observed WGG losses, with a total of 55.25% transformed. Transformation by afforestation is considered irreversible.

It is concluded that the WGG is of conservation importance, and that some of it has been transformed to exotic timber plantations. The grassland is under various threats; therefore it is recommended that: (1) The proposed management plan provided in this study be adopted, (2) further research on the WGG be done on medicinal plants, (3) phytosociological and floristic studies be conducted and, (4) the effects of fire and alien invasive plant species on the grassland be investigated.

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ACRONYMS

DWS	Department of Water and Sanitation
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
GIS	Geographical Information System
GTI	GeoTerra Image
GPS	Global Positioning System
IDP	Integrated Development Plan
LEDET	Limpopo Department of Economic Development, Environment and Tourism
LEMA	Limpopo Environmental Management Act 7 of 2003
m	Metres
mm	Millimetres
MAP	Mean Annual Precipitation
NEMBA	National Environmental Management Biodiversity Act 10 of 2004
NEMA	National Environmental Management Act 107 of 1998
NVFFA	National Veld and Forest Fire Act 101 of 1998
RSA	Republic of South Africa
S	Section
Ss	Subsection
SANBI	South African National Biodiversity Institute
WfW	Working for Water
WGG	Woodbush Granite Grassland

CHAPTER 1

INTRODUCTION AND LITERATURE REVIEW

1.1 GENERAL INTRODUCTION

1.1.1 South African grassland biome

The grassland biome of South Africa (known locally as grassveld) is situated mainly in the central, high lying regions of South Africa (O'Connor and Bredenkamp, 1997). It is one of seven biomes that make up the South African landscape. Being centrally located, it shares boundaries with the Savanna, Thicket, Nama Karoo and Forest biomes (Figure 1.1). The largest portion of its boundary is shared with the Savanna Biome. Grasslands are a major component of the natural vegetation, with about 40% of the earth covered in natural grassland (Reyers e*t al.*, 2005).

The grassland biome of South Africa harbours a rich species, community and ecosystem diversity. It hosts half of the South African endemic mammal species (Reyers and Tosh, 2003). The grassland biome is resource rich, providing a wide range of ecosystem services that favour human settlement in this biome (Reyers *et al.,* 2005). These services include water and nutrient cycling, soil stabilisation, energy supply, provision of food through current agricultural activities, and forage for livestock (Dzerefos *et al.,* 2016). Despite (and often because of) their value, grasslands across the world are one of the biomes most impacted on by human activities (Millennium Ecosystem Assessment, 2005a).

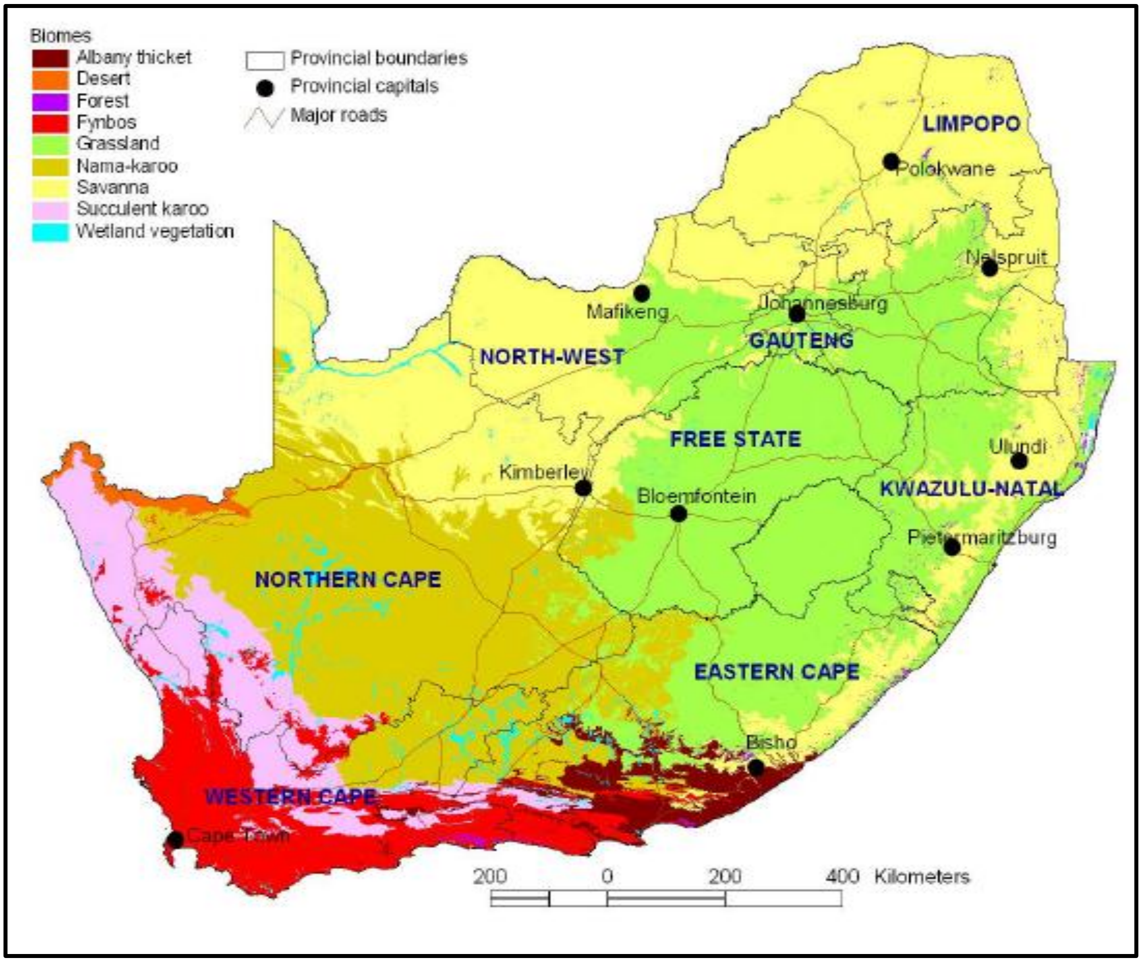


Figure 1.1 Biomes of South Africa in relation to the provincial boundaries (Mucina and Rutherford, 2006).

1.2 PROBLEM STATEMENT

Grassland transformation averages about 60% across South Africa, but in the Limpopo Province it is estimated to be almost 90% in the Woodbush Granite Grassland (Niemandt and Greve, 2015). This is the highest for any grassland area in the country. Afforestation in the Woodbush area has concentrated on the grassland area, leaving this ecosystem fragmented. Transformation by afforestation is considered irreversible (Mucina and Rutherford, 2006).

According to Hoffman (1997), there is clear evidence of structural and compositional changes of grasslands in southern Africa. The Woodbush Granite Grassland (WGG) has been identified as the most threatened vegetation type in Limpopo Province. This is because it has high conservation value, and few examples of this vegetation type (the WGG) remain in southern Africa, making this the vegetation type in most urgent need of conservation (Mucina and Rutherford, 2006).

1.3 MOTIVATION FOR THIS STUDY

The grassland biome of South Africa has been identified as critically endangered, and therefore being one of the biomes most in need of conservation attention (Reyers *et al*., 2005). The Haenertsburg Grassland is one of the last remaining patches of WGG in the Limpopo Province. It is estimated that 661 plant species (36 are considered threatened; Dzerefos *et al.*, 2016), 237 birds (8 threatened), 62 mammals (19 threatened), 38 reptiles (7 threatened), 11 amphibians (1 threatened), and an unknown number of invertebrate species (4 threatened) occur in the WGG (Grosel, 2016). Mucina and Rutherford (2006) listed the WGG as a critically endangered vegetation type and described it as totally irreplaceable.

The plight of the WGG has been recognised at national level, with it being listed as a critically endangered threatened ecosystem in December 2011 (National Gazette, 2011). This listing has implications in terms of triggering environmental impact assessment procedures in terms of the National Environmental Management Act (Act 107/1998). A preliminary assessment of the national spatial database for this vegetation type obtained from South African National Biodiversity Institute (SANBI) indicates that it contains errors, both with regard to the omission of existing grassland patches, and the incorrect identification of various transformed areas (Desmet *et al.,* 2013).

1.4 LITERATURE REVIEW

1.4.1 Ecosystem services and goods of Grassland Biome

Grasslands are among the ecosystems with the highest species richness in the world (Wilson*,* 2012), and provide a wide range of ecosystem services. Grasslands play an important role within the global carbon cycle, as 90% of their biomass is belowground, where accumulation rates are high, and decomposition of organic material slow

(Gibson, 2009). Ecosystem services and goods (Figure 1.2) are the benefits humans derive from ecosystems, and could be direct (e.g. food supply) or indirect (e.g. climate regulation) in the form of water regulation and supply, carbon storage, regulating biogeochemical cycles, environmental fluxes and biodiversity, reducing soil erosion and lowering nutrient loss, species diversity enhancement, recreation and support for livelihood (Reyers *et al.,* 2005). Further values of grassland include wildlife habitat, intrinsic ecosystem properties of structure, function and composition, and ecosystem services such as watershed protection, grazing, and scenery (Uys, 2006).

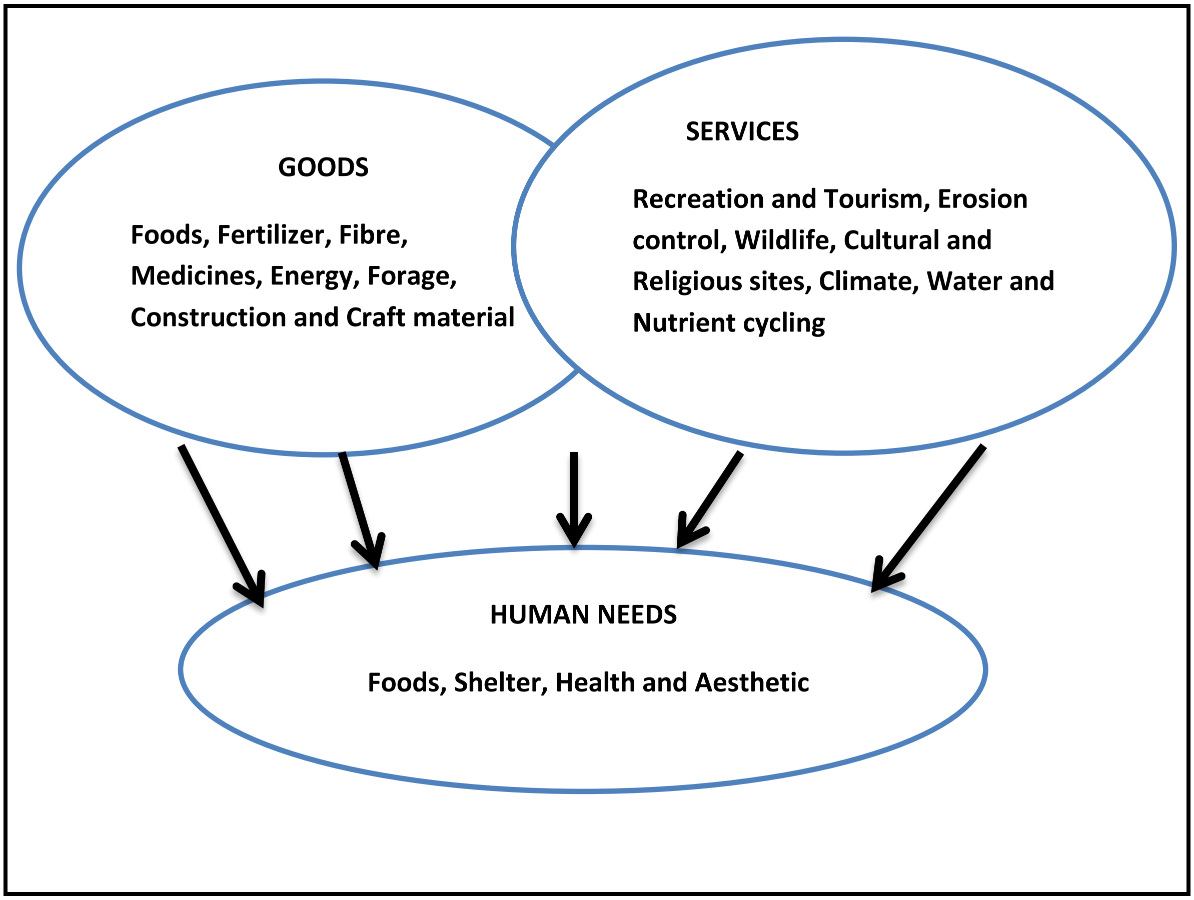


Figure 1.2 Goods and services provided by grasslands (White *et al*., 2000).

1.4.1.1 Water regulation and supply

One of the most valuable services provided by grasslands is that of water regulation. Grasslands are areas of importance to freshwater biodiversity, with 44 river ecosystems identified within the grasslands of South Africa. Six of these ecosystems are marginal to the grasslands, but the rest rely on the grassland biome for the maintenance of their biodiversity (Nel *et al*., 2004). South Africa's major mountain catchments are situated within the grassland biome (Reyers *et al*., 2005). For this reason a substantial amount of runoff for South Africa is generated within the biome, while many rivers (such as the Orange, Mzimvubu, Vaal, Mfolozi and Tugela) also flowing through grasslands (Reyers *et al.,* 2005). The grassland service of water regulation can be defined as the influence ecosystems have on the timing and magnitude of water runoff, flooding, and aquifer recharge, particularly in terms of the water storage potential of the ecosystem (Hönigová *et al*., 2012).

Grasslands play a crucial role in the hydrological cycle by reducing immediate runoff, and by storing runoff as groundwater, or in wetlands contributing to the service of water supply (Kotze and Morris, 2001). Grasslands are the great "collectors" of rain water as they hold the water as groundwater or in wetlands and release it slowly throughout the year (including during or before the dry season). This water is essential for crop and animal production in and adjacent to catchments (Kotze and Morris, 2001). The Southern Montane Grasslands of Mpumalanga, for example, provide a year-round water supply essential for driving of the power generators of the Highveld power stations, which produce 70% of South Africa's electricity requirements. Without this water, the coal fields of Mpumalanga would not be able to generate this power (South African Renewable Energy Database, 2003).

1.4.1.2 Carbon storage

Another specific characteristic that enhances the importance of grassland is its greater capacity to store carbon compared to arid land. Grasslands sequester carbon as soil organic matter, stored mostly belowground, reducing the amount of carbon in the atmosphere that contributes to climate change (Ponce-Hernandez *et al*., 2004). The mean annual primary production of grasslands is similar to that of forests and, given that more than two thirds of the annual grassland biomass production is allocated to belowground structures, the accumulation of deep soil organic matter layers makes an important contribution to carbon sequestration in most grassland ecosystems (Korner, 2002).

1.4.1.3 Regulating biogeochemical cycles

Grasslands perform an important function in decreasing the amount of carbon gas in the atmosphere, and in the solution of biochemical problems globally. Grasslands have considerable potential to absorb carbon present in the atmosphere and thus contribute to the reduction of the greenhouse effect. Thus grasslands can act as a significant carbon sink with the implementation of improved management (Conant *et al.,* 2001). The world's grasslands play an important role in regulation of the carbon cycle by storing 15% of global organic carbon (Nagendra, 2001).

1.4.1.4 Reduced soil erosion and lowered nutrient loss

Productive soil is a precious resource, and dense stands of properly managed grassland plants are quite effective in minimizing soil erosion, caused by wind and water. When soil is lost to erosion, nutrients associated with the topsoil, as well as fertilizer, which may have been applied, is lost as well (Mongwe, 2004).

Soil nutrient holding capacity also diminishes with erosion, which is likely to result in the need to apply additional fertilizer to restore or maintain nutrient balance. There is a strong relation between grasses and soils; dead residues generate humus, which promotes the formation of different soil structures. The fibrous root system of grasses directly advances the formation of soil structures (Carlier, 2005).

1.4.1.5 Species diversity and enhancement

Grasslands are rich in biodiversity, and provide habitat for birds, plants, reptiles, and butterflies amongst many others. Globally they house many important species and include 15% of the world's Centres of Plant Endemism, 11% of Endemic Bird Areas and 29% of eco-regions with outstanding biological distinctiveness (White *et al.,* 2000).

In southern Africa, high levels of plant diversity, especially of the forb layer, are characteristic of high rainfall grasslands (Hoare, 2003), including the coastal grasslands on infertile dune sands of the Indian Ocean coastal belt (Zaloumis and Bond, 2011). Family diversity of forbs in South African grasslands is particularly outstanding, with Uys (2006) reporting a mean of 26 plant families per 0.1 ha plot. This is two to three times richer than for similar sized plots from the Cape fynbos, famous for its high diversity (Uys, 2006). There are more than 100 endemic plant species in the Mpumalanga grasslands alone (Duthie, 1992).

1.4.1.6 Recreation

Grasslands offer opportunities for hunting, bird watching, hiking, and other outdoor recreational activities. In our direct human environment, they contribute to "human aesthetics" and relaxation (Reyers *et al*., 2005). Tourism activities include hiking and mountain climbing in especially the Drakensberg Mountains, which attract 18% of domestic visitors to the area. Bird watching is one of the major eco-tourism attractions in grasslands, and several birding "hotspots" are found throughout the biome in South Africa (Kruger and Crowson, 2004).

1.4.1.7 Support for livelihood

Medicinal plants, herbs and grasses used for supporting livelihood can be collected on grasslands (Kotze and Morris, 2001). Grasslands have been a traditional source of medicinal plants and other medicinal resources. Pharmaceutical use of medicinal and aromatic plants is connected with the content of active substances such as oils or tannins (Hönigová *et al.*, 2012). In South Africa, approximately 30% of all plants sold as traditional medicine grow in grasslands (Williams *et al.,* 2000). Plant species commonly used for medicinal purposes in KwaZulu-Natal are found within the Grassland Biome. These include: *Alepedia amatymbica, Mervilla natalensis* and *Eucomis autumnalis* (Kotze and Morris, 2001).

Approximately 80% of honey production in the KwaZulu-Natal, Mpumalanga, Eastern Cape and Gauteng provinces was derived in 2005 from grasslands. The total value of honey production attributed to grasslands was estimated at R3.5 million in 2005 (Reyers *et al.,* 2005).

Beef cattle farming make up approximately 41% of livestock activity and 16% of goat farming in South African provinces with grasslands. Sheep farming makes up the remaining 42% of livestock activity, of which 67% could be attributed to wool and 33% to meat (National Department of Agriculture, 2005).

1.4.2 Diversity and significance of vegetation in southern Africa

The physiographic diversity that is characteristic of southern Africa culminates in an exceptional concentration of phytogeographic units and high floristic diversity, with endemism at all taxonomic levels (Cowling and Hilton-Taylor, 1994). With 21 137 indigenous species (Arnold and De Wet, 1993) in 1 930 genera and 226 families, the flora of southern Africa is among the richest in the world compared to other areas of similar size, including those in the tropical areas of Africa (Cowling and Hilton-Taylor, 1994).

1.4.3 Conservation of grasslands

Conservation refers to the sustainable utilization of natural resources, which is possible if it is based on sound management practices. It could be described as the utilization and conservation of natural veld without adversely affecting the vegetation (Brown, 1997). To be able to utilize and conserve, one must be familiar with what is available, and how it would react to different management applications (Neke and Du Plessis, 2004). The term conservation has in the past been used broadly to include protection, use, maintenance, restoration and enhancement of the natural environment. The aim of biodiversity conservation in South Africa is to maintain and strengthen existing arrangements to conserve South Africa's indigenous biodiversity, both inside and outside of protected areas (Department of Environmental Affairs and Tourism, 2006).

Grasslands are facing a major conservation crisis (Hoekstra *et al.,* 2005), with this terrestrial ecosystem displaying the largest degree of habitat loss worldwide (Scholes and Biggs, 2005). According to Driver *et al.* (2012), the grassland biome is one of South Africa’s most threatened biomes with just 2.2% formally conserved, and more than 60% already irreversibly transformed, making it one of the top priorities for conservation action. The growing national understating of the importance of grassland habitat has resulted in the increased need for conserving grasslands (Hoekstra *et al.,* 2005).

Already in 2003, Cowling *et al.* (2003) stated that three of the nine southern African biomes had more than 10% of their area conserved (Desert, Fynbos and Savanna), whilst the Forest biome was approaching 9%. However, the Nama-Karoo, Grassland and Succulent Karoo biomes had less than 3% of their area conserved. The greater part of these biomes falls largely within South Africa (Cowling *et al.,* 2003).

In South Africa a number of grassland conservation programmes have been implemented to ensure that management of biodiversity contributes to sustainable development. Birdlife South Africa is one of these programmes, which is dedicated to working on conserving grasslands together with government departments, landowners and local communities, with the vision to protect and conserve the endemic and threatened bird species that occur in grasslands, mostly through education (Birdlife International, 2000).

1.4.4 Policy and strategy on conservation in South Africa

South Africa has a substantial body of law to conserve biodiversity, especially within protected areas. However, past approaches to biodiversity conservation have not given adequate attention to the conservation of landscapes and ecosystems outside protected areas. It has furthermore neglected to consider lesser known groups such as invertebrates, fungi and micro-organisms (Department of Environmental Affairs and Tourism, 2004).

1.4.4.1 Environmental law enforcement / Legal Protection

Section 24(b), subsections (i), (ii) and (iii) of the constitution of the Republic of South Africa, 1996 provides that the environment “must be protected for the benefit of present and future generations through reasonable legislative and measures that prevent pollution and ecological degradation, promote conservation, and secure ecological sustainable development and use of natural resources while promoting justifiable economic and social development”. One of the acts promulgated to give effect to section 24(b) is the National Environmental Management: Biodiversity Act, which provides for the management of biodiversity within the framework of the NEMA (Act 107 of 1998). It also provides for the sustainable use of indigenous biological resources and the fair equitable sharing of benefits arising from bio-prospecting that involve indigenous biological resources.

1.4.4.2 National Environmental Management Act 107 of 1998

The National Environmental Management Act (NEMA) is generally viewed as an attempt by government to comply with the requirement of section 24(b) of the Constitution. The purpose of NEMA is to provide for co-operative environmental governance by establishing principles for decision making on matters affecting the environment. This Act is also important for the protection of indigenous vegetation in the sense that the Act produced comprehensive principles that deal with matters affecting the environment. Sections 2(3), 2(4) (a) (i) and (h) of NEMA indicate that development should be socially, environmentally and economically sustainable, and also that sustainable development requires the consideration of all these factors to ensure that the disturbance of ecosystem and loss of biological diversity are avoided, or, where they cannot be altogether avoided, are at least minimized and remedied. These principles must be considered and taken into account by government in its decision-making.

Environmental management must be integrated, acknowledging that all elements of the environment are linked and interrelated. It must take into account the effects of decision-making on all aspects of the environment and people by pursuing the selection of the best practicable environmental option. Community empowerment must be promoted through environmental education, the raising of environmental awareness, the sharing of knowledge and experience and other appropriate means. Section 28(12) gives any member of the public the right to apply to court for a *mandamus* to compel the relevant government official to take the steps envisaged in section 28 to enforce preventative or remedial steps to be taken by those causing damage to the environment.

1.4.4.3 National Environmental Management: Biodiversity Act 10 of 2004

The National Environmental Management: Biodiversity Act (NEMBA) has its aim and purpose to provide for the management of biodiversity within the framework of NEMA. It also provides for the sustainable use of indigenous biological resources and the fair and equitable sharing of benefits arising from bio-prospecting that involve indigenous biological resources. NEMBA's Chapter 4 deals with the protection of threatened or protected ecosystems. According to section 52(1) (b), the MEC for environmental affairs in a Province may, in the Provincial Gazette publish a list of ecosystems in the province that are threatened and that need serious protection. Section 54 of the NEMBA indicates that there is a need for organs of state, including a municipality to prepare an environmental implementation or management plan in terms of Chapter 3 of NEMA, in which they should consider the protection of biodiversity as a matter of necessity.

1.4.4.4 National Veld and Forest Fire Act 101 of 1998

The aim of the National Veld and Forest Fire Act is to prevent and combat veld, forest and mountain fires throughout the country and thereby reduce the damage and loss caused by fires to life and fixed property, infrastructure improvements, and prohibit damage to plants through fire fighting. This also includes the protection of grassland.

1.4.4.5 Limpopo Environmental Management Act 7 of 2003

The Limpopo Environmental Management Act (LEMA) has its purpose of consolidating and amending the Environmental Management Legislation of the Province as well as the legislation assigned to the Province. The Act addresses issues such as protected areas, wild and alien plants and the legal protection of all indigenous plants. The Limpopo Environmental Management Act 7 of 2003 (LEMA) has a purpose of consolidating and amending the environmental management legislation of the province. Legislation assigned to the province makes provision for the protection of fauna and flora, which are mostly found in the grasslands. Furthermore, the Provincial Ordinance and Municipal by-laws repealed by the Limpopo Environmental Management Act 7 of 2003 stated that the picking of protected plants without a permit is prohibited. The Conservation of Agricultural Resources Act 43 of 1983 contains provisions concerning the control of weeds and invader plants. An amendment of the act has increased the number of invader plants to 198 and places a duty on landowners to remove and control invasive plants.

1.4.5 Grassland management strategies

Grassland management refers to the manipulation of natural vegetation in order to achieve pre-determined goals in this biome. The interaction between plants and animals that live in grasslands should also be taken into consideration when planning management strategies. Knowledge on grasslands functioning is important in any management decision to ensure long-term environmental health (Barlow, 1998). For example, proper grazing management maintains wildlife habitat, conserves the soil, and preserves the natural beauty of the grassland landscape (Dorrough, 1996).

Change is, however, part of every ecosystem, with fire, grazing and drought examples of various forces that cause such change. Grassland vegetation changes over time in response to these forces, and thus shifts in management strategies are constantly required to assist in maintaining a sustainable ecosystem (Neke and Du Plessis, 2004). Assessment and monitoring are required to understand the impact of changes in ecosystems (Barlow, 1998), as this information will be used in management strategies and practices. The health condition of plant communities, natural values and sensitivities, existence of rare species, and value of the grassland are examples of information that can be used in management strategies (Low and Rebelo, 1998).

1.4.6 Grassland transformation and threats

Although grasslands provide essential ecosystem services for economic development, this biome also supports a large human population whose resource demands have serious environmental implications, threatening its biodiversity (Reyers and Tosh, 2003). The threats in the South African grassland biome have arisen from human-induced habitat transformation because of its development potential. Grasslands are exploited for economic benefit in a number of ways, including large coal and diamond deposits, gold fields and agriculturally productive land (South African National Biodiversity Institute, 2004). Grasslands have suffered extensive degradation because they are one of the best areas for farming in South Africa, with large tracks of land converted to agriculture, mainly for maize production (Low and Rebelo, 1998). Developments such as farming activities lead to habitat destruction and have been linked to extremely high species extinction rates (Wilson, 1992).

Urban expansion, overgrazing, climate change, fire, as well as mining and afforestation have led to increased habitat fragmentation. The Grassland Biome supports the largest urban centre in South Africa, consisting of the Johannesburg-Midrand-Pretoria urban complex (Rutherford and Westfall, 1994), and several other large metropolitan areas such as Bloemfontein. Unnatural fire regimes pose serious threats to the Grassland Biome, especially to grassland specialist species, resulting in loss of habitat for these species (Cowling *et al.,* 1997).

1.4.6.1 Over-exploitation of resources

International demand for resources such as wild animals, certain types of plants, cause changes to terrestrial ecosystems (Convention on Biological Diversity, 2001). In some cases, the combination of domestic and international demand acts as a driver for the over-exploitation of resources, causing many species to become endangered or extinct (Convention on Biological Diversity, 2001). The grassland biome is not exempt from this exploitation.

1.4.6.2 Influence of plantations

International pressure has also caused a shift away from harvesting of timber from natural forests to the expansion of plantation forestry, especially into grasslands. This places a high demand on water resources, and contributes to the loss and fragmentation of natural grassland habitats (Department of Environmental Affairs and Tourism, 2004).

1.4.6.3 Rapid population growth

Rapid population growth, especially in developing countries, has had a serious impact on biodiversity of the grasslands. While humans have had an effect for the last 50,000 years, it has only been since the industrial revolution that the impact has been global rather than regional. This global impact is taking place via five primary processes: over-harvesting, introduction of alien species, pollution, habitat fragmentation and habitat destruction (Department of Environmental Affairs and Tourism, 2004).

1.4.6.4 Invasion of alien species

Invasion is the increase in density, cover and biomass of indigenous woody or shrubby plants in various grasslands, especially arid and semi-arid grasslands (Van Auken, 2000). Alien invasion is a form of land degradation (Archer, 1995a), and a major cause for concern because it is the most significant net contributor to grassland habitat loss; over 4 000 km of semi-pristine grassland vegetation has been lost to bush encroachment, and presumably due to the increasing spread of invasive alien plant species (Neke and Du Plessis, 2004).

Invasion into the remaining grasslands is responsible for the largest overall loss of this habitat type. This indicates an increasing presence of invasive alien plants, transforming the structure of the landscape away from grassland cover. Although bush encroachment has been of long concern in grassland and savannas, most research has focused on the effects of woody plants on grass production instead of the underlying ecological mechanisms driving encroachment (Coetzee *et al.,* 2007).

1.4.6.5 Vegetation change

The vegetation in any given area is dynamic and changes constantly as environmental conditions change. The equilibrium theory states that natural plant communities occur in a region as a result of gradual evolution, and that these communities exist in dynamic equilibrium with minor fluctuations in the environment. Unless there are major natural or man-made disturbances, the changes that occur in these communities are not part of the process known as plant or range succession (Bothma, 2002).

There are three factors, which will dramatically affect the vegetation change over time in an ecosystem. These are: climate, soil quality and human influences. The soil quality is important because the number of nutrients in a soil will affect the type of plants that are adapted to grow there (ECHEAT, 2004).

Plant richness in South Africa may be correlated with climatic variables and environmental variability at regional and local scales. Thus, changing climate has direct impacts on plant diversity in the country. Plant species densities are spatially variable across South Africa, and characterised by extraordinarily rich hotspots or Centres of Endemism. Significant climate change in these hotspots has the potential to cause the loss of large numbers of species (Rutherford, 1997).

Human influences are also arresting factors, usually leading to secondary succession. These can include deforestation, which leads to the removal of plants from the ecosystem that can in turn lead to soil erosion. Pollution caused by humans can affect vegetation on three different scales, namely; globally, nationally and locally. An example of national pollution that affects vegetation change is acid rain, which kills plants, and can change the balance of nutrients in the soil favouring only certain types of plants. An example of pollution on a global scale is climate change, which can affect whole countries and continents, furthermore leading to the extinction of many species. Other examples of factors, which affect vegetation change over time, include desertification and progressive downgrading of land caused by human mismanagement through actions such as overgrazing (ECHEAT, 2004).

1.4.7 Vegetation mapping

A vegetation map is a very useful tool for biological management of wildlife conservation areas and nature reserves in South Africa (Demers, 1991). According to Demers (1991), the role that vegetation maps play in planning scenarios is significant, as they not only form a baseline for studies relating to vegetation succession, but also provide important indicators of ecological responses to disturbance. A vegetation map is particularly useful for management planning, because it can be used to identify sensitive areas containing threatened species, important vegetation communities, and assist in developing management strategies for conservation goals.

Vegetation surveys collect data on species-diversity, a potentially valuable ecological indicator. The number of species recorded by vegetation surveys is, however, influenced by several factors, including inherent species-diversity, sampling method and sampling effort. Vegetation surveys have commonly been used to determine the distribution of plants species, damage to trees, area disturbances and many other factors (Schmidtlein and Sassin, 2004). They can also be used to gain information about water supply, soil pH and soil fertility amongst others (Schmidtlein and Sassin, 2004). Current vegetation mapping operates on a much broader theoretical and methodological platform by incorporating new approaches of remote sensing and spatial environmental correlation through Geographic Information System (GIS), as stated by Mucina and Rutherford (2006). According to Westhoff and Van der Maarel (1978), however, floristic classification still forms the framework for any plant ecological study, and also forms the basis of sound land-use planning, management and further research (Brown and Bredenkamp, 1994 & 1996; Brown, 1997).

1.4.8 Use of Geographic Information System techniques

A Geographic Information System (GIS) is a tool that combines ordinary statistics with geographic locations to create meaningful and clear maps, which are used in management strategies (Tripathi and Bhattarya, 2004). These maps are interactive and help to establish the relationships between spatial objects and the context in which they exist, such that they can be applied to developmental needs (Mbile *et al.,* 2003). In addition, GIS presents an opportunity to retrieve and transform research data, which can be more easily made available to various stakeholders at regional, national and international level. Using techniques to capture and manage spatially linked data, imposes a common structure on the information, making any analysis more systematic and strategic (Mbile *et al.,* 2003). Furthermore, using a GIS organization to file and analyse information is less time consuming, laborious and costly (Tripathi and Bhattarya, 2004).

A Geographic Information System is used to solve many human and natural problems. It has several advantages that lead to a better understanding of these issues, their causes and how to overcome them. Geographic Information System techniques have the ability to link spatial data and non-spatial data to support better decision-making. Furthermore, GIS is used to address problems associated with the storage, analysis and processing of indigenous knowledge (Mbile *et al.,* 2003).

Several studies have addressed the use of GIS and remote sensing in the management and control of vegetation worldwide. Singh (1989), for example, reviewed digital change detection techniques that use remotely sensed data. Anderson (1976) reviewed some land use and land cover classification systems that can be used in remotely sensed data. Mahmoodzadeh (2007) used remotely sensed data to monitor green space destruction in Tabriz, Iran. Adia and Rabiu (2008) applied remote sensing and GIS in how to identify changes that may occur in the green areas. Elias (2005) focused on how to use GIS and remote sensing in the management and survey of natural resources, including natural grassland.

1.5 AIM AND OBJECTIVES

1.5.1 Aim

The study aimed to identify and provide information on species of conservation importance, map the extent of transformation, and provide management recommendations for maintenance of the Woodbush Granite Grassland.

1.5.2 Objectives

The objectives of the study were to:

a. Provide information on species of Woodbush Granite Grassland; describe the vegetation and threats to the Woodbush Granite Grassland.
b. Compile a transformation map of the Woodbush Granite Grassland.
c. Propose an extensive management recommendation plan for the Woodbush Granite Grassland, which will provide a basis for the development of conservation and resource strategies, including assisting in the identification of conservation values.

1.6 SCOPE AND RESTRICTIONS OF THE RESEARCH

Given the outlined research aim and objectives, the scope of the study entailed the following aspects: the identification and recording of plant species (alien plants, critically endangered and threatened plant species) occurring within the Woodbush Granite Grassland; transformation mapping of the Woodbush Granite Grassland, and lastly, proposed management recommendation plan for this grassland.

The study had the following limitation:

Given the time frames available, not all plant species in the Woodbush Granite Grassland could be recorded and identified due to their specific phenology of short flowering times. It is, however, certain that most of the collected species have been identified.

1.7 RESEARCH OUTCOMES

The Woodbush Granite Grassland has species-rich communities of biodiversity importance that must be protected and conserved. The outcomes of the study are:

a. There are plant species of conservation importance.

b. A management plan for the Woodbush Granite Grassland is required.

1.8 ORGANISATION OF THE DISSERTATION

This dissertation consists of chapters on a number of correlated aspects of the vegetation of Woodbush Granite Grassland. The chapters are compiled in the form of essentially independent units. A comprehensive literature review, and discussion of the results are presented in each of the individual research chapters.

The dissertation is presented in 6 chapters. Chapter 1 provides the research background on the vegetation survey and mapping of the Woodbush Granite Grassland. A brief context, research motivation, literature review, aim and objectives of the research are provided. Study area description and location form the basis of Chapter 2.

Chapter 3 contains the first set of research findings, with particular reference to the vegetation of the Woodbush Granite Grassland. The chapter begins with a brief introduction. It also presents aim and objectives, methodology of data collection, processing and results. This is followed by discussion.

Chapter 4 encompasses research findings related to transformation mapping of the Woodbush Granite Grassland. It begins with a brief introductory section of grassland transformation. The chapter also presents its own aim and objectives, materials and methods, and results together with a discussion.

Chapter 5 covers the recommended management plan of the Woodbush Granite Grassland. Chapter 6 is the concluding chapter, which includes the conclusions and recommendations of the study. It furthermore presents a few areas for future research.

CHAPTER 2

STUDY AREA

2.1 LOCATION

The Woodbush Granite Grassland vegetation unit (Mucina and Rutherford, 2006) is a small ecosystem within the grassland biome, occurs in the Limpopo Province of South Africa (Figure 2.1). It is dominated by a mountainous plateau covered by grassland, with increased low-shrubs on the steeper south- and east-facing slopes (Mucina and Rutherford, 2006).

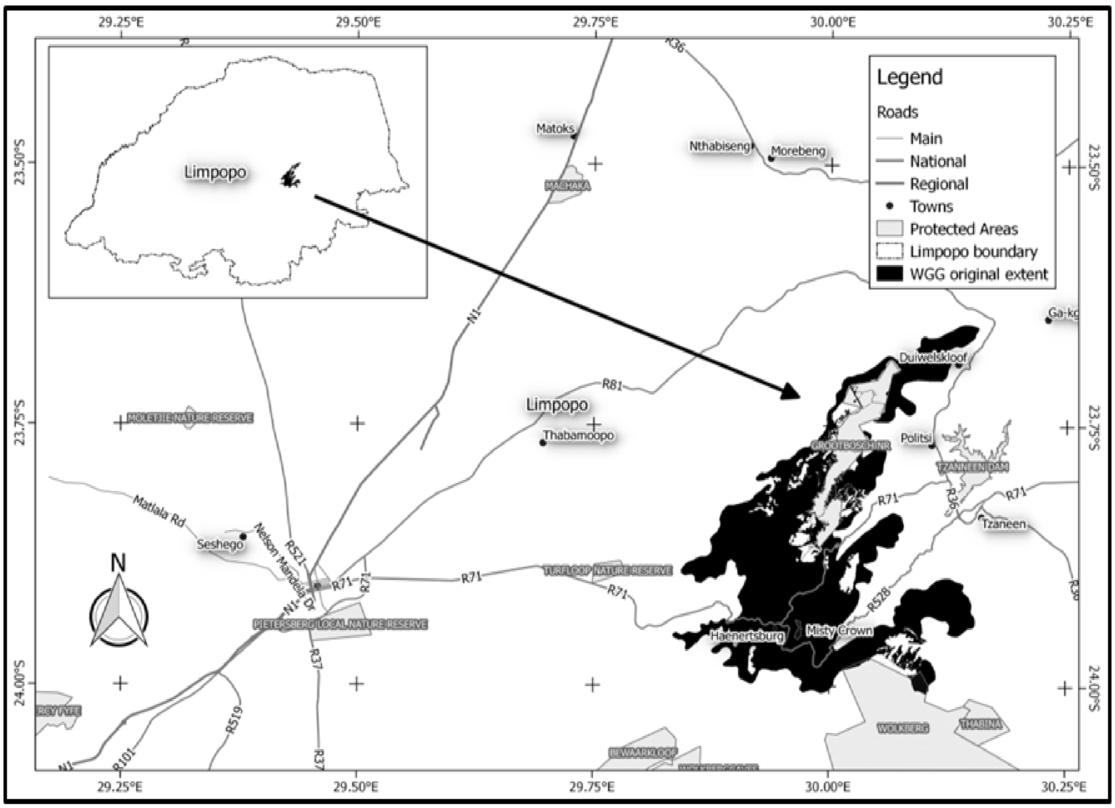


Figure 2.1 Location of the Woodbush Granite Grassland indicated in black (Egan, 2017; unpublished).

2.2 TOPOGRAPHY

Topographically, the landscape of the grassland biome ranges from flat or undulating hills and valleys, to a rugged mountain escarpment. On a broad scale, the Haenertsburg area is at a junction of the Eastern Escarpment and the Strydpoortberg, thus the topography is dominated by the Strydpoortberge and Wolkberg mountain ranges. There are a number of peaks of over 2000 m, with the Iron Crown being the highest by a good margin at 2126 m in the east-centre of the area (Mucina and Rutherford, 2006). These mountain ranges have steep northern slopes, with prominent cliffs, but gentler southern slopes due to the inclination of the rock strata (Department of Environmental Affairs and Tourism, 2012). The slightly lower, but still relatively high and rugged, areas to the south are underlain by dolomites. To the north of the mountain range, granites, gneisses and greenstone belts produce slightly gentler but still impressive slopes, with the top of Magoebaskloof to the east and a gentler descent to the west. A ridge of high ground runs north from Iron Crown continuing the line of the escarpment, and forming the main watershed between the Letaba River Basin draining eastwards, and tributaries of the Olifants River flowing westwards and then south (Strydom *et al.,* 1997).

2.3 METEOROLOGY

Winters of the grassland biome are generally cold and dry, with frequent frosts and snow falls in the higher reaches. The altitude, aspect variation and slope strongly influence the temperature (Strydom *et al.,* 1997). The Woodbush Granite Grassland is characterized by marked gradients in temperature and rainfall, due to the variability in altitude and the physiographic nature of the area. The climate is sub-tropical with summer rainfall and frequent mists occurring on the escarpment (Mucina and Rutherford, 2006). Rainfall varies spatially from 400 to 2500 mm per annum, corresponding to the mean annual runoff in other parts of the world where similar vegetation is found (O'Connor and Bredenkamp, 1997). Rainfall is strongly seasonal (summer), and the growing season lasts approximately half the year (Mucina and Rutherford, 2006). The physiography of the area is also responsible for a prominent south-easterly orographic effect in the rainfall pattern, leading to high falls on the south eastern side of prominent physiographic barriers, and resultant rain shadows on the north western side (Strydom *et al.,* 1997).

The long term mean annual rainfall ranges from 1050 to 1938 mm, with the highest rainfall occurring on the high-lying plateau areas (Strydom *et al.,* 1997). Approximately 90% of the annual rainfall occurs from October to March, resulting in a long dry season (Weather Bureau, 2003). The annual summer rainfall for the region with a mean annual precipitation (MAP) range from 700 mm in the east to 1500 mm in the west (mean annual precipitation 1166 mm), with a peak in January (Mucina and Rutherford, 2006).

The mean annual temperature ranges between 15.3°C and 19.2°C, with the high temperatures at the lower lying areas and the north-facing aspects. The lowest temperatures are found at the foot slopes and valley bottoms, falling as low as 2.8°C because of the strong inversion of cold air during the winter months (Strydom *et al.,* 1997). Some precipitation may occur in winter. Mist is common with an orographic effect on the escarpment (Mucina and Rutherford, 2006).

2.4 GEOLOGY

The Woodbush Granite Grassland occurs on the Archaean Turfloop Granite, relicts of Goudplaats gneiss and occasional Dolerite dykes or sills and quartz veins (Mucina and Rutherford, 2006). The oldest unit in the area is believed to be the Goudplaats Gneiss, which forms a basement to the greenstone belts, primarily the Pietersburg Group. The latter consists mainly of amphibolites (Eersteling Fm.) and quartz-chlorite schists (Vrischgewaagd Fm; Department of Environmental Affairs and Tourism, 2012).

The gneiss shows a well-developed north-east foliation, particularly in the north-west of the area, where the greenstone fragments follow the same trend. Overlying these older rocks are the shales, quartzites and minor volcanics of the Wolkberg Group (Transvaal Supergroup), including the conglomeratic Black Reef Formation. This group is in turn overlain by the dolomites of the Chuniespoort Group (Strydom *et al.,* 1997). Late stage intrusions are limited to an isolated Karoo dolerite intrusion in the centre of the area and numerous small doleritic dykes, of indeterminate age (although they are most probably of Karoo age as well). A few quartz veins are also found in the centre of the area. Aside from small quarries and borrow pits for road construction materials, there are no active mines in the area (Department of Environmental Affairs and Tourism, 2012).

2.5 VEGETATION

The Woodbush Granite Grassland is characterised by grassland-covered mountainous plateaus (Mucina and Rutherford, 2006). Prominent shrub species include *Tricalysia lanceolata* (tall shrub), *Asparagus virgatus*, *Dicliptera clinopodia* and *Eriosema nutans* (low shrubs). Grass species are most dominant in this vegetation unit and include, amongst others; *Eragrostis plana, E. racemosa, Hyparrhenia hirta, Microchloa caffra, Monocymbium ceresiiforme, Paspalum scrobiculatum* and *Stipa dregeana* var. *dregeana*. Common herb species include; *Berkheya, Echinacea, Chamaecrista mimosoides, Helichrysum cephaloideum, H. nudifolium* var. *pilosellum* and *Hypolepsis sparsisora* (herbs); *Asplenium andersonii, A. lobatum, Agapanthus inapertus* subsp. *inapertus* (geophytic herb) and *Aloe zebrina* (succulent herb). Endemic taxa include herbs such as *Wahlenbergia brachita* and *Chlorophytum radula* (geophytic herb; Mucina and Rutherford, 2006).

2.6 LAND USE

The land use of the Woodbush Granite Grassland in the Haenertsburg area includes stock farming, very limited planting of crops, large areas under plantations and recreational activities. Large areas are informally conserved due to limitations on agriculture, and play an important role in conserving natural biodiversity resources. Some of the cultivated lands and Acacia Valley Bushveld areas are used for grazing of livestock (Hemag, 2004). Plantations cover much of what was previously mountain grassland (Mucina and Rutherford, 2006). Grassland units have been subjected to poorly planned exploitation in terms of timber plantations. There are a number of pits, holes, trenches, caves and tunnels on the Paeroa and Colberg farms, which is the site of the old Iron Crown Mine (Department of Environmental Affairs and Tourism, 2012).

CHAPTER 3

VEGETATION SURVEY

3.1 INTRODUCTION

In South Africa the grassland biome covers an area ranging from the interior of the Eastern Cape and KwaZulu-Natal provinces over the Drakensberg escarpment and into the central plateau (Low and Rebelo, 1996). Thus the grassland biome makes up the greater portion of six provinces in South Africa. Approximately 24.6% of South Africa, Lesotho and a portion of Swaziland also lies within the Grassland Biome (Mucina and Rutherford, 2006).

The Woodbush Granite Grassland (estimated at 40 823 ha) is a small ecosystem within the grassland biome, occurring only on the northern Drakensberg Escarpment in the area of Tzaneen, Modjadjiskloof and Haenertsburg (Figure 3.1). Its original extent has been drastically reduced by habitat transformation, mostly in the form of silviculture (Mucina and Rutherford, 2006). The Woodbush Granite Grassland is Limpopo's highest conservation priority, and it requires effective conservation and protection of the remaining patches (Desmet *et al.,* 2013).

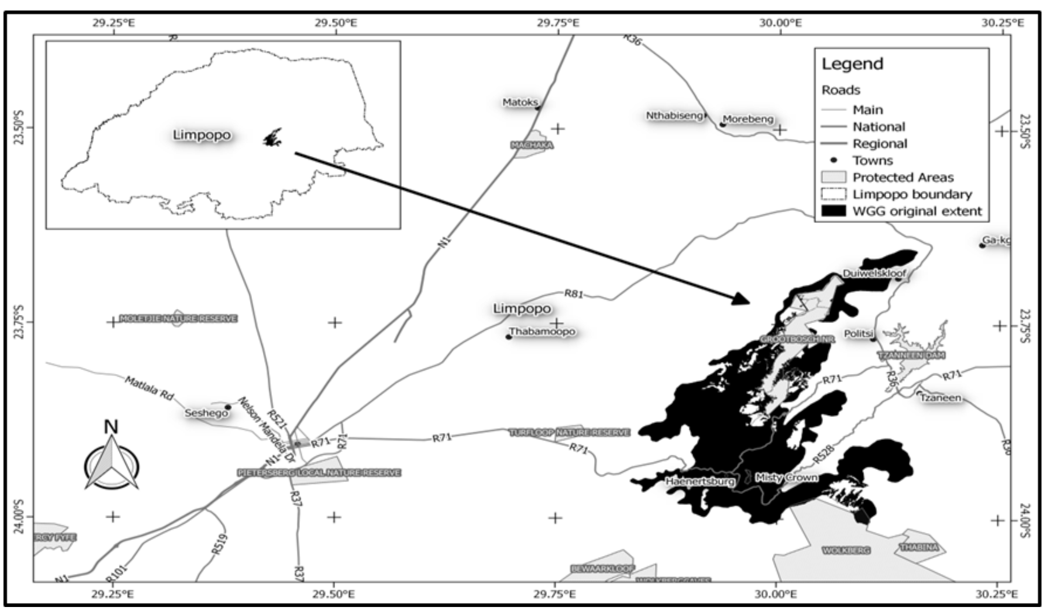


Figure 3.1 Original extent of the Woodbush Granite Grassland (Egan, 2017; unpublished).

3.2 SPECIFIC PURPOSE OF STUDY

3.2.1 Aim

The study sought to describe the vegetation type, provide information on species of conservation importance, and identify threats to the Woodbush Granite Grassland.

3.2.2 Objectives

a. Provide site characterisation and a vegetation description of the study area.

b. Identify species of conservation importance (Red data listed species and medicinal plants).

c. Identify significant threats, as related to:

- Invasive alien plants and bush encroachment.
- Medicinal plant harvesting.
- The potential for fire.
- Urban development risks.

3.3 MATERIALS AND METHODS

3.3.1 Study area

The study was carried out at the Iron Crown Grassland, Haenertsburg Commonage Grassland, Ebenezer Dam Nature Reserve, and the Ebenezer Dam Perimeter Grassland (Figure 3.2).

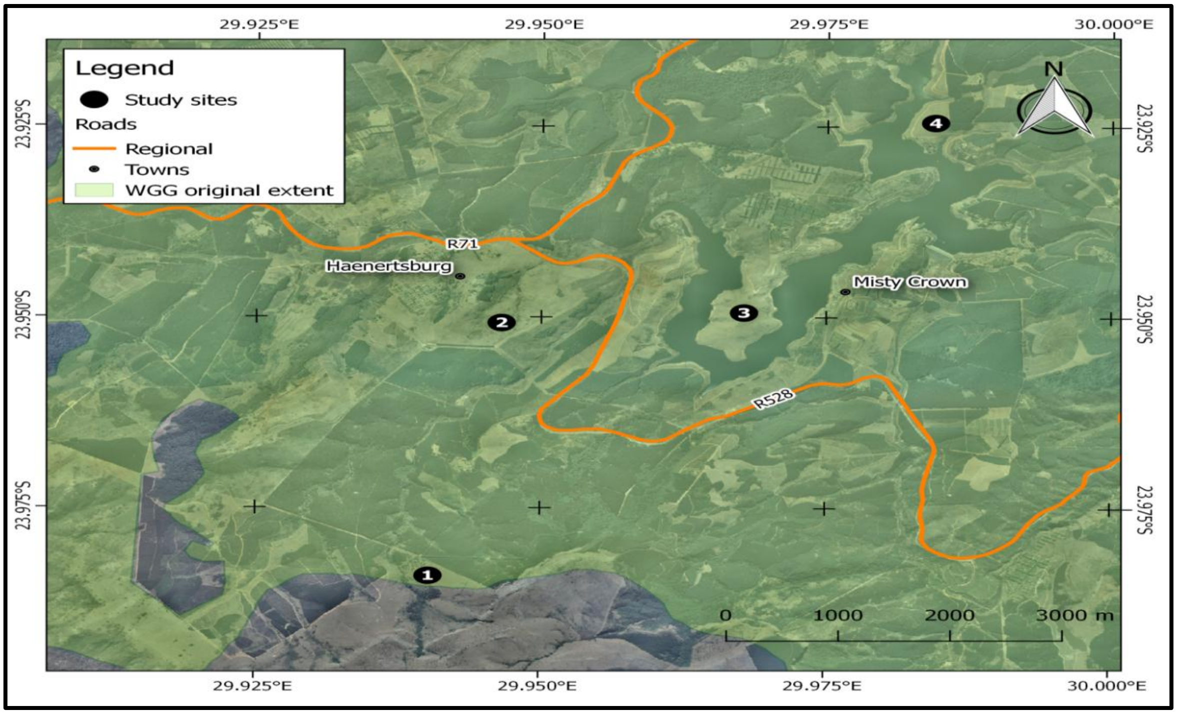


Figure 3.2 The study sites with sampled plots indicated with numbers (1= Iron Crown Grassland; 2=Haenertsburg Grassland; 3=Ebenezer Dam Nature Reserve Grassland and 4=Ebenezer Dam Perimeter Grassland (Egan, 2017; unpublished).

3.3.2 Survey method

A modified Braun-Blanquet method was applied to obtain baseline vegetation data. On all sites a simple random placement selection method was used for the plots. A plot size of 25 m by 25 m, according to the minimal area value of grasslands (Westhoff and Van der Maarel, 1978) was used for sampling areas containing trees and shrubs. Furthermore, a plot size of 25 x 25 m was subdivided into subplots of 1 x 1 m for sampling areas containing just herbaceous species. These subplots were placed at the four corners and one at the centre of the large quadrat. Altogether 28 sample plots and 140 subplots were surveyed (6 of 25x25 m and 30 of 1x1 m) at the Iron Crown Grassland, 8 of 25x25 m and 40 of 1x1 m at the Haenertsburg Grassland, 5 of 25x25 m and 25 of 1x1 m at the Ebenezer Dam Perimeter Grassland, and 9 of 25x25 m and 45 of 1x1 m at the Ebenezer Dam Nature Reserve Grassland. At each plot all plant species occurring within the quadrat were recorded. The centroid of each plot was recorded using a GPS. Height of trees was measured using a calibrated stick in accordance with Binns (1997).

The study also documented, via the modified Braun-Blanquet data collection sheet (Appendices 1 and 2), the main habitat variables that are correlated with differences in floristically-defined plant communities, according to Bredenkamp and Brown (2003). These are: geology, topography (landform, aspect and slope) and altitude. Habitat factors recorded for this study included soil type, degree of animal tracking, and signs of fire.

A cover score was allocated to each plant species. Cover was estimated via a 6 point scale. The cover scale used was 1= <5% cover; 2 = 5-25% cover; 3 = 25-50% cover; 4 = 50-75% cover; 5 = >75% cover.

The Red Data list of South African plants (Raimondo, 2011) was used to check the threat status of plants and plant endemism.

The structure of vegetation at each plot was recorded by noting the dominant species within each stratum, and estimating the percentage canopy cover. Appendices 1 and 2 detail the vegetation structure recording sheet, site feature recording and coding explanation sheet.

3.3.3 Data analysis

For the description of vegetation structure, height, canopy cover, and species importance value were used. The species list generated was checked for any unusual species occurrences or significant records.

3.3.4 Plant identification

This study was conducted over a one year period to include one winter and two summer seasons, which aided in the taxonomic identification of species. Plant samples (voucher specimens) were collected and taxonomically identified at the Larry Leach Herbarium of the University of Limpopo.

3.4 RESULTS

3.4.1 Iron Crown Grassland

3.4.1.1 Site description

The site lies adjacent to a *Pinus elliotti* plantation, and is located at 23.99088°S 029.93567°E, with a terrain elevation of 2126 m above sea level (Figure 3.3). Habitat for this site is described as a mountain slope, covered with herbs and grasses as general life forms. The site contained areas with bare rocks, which occurred from the mid slope to the peak of the site (Figure 3.4). The soil type was a brown sandy loam. The degree of surface erosion ranged from low to medium, and there were termite mounds on several parts of the site. Anthropogenic evidence included man-made pits and a hiking trail. The amount of animal spoor present was recorded as medium.

Cover litter percentage amounted to 25%, and cover of bare rocks was 45%. Cover of small stones was recorded at 15%, medium stones at 25% and large stones at 35-40%.

Figure 3.3 Lower to mid-slope of the Iron Crown Grassland in the background during winter survey.

Figure 3.4 Upper slope of the Iron Crown Grassland.

3.4.1.2 Vegetation description

Although the site was densely vegetated with herbs, the tree and shrub stratum had relatively low densities. Average height of shrubs was 1.1 m (maximum 120 cm; minimum 50 cm), with the herbaceous layer having an average height of 70 cm (maximum 90 cm; minimum 30 cm). The mean height of trees was 2.9 m (maximum 3.5 m; minimum 2.7 m). The canopy cover for the tree stratum was 10%, for the shrub stratum it was 20%, for the grass stratum 40%, and the herb layer 30%.

The vegetation of the study site was dominated by species of the Poaceae and Asteraceae families, which accounted for just more than 60% of all found species. The dominant species for the grass layer was *Hyparrhenia hirta*; *Helichrysum acutatum* and *Pteridium aquilinum* for the herb layer; *Athrixia phylicoides* for the shrub layer, and *Protea rubropilosa* for the tree layer. Several *Gladious* species were observed, but due to identification difficulties during winter they are treated as a single entity, thus this site contained slightly more than the 18 documented species listed in Table 3.1.

The 18 identified species consisted of 2 trees species, 2 shrub species, 1 fern species, 6 grass species, and 7 herb species.

3.4.1.3 Species of conservation importance

Of the 18 identified species, 4 are endemic to South Africa, but widely distributed in the Limpopo Province (Table 3.1). None of these 4 species are classified as threatened, with all 4 classified as Least Concern (LC). The other 14 species were not endemic to South Africa.

Species of medicinal value documented at this site were *Lippia javanica* and *Athrixia phylicoides*.

Table 3.1 Plant species of the Iron Crown Grassland.

Species	**Family**	**Threat status**	**Plant endemism**
Acacia melanoxylon	Fabaceae	Not evaluated	Not endemic to SA
Athrixia phylicoides	Asteraceae	LC	SA endemic
Chamaecrista mimosoides	Fabaceae	LC	Not endemic to SA
Dierama galpinii	Iridaceae	LC	Not endemic to SA
Eragrostis racemosa	Poaceae	LC	Not endemic to SA
Helichrysum acutatum	Asteraceae	LC	Not endemic to SA
Helichrysum chrysocephalum	Asteraceae	LC	Not endemic to SA
Helichrysum confertifolium	Asteraceae	LC	SA endemic
Hyparrhenia hirta	Poaceae	LC	Not endemic to SA
Lippia javanica	Verbenaceae	LC	Not endemic to SA
Melinis nerviglumis	Poaceae	LC	Not endemic to SA
Oxalis semiloba	Oxalidaceae	LC	Not endemic to SA
Panicum maximum	Poaceae	LC	Not endemic to SA
Protea rubropilosa	Proteaceae	LC	SA endemic
Pteridium aquilinum	Dennstaedtiaceae	LC	Not endemic to SA

Setaria sphacelata	Poaceae	LC	Not endemic to SA
Themeda triandra	Poaceae	LC	Not endemic to SA
Watsonia transvaalensis	Iridaceae	LC	SA endemic

3.4.1.4 Identified threats

a. Alien invasive plants

The most dominant alien invasive plant species recorded was *Acacia melanoxylon*, and the invasive species being the *Pteridium aquilinum* which had invaded a large patch of the site (Figure 3.5), leaving the site with relatively few grass individuals. *Pteridium aquilinum* was spreading further into the site, as evidenced by the high number of seedlings.

Figure 3.5 *Pteridium aquilinum* invading the grassland at the Iron Crown Grassland.

b. Medicinal plant species collection

There were signs of collection of *Athrixia phylicoides* (most probably by Traditional Health Practitioners)

c. Fire

The site is under potential threat of arson by people and wild fires.

d. Urban development

The site is not under any immediate threat of urban development.

3.4.2 Haenertsburg Grassland

The Haenertsburg Grassland covers an area from the graveyard stretching to the Haenertsburg Primary School, and continues down next to the George's Valley.

3.4.2.1 Site description

A *Pinus elliotti* plantation is found next to the study site (Figure 3.6), and it is located at coordinates 23.95176°S 029.94163°E, with an elevation of 1500 m. The peak of the site gives a view of the Ebenezer Dam (Figure 3.7). Habitat for the site can best be described as hill slope, and life form being herbs and grass. There were bare rocks recorded at the parts of this site. The soil type was sandy loam brown. Degree of erosion was low, and there were no termite mounds. Anthropogenic evidence included a hiking trail. The amount of animal tracks present was classified as medium, some grazing by cattle had been observed on the site mainly early in the growing season after the area was burnt. A portion of the site had previously been burned (Figure 3.8). Two water springs were found on this site.

Cover litter percentage amounted to 40%, and cover of bare rocks was 20%. Cover of small stones was recorded at 10%, medium stones at 10% and large stones at 15-20%.

Figure 3.6 *Pinus elliotti* plantation bordering the Haenertsburg Grassland.

Figure 3.7 Setting up a quadrat on the Haenertsburg Grassland.

Figure 3.8 Block burning at the Haenertsburg Grassland.

3.4.2.2 Vegetation description

The site was densely vegetated with herbs, while the tree stratum has a relatively low species diversity. The average height of shrubs was 1.1 m (maximum 130 cm; minimum 55 cm), with the herbaceous layer having an average height of 65 cm (maximum 80 cm; minimum 35 cm). The average height of trees was 2.5 m (maximum 3.5 m; minimum 1.9 m). The canopy cover of the tree stratum contributed 10% to overall cover, shrub stratum 25%, and the grass stratum 30%, the herb stratum was 35%.

The vegetation of the study site was dominated by species of the Asteraceae and Poaceae families, which accounted for just more than 55% of all found species. All identified species are listed in Table 3.2.

A total of 47 species were identified, which included 22 herb, 11 grass, 9 shrub, 3 fern and 2 tree species. The dominant grass species were *Panicum maximum* and *Hyparrhenia hirta*, dominant herbs were *Helichrysum confertifolium, Helichrysum* *rugulosum, Helichrysum splendidum* and *Athrixia phylicoides*, the dominant fern was *Pteridium aquilinum*, while the dominant tree was *Searsia pentheri*.

3.4.2.3 Species of conservation importance

Of the identified species, none were found to be threatened according to the Red Data list of South Africa, 2 species are classified as not evaluated, with 1 classified as data deficient taxonomically (DDT), 44 were classified as of Least Concern (LC). Five species are endemic to South Africa and widely distributed in Limpopo Province, the rest (42) are not endemic to South Africa (Table 3.2).

Species of medicinal value documented at the Haenertsburg Grassland included *Athrixia phylicoides* and *Lippia javanica*.

Table 3.2 Species list of the Haenertsburg Grassland.

Species	**Family**	**Threat status**	**Endemic**
Alepidea longifolia	Apiaceae	DDT	SA endemic
Aloe ecklonis	Asphodelaceae	LC	Not endemic to SA
Aloe zebrina	Asphodelaceae	LC	Not endemic to SA
Andropogon eucomus	Poaceae	LC	Not endemic to SA
Artemisia afra	Asteraceae	LC	Not endemic to SA
Athrixia phylicoides	Asteraceae	LC	SA endemic
Berkheya setifera	Asteraceae	LC	Not endemic to SA
Chamaecrista mimosoides	Fabaceae	LC	Not endemic to SA
Crabbea hirsuta	Acanthaceae	LC	Not endemic to SA
Cymbopogon excavatus	Poaceae	Not evaluated	Not endemic to SA
Cymbopogon validus	Poaceae	Not evaluated	Not endemic to SA
Dierama galpinii	Iridaceae	LC	Not endemic to SA
Diospyros lycioides	Ebenaceae	LC	Not endemic to SA
Eragrostis chloromelas	Poaceae	LC	Not endemic to SA
Eragrostis racemosa	Poaceae	LC	Not endemic to SA
Gerbera piloselloides	Asteraceae	LC	Not endemic to SA
Helichrysum acutatum	Asteraceae	LC	Not endemic to SA
Helichrysum chrysocephalum	Asteraceae	LC	Not endemic to SA
Helichrysum confertifolium	Asteraceae	LC	SA endemic
Helichrysum piloselium	Asteraceae	LC	Not endemic to SA
Helichrysum rugulosum	Asteraceae	LC	Not endemic to SA
Helichrysum splendidum	Asteraceae	LC	Not endemic to SA

Helichrysum umbraculigerum	Asteraceae	LC	Not endemic to SA
Hyparrhenia hirta	Poaceae	LC	Not endemic to SA
Indigofera heterotricha	Fabaceae	LC	Not endemic to SA
Lippia javanica	Verbenaceae	LC	Not endemic to SA
Lycopodium cernuum	Lycopodiaceae	LC	Not endemic to SA
Maesa lanceolata	Maesaceae	LC	Not endemic to SA
Microlepia speluncae	Dennstaedtiaceae	LC	Not endemic to SA
Otholobium polystictum	Fabaceae	LC	Not endemic to SA
Oxalis semiloba	Oxalidaceae	LC	Not endemic to SA
Panicum maximum	Poaceae	LC	Not endemic to SA
Panicum natalense	Poaceae	LC	Not endemic to SA
Pennisetum macrourum	Poaceae	LC	Not endemic to SA
Pentanisia angustifolia	Rubiaceae	LC	Not endemic to SA
Pteridium aquilinum	Dennstaedtiaceae	LC	Not endemic to SA
Ranunculus multifidus	Ranunculaceae	LC	Not endemic to SA
Rhynchosia monophylla	Fabaceae	LC	Not endemic to SA
Searsia pendulina	Anacardiaceae	LC	Not endemic to SA
Searsia pentheri	Anacardiaceae	LC	Not endemic to SA
Searsia pondoensis	Anacardiaceae	LC	SA endemic
Setaria sphacelata	Poaceae	LC	Not endemic to SA
Themeda triandra	Poaceae	LC	Not endemic to SA
Urochloa brachyura	Poaceae	LC	Not endemic to SA
Vernonia galpinni	Asteraceae	LC	Not endemic to SA
Vernonia myriantha	Asteraceae	LC	Not endemic to SA
Watsonia transvaalensis	Iridaceae	LC	SA endemic

3.4.2.4 Identified threats

a. Alien invasive species

Invasive species at this site were mainly found along the road, on the edge of the watercourse, and the edge of the grassland next to the plantation. The most dominant species spreading into the grassland were *Pteridium aquilinum, Solanum mauritianum*, *Lilium longiflorum*, *Cestrum* sp., *Crocosmia* sp., *Acacia melanoxylon*, *Pinus ellioti, Cotoneaster salicifolius* and *Crataegus mexicana.* The plantation bordering the grassland poses a serious threat to the grassland, as there is potential for more invasive species from the plantation to spread into the grassland.

b. Medicinal plants species collection

Excessive collection of medicinal plants at this site is a serious issue. The most collected plant of medicinal use was *Athrixia phylicoides.* Figure 3.9 shows the plant is collected in its entirety, leaving only a bare patch.

Figure 3.9 Site where *Athrixia phylicoides* was collected.

c. Fire

Because the site is located near a residential area it is more at risk of arson which could spread into the grassland.

d. Urban development

This site when compared to all other sites has the greatest potential threat of urban expansion because it is located next to a residential area.

3.4.3 Ebenezer Dam Grassland

The Ebenezer Dam is built on the Great Letaba River near Tzaneen; it lies within the George's Valley (Groot Letaba) drainage. The site was divided into two sub-sites; the

Ebenezer Dam Nature Reserve Grassland and the Ebenezer Dam Perimeter Grassland.

3.4.3.1 Ebenezer Dam Nature Reserve Grassland

3.4.3.1.1 Site description

The site is adjacent to the Ebenezer Dam, no plantation is close to the site. It is located at 23.90867°S 029.9854°E, and at an elevation of 1376 m. Habitat at this site can best be described as hill slope, with the dominant life forms being herbs and grasses. There were few bare rocks on the site. The soil was a brown sandy loam. No evidence of erosion was noted. Termite mounds were found on different parts of the site. Anthropogenic evidence included a gravel road on the site. The number of animal tracks was low. The site was burned during the winter survey, and when data was collected in summer signs of burning were still evident (Figure 3.10), and therefore data could only be collected during the two summer surveys.

Cover litter percentage amounted to 15%, and cover of bare rocks was 10%. Cover of small stones was recorded at 15%, medium stones at 10% and large stones at 10%.

Figure 3.10 A previously burned patch on the Ebenezer Dam Nature Reserve Grassland.

3.4.3.1.2 Vegetation description

The site was densely vegetated with herbs and presence of shrubs. The tree stratum had low species diversity. The shrubs had an average height of 90 cm (maximum 120 cm; minimum 45 cm); herbaceous layer had an average height of 65 cm (maximum 90 cm; and minimum 15 cm). The average height of trees was 1.7 m (maximum 2 m; minimum 1.5 m). The canopy cover of tree stratum contributed 5% to canopy cover, the shrub stratum 40%, and herb layer 55%.

The general vegetation of the study area was dominated by the presence of species from the Asteraceae and Poaceae families, which accounted for more than 50% of all species. Species identified are listed in Table 3.3.

The total number of species identified at this sub-site amounted to 52 species, of which 20 were herbs, 15 grasses, 11 shrubs, 3 ferns, and 3 tree species. The dominant grass species were *Panicum maximum, Panicum natalense* and *Hyparrhenia hirta*. Dominant herbs were *Helichrysum rugulosum, Helichrysum splendidum* and *Athrixia phylicoides*. The dominant fern was *Lycopodium cernuum*, while the dominant tree was *Maesa lanceolata*. A cluster of *Aloe zebrina* (Figure 3.11) was found at the upper slope of the site.

3.4.3.1.3 Species of conservation importance

Five of the identified species are endemic to South Africa, but are widely distributed in Limpopo Province, the rest (47) are not endemic to South Africa (Table 3.3). None of the species were found to be threatened according to the Red Data list of South Africa, there was 1 species that was not evaluated, 1 is classified as data deficiency taxonomically (DDT), and 50 are classified as of least concern (LC).

Dominant plant species of medicinal use were *Athrixia phylicoides* and *Berkheya setifera*.

Figure 3.11 *Aloe zebrina*.

Table 3.3 Species list of the Ebenezer Dam Nature Reserve Grassland.

Species	**Family**	**Threat status**	**Endemic**
Alepidea longifolia	Apiaceae	DDT	SA endemic
Aloe ecklonis	Asphodelaceae	LC	Not endemic to SA
Aloe zebrine	Asphodelaceae	LC	Not endemic to SA
Andropogon eucomus	Poaceae	LC	Not endemic to SA
Artemisia afra	Asteraceae	LC	Not endemic to SA
Athrixia phylicoides	Asteraceae	LC	SA endemic
Berkheya setifera	Asteraceae	LC	Not endemic to SA
Brachiaria brizantha	Poaceae		
Chamaecrista mimosoides	Fabaceae	LC	Not endemic to SA
Crabbea hirsuta	Acanthaceae	LC	Not endemic to SA
Cymbopogon excavates	Poaceae	Not evaluated	Not endemic to SA
Dierama galpinii	Iridaceae	LC	Not endemic to SA
Diospyros lycioides	Ebenaceae	LC	Not endemic to SA
Eragrostis chloromelas	Poaceae	LC	Not endemic to SA
Eragrostis inamoena	Poaceae	LC	Not endemic to SA
Eragrostis racemosa	Poaceae	LC	Not endemic to SA
Gerbera piloselloides	Asteraceae	LC	Not endemic to SA
Gnidia caffra	Thymelaeaceae	LC	Not endemic to SA
Gymnosporia senegalensis	Celastraceae	LC	Not endemic to SA
Helichrysum acutatum	Asteraceae	LC	Not endemic to SA
Helichrysum chrysocephalum	Asteraceae	LC	Not endemic to SA
Helichrysum confertifolium	Asteraceae	LC	SA endemic
Helichrysum piloselium	Asteraceae	LC	Not endemic to SA
Helichrysum rugulosum	Asteraceae	LC	Not endemic to SA
Helichrysum splendidum	Asteraceae	LC	Not endemic to SA
Helichrysum umbraculigerum	Asteraceae	LC	Not endemic to SA
Hyparrhenia hirta	Poaceae	LC	Not endemic to SA
Hypericum revolutum	Hypericaceae	LC	Not endemic to SA
Indigofera heterotricha	Fabaceae	LC	Not endemic to SA
Lippia javanica	Verbenaceae	LC	Not endemic to SA
Lycopodium cernuum	Lycopodiaceae	LC	Not endemic to SA
Maesa lanceolata	Maesaceae	LC	Not endemic to SA
Melinis nerviglumis	Poaceae	LC	Not endemic to SA
Microlepia speluncae	Dennstaedtiaceae	LC	Not endemic to SA
Otholobium polystictum	Fabaceae	LC	Not endemic to SA
Oxalis semiloba	Oxalidaceae	LC	Not endemic to SA
Panicum maximum	Poaceae	LC	Not endemic to SA
Panicum natalense	Poaceae	LC	Not endemic to SA
Pentanisia angustifolia	Rubiaceae	LC	Not endemic to SA
Pteridium aquilinum	Dennstaedtiaceae	LC	Not endemic to SA
Ranunculus multifidus	Ranunculaceae	LC	Not endemic to SA

Rhynchosia monophylla	Fabaceae	LC	Not endemic to SA
Searsia pendulina	Anacardiaceae	LC	Not endemic to SA
Searsia pentheri	Anacardiaceae	LC	Not endemic to SA
Searsia pondoensis	Anacardiaceae	LC	SA endemic
Setaria sphacelata	Poaceae	LC	Not endemic to SA
Sporobolus centrifugus	Poaceae	LC	Not endemic to SA
Themeda triandra	Poaceae	LC	Not endemic to SA
Urochloa brachyura	Poaceae	LC	Not endemic to SA
Vernonia galpinni	Asteraceae	LC	Not endemic to SA
Vernonia myriantha	Asteraceae	LC	Not endemic to SA
Watsonia transvaalensis	Iridaceae	LC	SA endemic

3.4.3.1.4 Identified threats

a. Alien invasive

There was a number of invasive species recorded at this site, and there is potential for those species to spread further into the grassland, particularly *Pteridium aquilinum,* which is strongly colonising this site*.* Other invasive species present included *Acacia mearnsii*, *Solanum mauritianum* and *Lilium longiflorum*.

b. Medicinal plant species collection

There were signs of collection of plants of medicinal use, and most noted collected species was *Athrixia phylicoides*.

c. Fire

There is a potential threat of fire being caused by people being on the site.

d. Urban development

The site is not under any immediate threat of urban development.

3.4.3.2 Ebenezer Dam Perimeter Grassland

3.4.3.2.1 Site description

A *Pinus elliotti* plantation lies adjacent to the study site as shown in Figure 3.12, and it is located at coordinate 23.92237°S 029.98504°E, and at an elevation of 1386 m. Habitat is a hill slope, while the dominant life forms were grasses and herbs. There were no bare rocks on the site. The soil type was a brown sandy loam. The degree of erosion was low. There were termite's mounds throughout the study site. On the middle, upper slope there was a strip of long grasses that crosses the site. The number of animal tracks were low. There were no trees at this site.

Cover litter percentage amounted to 20%, and cover of bare rocks was 0%. Cover of small stones was recorded at 10%, medium stones at 10% and large stones at 5%.

Figure 3.12 Plantation in the background at the Ebenezer Dam Perimeter Grassland.

3.4.3.2.2 Vegetation description

The site was vegetated with herbs; the shrub stratum had a relatively low species diversity. Shrubs had an average height of 90 cm (maximum 80 cm; minimum 45 cm), herbaceous layer had an average height of 55 cm (maximum 70 cm; minimum 30 cm. The canopy cover of the tree stratum was 0%, the shrub stratum 40%, while the herb layer contributed 60% to the cover.

Dominant families were the Poaceae and Asteraceae, which accounted for more than 50% of all species. Twenty eight species were recorded at this sub-site (Table 3.4), of which 12 were herbs, 8 grasses, 5 shrubs, and 3 fern species. The dominant grass species were *Panicum maximum, Panicum natalense* and *Hyparrhenia hirta*, the dominant herb was *Helichrysum rugulosum,* while the dominant fern was *Pteridium aquilinum.*

3.4.3.2.3 Species of conservation importance

There were 2 species (Table 3.4) that are endemic to South Africa, they are also widely distributed in the Limpopo Province. The other 26 species are not endemic to South Africa. None of the species were found to be threatened according to the Red Data list of South Africa, there was 1 species that was not evaluated, and 27 were classified as of least concern (LC).

The most dominant species of medicinal use were *Athrixia phylicoides* and *Lippia javanica*.

Table 3.4 Species list of the Ebenezer Dam Perimeter Grassland.

Species	**Family**	**Threat status**	**Endemic**
Aloe ecklonis	Asphodelaceae	LC	Not endemic to SA
Aloe zebrina	Asphodelaceae	LC	Not endemic to SA
Artemisia afra	Asteraceae	LC	Not endemic to SA
Athrixia phylicoides	Asteraceae	LC	SA endemic
Chamaecrista mimosoides	Fabaceae	LC	Not endemic to SA
Cymbopogone validus	Poaceae	Not evaluated	Not endemic to SA
Dierama galpinii	Iridaceae	LC	Not endemic to SA
Eragrostis inamoena	Poaceae	LC	Not endemic to SA
Eragrostis racemosa	Poaceae	LC	Not endemic to SA
Helichrysum acutatum	Asteraceae	LC	Not endemic to SA
Helichrysum chrysocephalum	Asteraceae	LC	Not endemic to SA

Helichrysum confertifolium	Asteraceae	LC	SA endemic
Helichrysum umbraculigerum	Asteraceae	LC	Not endemic to SA
Hyparrhenia hirta	Poaceae	LC	Not endemic to SA
Hypericum revolutum	Hypericaceae	LC	Not endemic to SA
Indigofera heterotricha	Fabaceae	LC	Not endemic to SA
Lippia javanica	Verbenaceae	LC	Not endemic to SA
Lycopodium cernuum	Lycopodiaceae	LC	Not endemic to SA
Melinis nerviglumis	Poaceae	LC	Not endemic to SA
Microlepia speluncae	Dennstaedtiaceae	LC	Not endemic to SA
Panicum maximum	Poaceae	LC	Not endemic to SA
Panicum natalense	Poaceae	LC	Not endemic to SA
Pteridium aquilinum	Dennstaedtiaceae	LC	Not endemic to SA
Ranunculus multifidus	Ranunculaceae	LC	Not endemic to SA
Rhynchosia monophylla	Fabaceae	LC	Not endemic to SA
Searsia pondoensis	Anacardiaceae	LC	Not endemic to SA
Setaria sphacelata	Poaceae	LC	Not endemic to SA
Themeda triandra	Poaceae	LC	Not endemic to SA

3.4.3.2.4 Identified threats

a. Alien invasive species

A major threat identified at this site was the spread of pine seeds from the plantation into the grassland. *Pteridium aquilinum* was the most dominant invasive species (Figure 3.13).

b. Medicinal plant species collection

No signs of collection of medicinal plants were noted during the survey.

c. Fire

There is potential for arson by people as the site is immediately above a fishing area where fires are often lit for braais (Barbeques).

d. Urban development

The site is under no immediate threat of urban development.

Figure 3.13 *Pteridium aquilinum* invading the study Ebenezer Dam Perimeter Grassland.

3.4.4 Woodbush Granite Grassland

3.4.4.1 Area description

The altitudinal range for the study area is between 1 300 - 2 230 m a.s.l. The Iron Crown Grassland is located at the highest elevation and the Ebenezer Dam Nature Reserve occurred at the lowest elevation in the study area. The soil type was sandy loam throughout the study area. The degree of erosion ranged from low to medium on all sites. Rock cover was high at the Iron Crown Grassland and low at the other study sites. The number of animal tracks was recorded as low to medium on all sites. Three sites (Iron Crown Grassland, Haenertsburg Grassland and the Ebenezer Dam Perimeter Grassland) were found to border plantations. There were hiking trails on the Iron Crown Grassland and the Haenertsburg Grassland. A unique feature of the

Haenertsburg Grassland is that it has two water springs, while the Ebenezer Dam Perimeter Grassland had no tree cover.

3.4.4.2 Vegetation composition

a. Species diversity

Species-wise, *Protea rubropilosa* was only recorded at the Iron Crown Grassland, while *Aloe ecklonis* and *Aloe zebrina* were only recorded at the Haenertsburg Grassland, Ebenezer Dam Nature Reserve Grassland and the Ebenezer Dam Perimeter Grassland. The list of plants in Table 3.5 gives an indication of the value and sensitivity of the study area, as well as of the state of knowledge about plant diversity of the study area. Several specimens could not be identified and may represent important species.

A total of 57 plant species and 20 families were identified from Woodbush Granite Grassland (Table 3.5). The Poaceae and Asteraceae were found to be the most dominant families throughout the Woodbush Granite Grassland, represented by 15 species and 13 species, respectively. Of the 57 identified species, 6 were trees, 20 herbs, 10 shrubs, 3 ferns and 18 grasses.

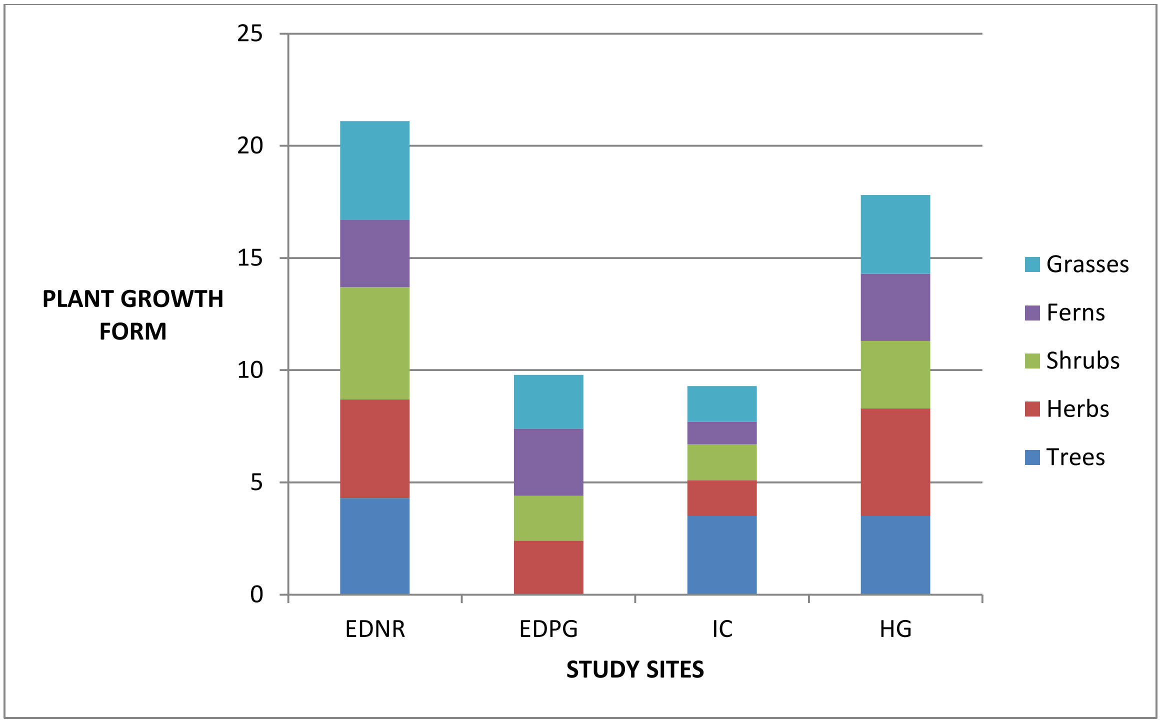
Table 3.5 Plant species of the Woodbush Granite Grassland, as well as their threat and endemic status.

Species	**Family**	**Threat status**	**Endemic**
Acacia melanoxylon	Fabaceae	Not evaluated	Not endemic to SA
Alepidea longifolia	Apiaceae	DDT	SA endemic
Aloe ecklonis	Asphodelaceae	LC	Not endemic to SA
Aloe zebrina	Asphodelaceae	LC	Not endemic to SA
Andropogon eucomus	Poaceae	LC	Not endemic to SA
Artemisia afra	Asteraceae	LC	Not endemic to SA
Athrixia phylicoides	Asteraceae	LC	SA endemic
Berkheya setifera	Asteraceae	LC	Not endemic to SA
Brachiaria brizantha	Poaceae		

Chamaecrista mimosoides	Fabaceae	LC	Not endemic to SA
Crabbea hirsuta	Acanthaceae	LC	Not endemic to SA
Cymbopogon excavatus	Poaceae	Not evaluated	Not endemic to SA
Cymbopogon validus	Poaceae	Not evaluated	Not endemic to SA
Dierama galpinii	Iridaceae	LC	Not endemic to SA
Diospyros lycioides	Ebenaceae	LC	Not endemic to SA
Eragrostis chloromelas	Poaceae	LC	Not endemic to SA
Eragrostis inamoena	Poaceae	LC	Not endemic to SA
Eragrostis racemosa	Poaceae	LC	Not endemic to SA
Gerbera piloselloides	Asteraceae	LC	Not endemic to SA
Gnidia caffra	Thymelaeaceae	LC	Not endemic to SA
Gymnosporia senegalensis	Celastraceae	LC	Not endemic to SA
Helichrysum acutatum	Asteraceae	LC	Not endemic to SA
Helichrysum chrysocephalum	Asteraceae	LC	Not endemic to SA
Helichrysum confertifolium	Asteraceae	LC	SA endemic
Helichrysum piloselium	Asteraceae	LC	Not endemic to SA
Helichrysum rugulosum	Asteraceae	LC	Not endemic to SA
Helichrysum splendidum	Asteraceae	LC	Not endemic to SA
Helichrysum umbraculigerum	Asteraceae	LC	Not endemic to SA
Hyparrhenia hirta	Poaceae	LC	Not endemic to SA
Hypericum revolutum	Hypericaceae	LC	Not endemic to SA
Indigofera heterotricha	Fabaceae	LC	Not endemic to SA
Lippia javanica	Verbenaceae	LC	Not endemic to SA
Lycopodium cernuum	Lycopodiaceae	LC	Not endemic to SA
Maesa lanceolata	Maesaceae	LC	Not endemic to SA
Melinis nerviglumis	Poaceae	LC	Not endemic to SA
Microlepia speluncae	Dennstaedtiaceae	LC	Not endemic to SA
Otholobium polystictum	Fabaceae	LC	Not endemic to SA
Oxalis semiloba	Oxalidaceae	LC	Not endemic to SA
Panicum maximum	Poaceae	LC	Not endemic to SA

Panicum natalense	Poaceae	LC	Not endemic to SA
Pennisetum macrourum	Poaceae	LC	Not endemic to SA
Pentanisia angustifolia	Rubiaceae	LC	Not endemic to SA
Protea rubropilosa	Proteaceae	LC	SA endemic
Pteridium aquilinum	Dennstaedtiaceae	LC	Not endemic to SA
Ranunculus multifidus	Ranunculaceae	LC	Not endemic to SA
Rhynchosia monophylla	Fabaceae	LC	Not endemic to SA
Searsia pendulina	Anacardiaceae	LC	Not endemic to SA
Searsia pentheri	Anacardiaceae	LC	Not endemic to SA
Searsia pondoensis	Anacardiaceae	LC	SA endemic
Setaria sphacelata	Poaceae	LC	Not endemic to SA
Searsia transvaalensis	Anacardiaceae	LC	Not endemic to SA
Sporobolus centrifugus	Poaceae	LC	Not endemic to SA
Themeda triandra	Poaceae	LC	Not endemic to SA
Urochloa brachyura	Poaceae	LC	Not endemic to SA
Vernonia galpinni	Asteraceae	LC	Not endemic to SA
Vernonia myriantha	Asteraceae	LC	Not endemic to SA
Watsonia transvaalensis	Iridaceae	LC	SA endemic

The Ebenezer Dam Nature Reserve had the highest number (52) of species, while the Iron Crown Grassland had the lowest (18). The site with the highest number (3) of tree species was the Ebenezer Dam Nature Reserve. In contrast the Ebenezer Dam Perimeter Grassland had no trees. The Haenertsburg Grassland had the most herbs (22), while the Iron Crown had the fewest (7). Shrubs were most bountiful at the Ebenezer Dam Nature Reserve (11), while they were most scarce at the Iron Crown site (2). All sites had the same number of fern species (3), except for the Iron Crown site, which had only one fern species. The Ebenezer Dam Nature Reserve had more grass species (15), while the Iron Crown had the fewest (6) (Figure 3.14).



EDNR = Ebenezer Dam Nature Reserve Grassland; EDPG = Ebenezer Dam Perimeter Grassland; IC = Iron Crown Grassland; HG = Haenertsburg Grassland.

Figure 3.14 Distribution of the various growth forms in the study area.

Distribution of species by their habit

Herb species was proportionally the most abundant (40%) in the study area, followed by grass species (30%), shrubs (15%), trees (10%), and lastly ferns with 5% (Figure 3.15).

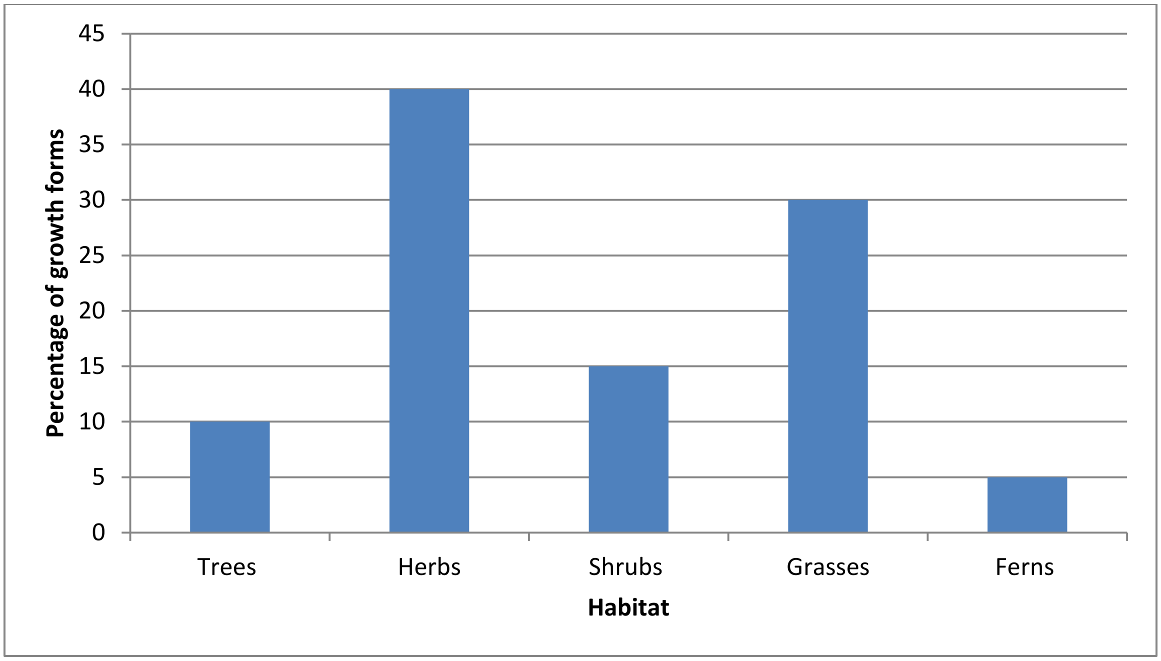


Figure 3.15 Species by their habit in the Woodbush Granite Grassland.

b. Species height

Species in the study area could be classified into the following broad height classes: 2.5 - 6 m for trees, 20 - 140 cm herbs, 30 - 180 cm for shrubs, 30 - 130 cm for ferns, and 30 - 140 cm for grasses. Most of the high trees were found at the Iron Crown Grassland, while the tallest shrubs occurred at the Haenertsburg Grassland. The tallest ferns appeared at the Ebenezer Dam Perimeter Grassland, while the tallest herbs occurred at the Ebenezer Dam Nature Reserve. The tallest grasses occurred at the Iron Crown Grassland and the Haenertsburg Grassland.

c. Canopy cover

All sites had a low tree stratum cover, with no site having more than a 10% tree stratum cover. The highest shrub stratum cover was recorded at the Ebenezer Dam Nature Reserve Grassland and the Haenertsburg Grassland. The Ebenezer Dam Nature Reserve Grassland had the highest herb stratum of all sites.

d. Dominant species

The most dominant grass species in the study area were *Hyparrhenia hirta* and *Panicum natalense*. The most dominant tree was *Searsia pentheri*. *Pteridium aquilinum* was the most dominant fern, *Athrixia phylicoides* the most dominant shrub, and *Helichrysum rugulosum* the most dominant herb.

e. Growth forms

The growth form in all four study sites was found to be very similar; being composed chiefly of grasses and herbs.

3.4.4.3 Species of conservation importance

Out of the 57 identified species, 51 are not endemic to South Africa, leaving only 6 endemics. No species was found to be classified as threatened in the Red Data list, while 3 were not evaluated; 1 with data deficiency taxonomically (DDT), and 53 were classified as Least Concern (LC).

a. Species of medicinal use

Table 3.6 list the species of medicinal use and their use for the Woodbush Granite Grassland. The table indicates that most of the medicinal plants are found at the Haenertsburg Grassland. The site with the lowest number of species of medicinal use was the Iron Crown. Two species that were found on all sites included *Athrixia phylicoides* and *Lippia javanica.*

Table 3.6 Medicinal plants of the Woodbush Granite Grassland (Hemag, 2004; Rampedi, 2010).

Plant species	**Study site**	**Uses**
Aloe ecklonis	EDNR, EDPG and HG	Treat burn wounds
Aloe zebrina	EDNR, EDPG and HG	Treat stomach problems
Athrixia phylicoides	EDNR, EDPG, IC and HG	For use of skin disruptions, cardiovascular disorders, tiredness and respiratory ailments

Berkheya setifera	EDNR, HG	Treat stomach aches
Dicoma zeyheri	HG	Treat chest ailments
Drimia elata	HG	Used for pain relief
Eucomis autumnalis	HG	Treat colic, respiratory and urinary problems
Eulophia ovalis	HG	Treat infertility
Kniphofia splendida	HG	Soothe chest complaints
Lippia javanica	EDNR, EDPG, IC and HG	Medicinal tea used to treat coughs, colds and fever
Mentha aquatica	HG	Treat colds
Scadoxus puniceus	HG	Treat coughs
Scillia natalensis	HG	Used as a birthing aid and leaves are fed to a child who is late in walking

EDNR = Ebenezer Dam Nature Reserve Grassland; EDPG = Ebenezer Dam Perimeter Grassland; IC = Iron Crown Grassland; HG = Haenertsburg Grassland.

3.4.4.4 Identified threats

a. Alien invasive species

The sites found to be at the highest risk of the spread of invasive species was the Haenertsburg Grassland and the Ebenezer Dam Nature Reserve Grassland as they had the highest number of alien invasive species, while the Ebenezer Dam Perimeter Grassland had the lowest risk. Table 3.7 indicates that species in Category 1 are the highest (7), while the lowest were Category 2 (3) species. Species in Category 3 were mainly found at the Haenertsburg Grassland.

Table 3.7 Alien invasive plant species at the Woodbush Granite Grassland.

*__Category 1__ (invader plants must be removed & destroyed immediately)	**Category 2** (Invader plants may be grown under conditions only)	**Category 3** (Invader plants may no longer be planted)
Araujia sericifera (Moth catcher)	*Acacia dealbata* (Silver wattle)	*Cotoneaster pannosus* (Silver-leaf cotoneaster)

Cestum aurantiacum (Orane cestrum)	*Acacia mearnsii* (Black wattle)	*Ipomoea pupurea* (Morning glory)
Cestum elegans (Crimson cestrum)	*Acacia melanoxylon* (Australian blackwood)	*Lingustum lucidum* (Chinese wax-leaved privet)
Lantana camara *(Lantana/ tickberry cherry pie)*		*Lilium formosanum* (Formosa lily)
Rubus cuneifolla (Bramble)		*Lingustum ovalifolium* (California privet)
Sesbania punicea (Red sesbania)		
Solanum mauritianum (Bugweed)		*Pyracantha crenulata* (Himalaya fire thorn)

*CARA classification categories

b. Medicinal plant species collection

Most signs of collection of plants of medicinal use were recorded at the Haenertsburg Grassland and the Iron Crown, while at the Ebenezer Dam Perimeter Grassland there were no signs of collection of plant species.

c. Fire

The sites with the highest risk of fire were the Haenertsburg Grassland and the Ebenezer Dam Nature Reserve Grassland, while the Ebenezer Dam Perimeter Grassland was viewed as having the lowest risk.

d. Urban development

Urban development was another threat identified on the study area. The site with the highest risk of urban development was found to be the Haenertsburg Grassland, while the Ebenezer Dam Nature Reserve and the Ebenezer Dam Perimeter Grassland were under no immediate risk of development.

Table 3.8 summarises the identified threats per site. It indicates that the Haenertsburg Grassland had the highest risk of identified threats, while the Ebenezer Dam Nature Reserve Grassland had the lowest risk of threats.

Table 3.8 Study sites and their identified threats.

	STUDY SITES			
PARAMETERS	Iron Crown Grassland	Haenertsburg Grassland	Ebenezer Dam Nature Reserve Grassland	Ebenezer Dam Perimeter Grassland
Alien invasive				
Medicinal plants collection				
Fire				
Urban development				

The red colour indicates that the site is more at risk under the parameter while the green shows that there is less impact of the parameter on the site.

3.5 DISCUSSION

3.5.1 Area description

The altitude, or elevation of the land with respect to the level of the sea surface, influences plant growth and development. The effect of land elevation on plant growth and development is apparent when exploring a high-rise mountain. Dominance of certain plant types varies with elevation. This was shown in the study by different species found at the Iron Crown (higher altitude) vs. the Ebenezer Dam Nature Reserve (lower altitude).

3.5.2 Vegetation composition

Natural grassland systems throughout South Africa support diverse plant communities. In the present study, herbs dominated the grassland in terms of number of species.

Family diversity of forbs in South African grasslands and savannas is particularly striking. In terms of floristic and vegetation composition in the studied area, Poaceae (Gramineae) and Asteraceae are represented by the highest number of species. A floristic analysis shows that the majority of plants in the study area are perennials, and the minority group is trees. The dominance of members of Poaceae and Asteraceae coincides with the findings reported by Al-Turki and Al-Qlayan (2003), El- Ghanem *et al.* (2010), and Alatar *et al.* (2012). The common species of *E. racemosa-Hyparrhenia hirta* grassland community (for the Haenertsburg Grassland) as described by Mucina and Rutherford (2006) coincides well with common species recorded for the grassland species by this study.

3.5.3 Species of conservation importance

There are endemic species, indigenous plants, medicinal plants and rare plant species, which are in need of conservation in the study area. Endemic species are often endangered due to their limited range, and therefore more severely affected by habitat transformation and degradation. The Woodbush Granite Grassland is known to have 4 endemic plant species (Hemag, 2004), although our study found 6. Conservation of endemic species together with their habitat should be a first priority for biodiversity conservation in the province through the use of a conservation plan for the Woodbush Granite Grassland.

Thirteen species of medicinal use were identified (Table 3.6). These medicinal plant species play a vital role in the primary health care of rural communities around the Haenertsburg area. Medicinal plants are still widely used in the primary health-care system of South Africa, particularly by the African population. According to Mander and Le Breton (2005), there are up to 100 million traditional-remedy consumers in southern Africa and as many as 500,000 traditional healers. Medicinal plants are often a basic requirement for the treatment of certain conditions irrespective of education and income levels (Cocks and Dold, 2000).

The intensive harvesting of wild medicinal plants due to their increasing use has in many places resulted in overexploitation, and forms a serious threat to biodiversity in

Limpopo Province. This could be the case at the Woodbush Granite Grassland. Several studies such as (Mudau *et al*., 2007) attest to a trend of increasing harvesting pressures on traditional supply areas linked to a growing shortage in supply of popular medicinal plant species.

Until recently, biodiversity conservation in South Africa was based on a law enforcement approach, but it has become increasingly evident that this approach has failed and that new, participatory methods are required. In response to the overexploitation of natural populations of medicinal plants, several efforts have been attempted to conserve the diversity of medicinal plants in the past. Two approaches gaining increasing attention are conservation of biodiversity by local community groups (Fabricius *et al.,* 2004) and stimulation of cultivation as a means to relieve the over-exploitation of natural populations (Mander *et al.,* 1996). A first systematic effort to stimulate cultivation of medicinal plants was initiated by the Durban Parks Department in 1983 by establishing a medicinal plant nursery in the Silverglen Nature Reserve (Crouch and Edwards, 2004). Since this initiative, several other efforts have been undertaken to stimulate medicinal plant cultivation through the establishment of medicinal plant nurseries, and this approach could possibly be adopted for conservation of medicinal plants at the Woodbush Granite Grassland.

Athrixia phylicoides leaves has been used by many generations to produce herbal tea and a medicinal decoction in order to treat a wide range of ailments such as headaches, heart disease, vomiting, and skin disorders (Mudau *et al*., 2007). Based on results from Rampedi (2010), *Athrixia phylicoides* is the most important indigenous plant species for tea-making in the Limpopo Province. In the rural areas of South Africa, in particular the Limpopo, Mpumalanga and KwaZulu-Natal provinces, communities use a decoction of the tea to deal with illnesses such as high blood pressure and diabetes (Olivier and Rampedi, 2008). *Athrixia phylicoides* is harvested throughout the year by women in large quantities (Rampedi, 2010).

Lippia javanica (fever tea) is mostly used for brewing traditional and medicinal tea (Rampedi, 2010). Different parts of the plant are used for different applications. The

Xhosa people are known to drink it for treatment of cough, colds and bronchial problems in general (Van Wyk *et al.,* 1997).

3.5.4 Identified threats

Threats to the Woodbush Granite Grassland are the result of spread of alien invasive plants, uncontrolled collection of medicinal plants, veld fires and urban development.

a. Invasive alien species

Alien invasive species have a major impact on biodiversity throughout South Africa and the Limpopo Province is no exception. Invasive alien plants cause land cover transformation- they disrupt ecosystem structure and function and are a threat to the Woodbush Granite Grassland (Richardson *et al.,* 1997). Invasive plants have been ranked alongside deforestation, urbanization, pollution and cultivation as “major agents” of land cover change (Cronk and Fuller, 1995).

The Woodbush Granite Grassland is invaded by a number of alien plants (Mucina and Rutherford, 2006). A number of invasive species were observed in the study area; however, the fern, *Pteridium aquilinum*, was identified as a common invasive plant species on all study sites. This species has the potential to spread further into the grassland; thereby making the Woodbush Granite Grassland even more threatened and in dire need of a proper management plan (refer to Chapter 5). Despite the threat of invasive species invading the area, much of the vegetation, with the exception of the lower slopes, is still in a relatively pristine condition.

b. Collection of medicinal plants

A large percentage of South Africa’s population uses traditional medicine for primary health care. Many traditional medicinal plants are therefore becoming scarcer, thus it is vital that this natural heritage is protected and managed correctly both for present and future generations. Population growth has caused increased harvesting pressure on frequently used natural resources including medicinal plants (Rampedi, 2010), and thus provision of medicinal plants to meet demand has become an environmentally destructive activity (Rampedi, 2010).

Athrixia phylicoides was documented as the most collected species, particularly on the Iron Crown Grassland and Haenertsburg Grassland sites. The hard stems of this species are used for hand brooms, which are major sources of income for rural women (Rampedi, 2010). However, the harvesting of its stems for broom sticks has a devastating impact on the viability of the plant population. This is because harvesters uproot the entire plant (Figure 3.9), thus allowing for no future reproduction. If such harvesting practices proceed unabated, natural populations of this species may be severely reduced.

c. Fire

Natural resource managers and conservationists in the past viewed anthropogenic fires as destructive elements to the vegetation communities (Greg and Jackie, 2004). Anthropogenic fires and uncontrolled fire spread might be damaging to fire sensitive plant communities of the WGG. Humans generally set fires in the grassland, which do more harm to the landscape than benefit it. This is because when uninformed inhabitants set fires at the wrong time and under the wrong environmental conditions, which leads to the destruction of either young shoots or the decimation of basal growth points of grass.

As in most countries with wildfires, the risk can be managed to acceptable levels at acceptable cost, provided a comprehensive approach, based on integrated natural resource management within a proper development planning and management framework, is adopted and applied consistently. South Africa has adopted the National Veld and Forest Fire Act (the Act), No. 101 of 1998 as a major instrument for improved management of veldfires in the country (Woodbush Granite Grassland included).

d. Urban development

The biggest impact that humans have on grassland is by converting pristine areas for urban development. Continued urbanisation in South Africa (including Limpopo Province, and Haenertsburg), and associated urban sprawl, as well as a decrease in household numbers (more houses accommodating fewer people per household) is currently and will continue to place pressure on available and potentially environmentally sensitive land (Department of Environmental Affairs, 2012). Development, through illegal demarcation of land is also a concern as people will take advantage of the availability of grassland areas.

The Haenertsburg Grassland is under threat of urban development; there was an recently an attempted land grab of the natural areas adjacent to Haenertsburg Grassland (Limpopo Department of Economic Development, Environment and Tourism, 2015). These development activities can lead to habitat destruction which have been linked to the extremely high current species extinction rates being experienced worldwide (United Nations Environment Programme, 1995); a terrible situation that the South African grassland is also facing. Clarifying the extent to which any potential conflicts between development potential and conservation importance may occur would allow for more efficient and effective conservation planning by focusing the allocation of limited resources available (Margules and Pressey, 2000).

CHAPTER 4

TRANSFORMATION OF THE WOODBUSH GRANITE GRASSLAND

4.1 INTRODUCTION

4.1.1 Habitat transformation

The grassland biome is heavily utilised by human activities, and faces increasing anthropogenic pressure as the human population increases (Myers *et al.,* 2000; Reyers *et al.,* 2001; Hoekstra *et al.,* 2005). Land-use change and degradation of natural ecosystems are principal causes for losses of biodiversity and ecosystem functions (Sala, 2000). Like other grassy biomes around the world, South Africa's grasslands have been subjected to much human alteration, mostly in the form of conversion to crop land and forestry, but also due to urban expansion and mining activities (Van Wyk, 1998; Mucina and Rutherford, 2006).

The Millennium Ecosystem Assessment highlighted that while most global biomes had lost 20 – 50% of their area to cropland conversion, temperate grasslands lost more than 70% of their natural cover by 1950 and a further 15.4% since then (MEA, 2005b). This makes grasslands one of the greatest conservation priorities globally. The need for conservation action in the grasslands of the world is also reflected by the threatened status of temperate grasslands in the Global 200 eco-regions assessment (Olson and Dinerstein, 1998), as well as the report drawn up by the World Resources Institute in their Pilot Assessment of Global Ecosystems (White *et al.,* 2000), where declines in grassland condition, biodiversity and ecosystem service delivery were highlighted as major concerns.

The grassland biome is the most transformed biome in South Africa, with 30% of the transformation being irreversible (Van Oudtshoorn *et al.,* 2011). Another 30% is only partially degraded by agriculture and bad management practices, or is encroached upon by woody species. The remaining 40% remains relatively pristine. However, fragmentation of grassland patches in South Africa increased drastically in six years between 1994 and 2000 from 4017 patches to 13503, while average patch size decreased substantially from 44.5 km^2 to only 13.75 km^2 (Matsika, 2007). Transformation of this magnitude has made grasslands the most threatened biome in South Africa (Van Wyk, 1998).

Transformations include both changes in area and patch configuration. Such changes over time lead to different stages: incision, perforation, dissection, dissipation, shrinkage and attrition (Forman, 1995). The degree of fragmentation provides critical information to infer ecosystem changes, even when the details of all ecological process affected are unknown (O'Neill *et al*., 1997). Such changes have important consequences on biodiversity, as well as water and carbon fluxes, both at local and regional levels (Herkert *et al.,* 2003). Landscape fragmentation studies have been mostly concentrated in forests (Roy and Tomar, 2000; Riitters *et al.,* 2002), but this kind of analysis has been extended to other natural systems, such as shrub lands (Kemper *et al.,* 2000), grasslands (Coppedge *et al*., 2002; Egbert *et al*., 2002) and even aquatic environments (Bell *et al.,* 2001). The relatively small number of studies on grassland fragmentation might be due not only to the long history of land cover conversion of these systems, but also to the traditional lack of recognition of the conservation value of grasslands (Baldi *et al*., 2006).

4.1.2 Habitat fragmentation

Human land use activities have had a high impact upon the available natural resource base, resulting in widespread land-cover transformation (Neke and Du Plessis, 2004, Reyers *et al.,* 2005. Habitat transformation leads to fragmentation and isolation of populations, which can lead to the breakdown of metapopulations (Hanski, 1998). Fragmentation is a phenomenon that may occur as a result of habitat loss but it is also a complex naturally occurring landscape scale "process in and of itself" (McGarigal and McComb, 1995, Fahrig, 2003). Fragmentation involves the transformation of large, contiguous habitats into a number of smaller, increasingly isolated patches that are separated from each other by a matrix of habitats different to the original, with a decrease in the total area of the original habitat (Wilcove *et al.,* 1986; McGarigal *et al.,* 2002). Fragmentation changes the spatial configuration of that landscape (Fahrig, 2003), and therefore alters the specific properties of that ecosystem that make it suitable for associated floral and faunal species to persist. Increased edge effects, decreased patch areas, and therefore smaller available home ranges (Bender *et al.,* 1998), decreased connectivity and increased isolation between the remaining patches are all associated with habitat fragmentation (Fahrig, 2003). The implications of on-going fragmentation are not the same for all species; the changes in the landscape create artificial selective pressures that are hostile to specialist, large-bodied species (Harrison and Bruna, 1999), and favourable to smaller, edge-specialist or habitat generalist species (Gibbs and Stanton, 2005).

4.2 SPECIFIC PURPOSE OF STUDY

4.2.1 Aim

Identify areas of the Woodbush Granite Grassland that have been transformed.

4.2.2 Objective

To map and quantify the primary contributors of transformation to the Woodbush Granite Grassland.

4.3 MATERIALS AND METHODS

4.3.1 Extent of the Woodbush Granite Grassland

The Desmet modelled extent of the Woodbush Granite Grassland was used. The modelled Woodbush Granite Grassland boundary original extent was taken directly from Desmet *et al.* (2013), in the Limpopo Bioregional Assessment.

4.3.2 Data preparation

The 10 m resolution GeoTerraImage (GTI) land cover data for Limpopo from 2008/2009 were extracted for the Woodbush Granite Grassland, using the Woodbush Granite Grassland boundary modelled in Desmet *et al.* (2013) as a mask. Five categories of transformation were defined (Table 4.1). Data were extracted and aggregated from the land cover in the 5 categories using Quantum GIS's raster calculator, and vectorised using the QGIS polygonize function. Data were converted to Africa Lambert's Conformal Conic projection (EPSG: 102024), and area was calculated in square kilometres and hectares in this projection, before converting the final vector to WGS84 geographic projection (EPSG: 4326).

Table 4.1 Categories of transformation derived from GTI 2013 Land Cover data.

Categories	**Constituent Land Cover Classes**
Plantation	Plantation: woodlots; clear-felled vegetation; woodlots & plantation; plantation: pine; plantation: eucalyptus
Cultivation	Greenhouse shadecloth; cultivation: pivot old field; cultivation: pivot recent crop; cultivation: subsistence; cultivation: old fields; cultivation: recently cropped all; cultivation: feedlots; chicken/pig batteries; cultivation: orchards; smallholdings
Dams	Man-made water
Human settlement	Golf course; sports fields; urban: new development; urban: commercial; urban: industrial/transport; urban: residential; urban: rural cluster (low density); urban: built-up other; township: formal; township informal; urban landfills; airstrips
Mining	Mines-quarries: pits; mines-quarries: tailings

4.4 RESULTS

4.4.1 Plantations

Plantations (Plantation: woodlots; clear-felled vegetation; woodlots and plantation; plantation: pine; plantation: eucalyptus) are the leading contributors to transformation of the Woodbush Granite Grassland. Figure 4.1 presents plantation activities on the Woodbush Granite Grassland.

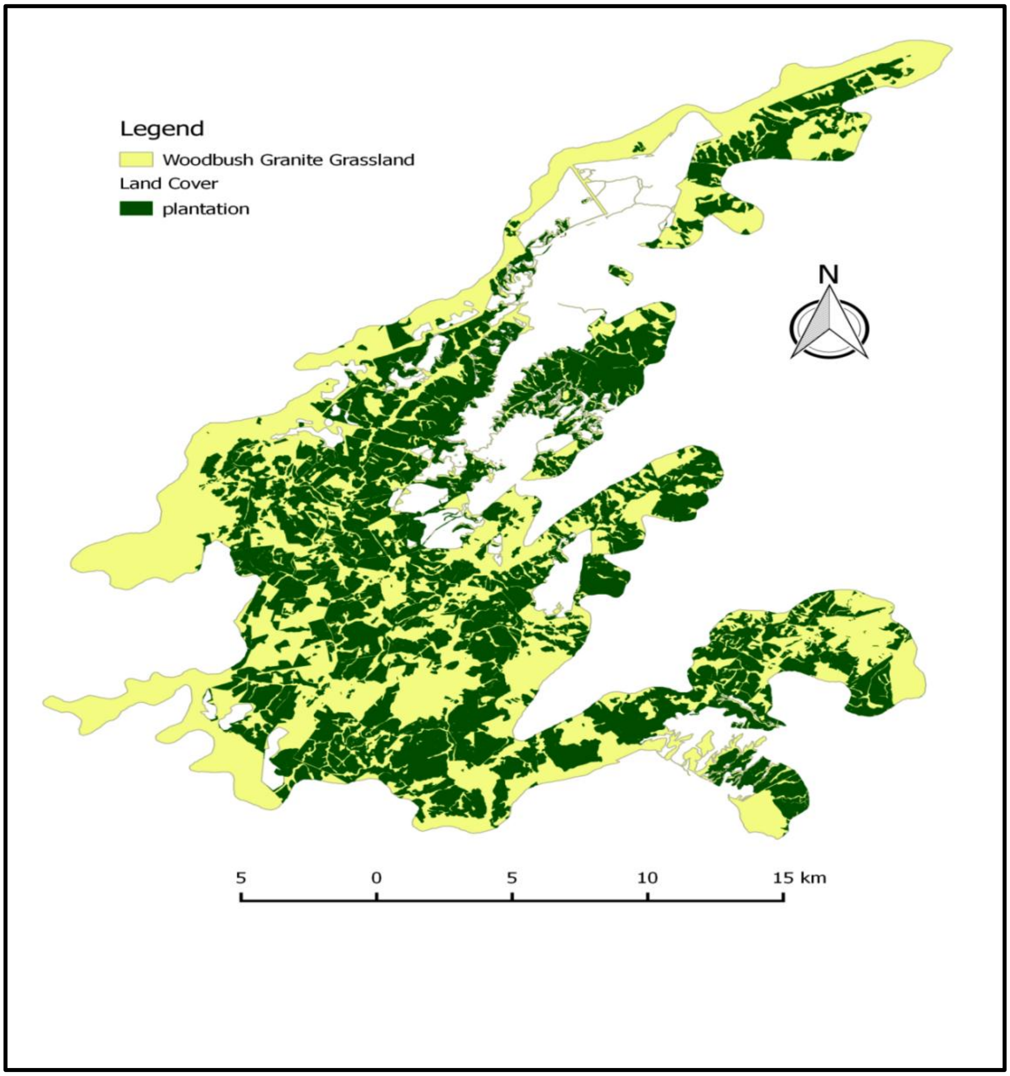


Figure 4.1 Plantation cover on the Woodbush Granite Grassland.

4.4.2 Cultivation

There are several patches within the Woodbush Granite Grassland where cultivation activities are practiced, including old fields of cultivation to recently cropped areas (Figure 4.2).

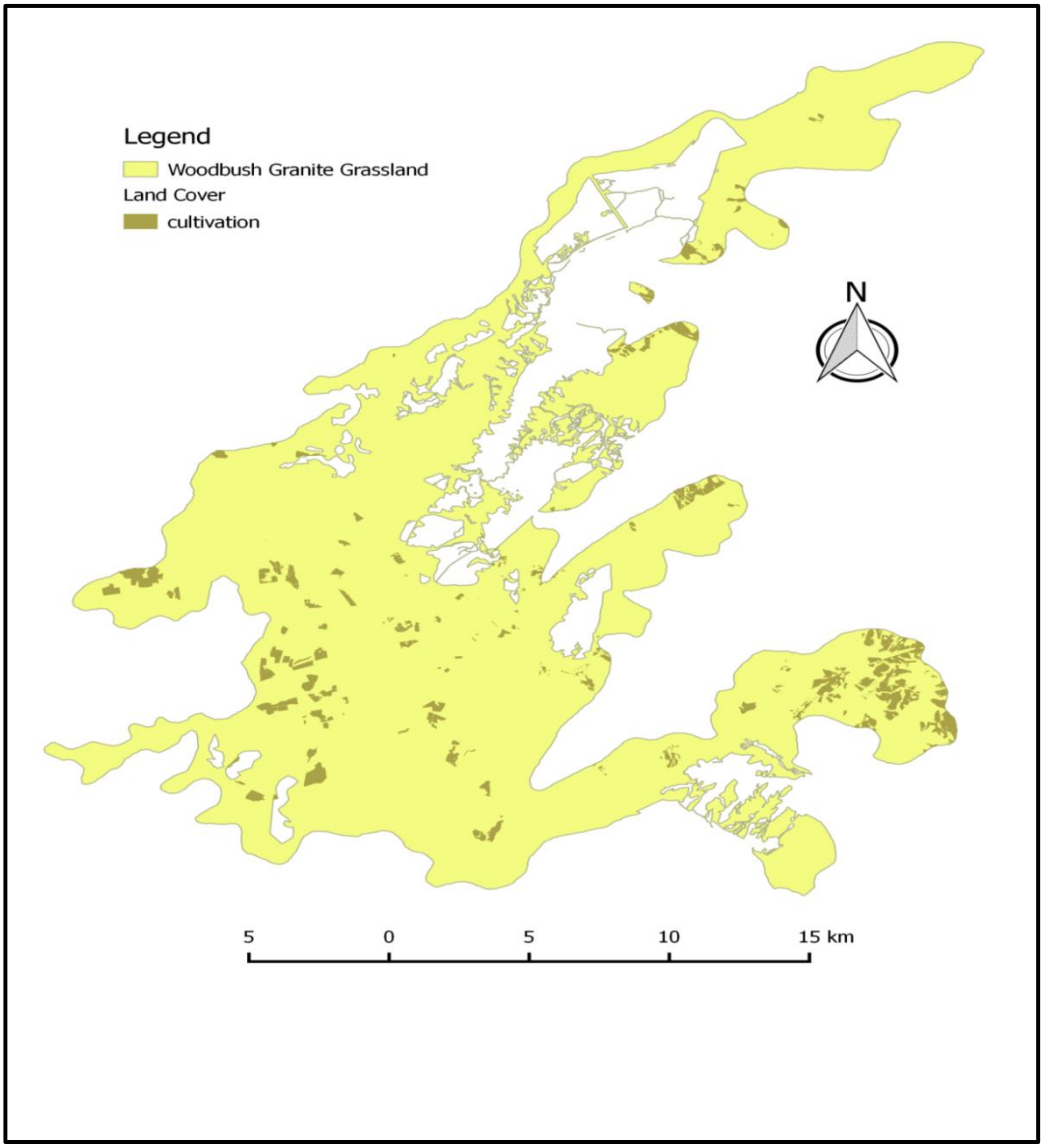


Figure 4.2 Cultivation on the Woodbush Granite Grassland.

4.4.3 Dams

As indicated in Chapter 2, there are water bodies in the Woodbush Granite Grassland with two natural springs on the Haenertsburg Grassland that feed into the Ebenezer Dam, which is an important water storage dam for the entire area (Figure 4.3).

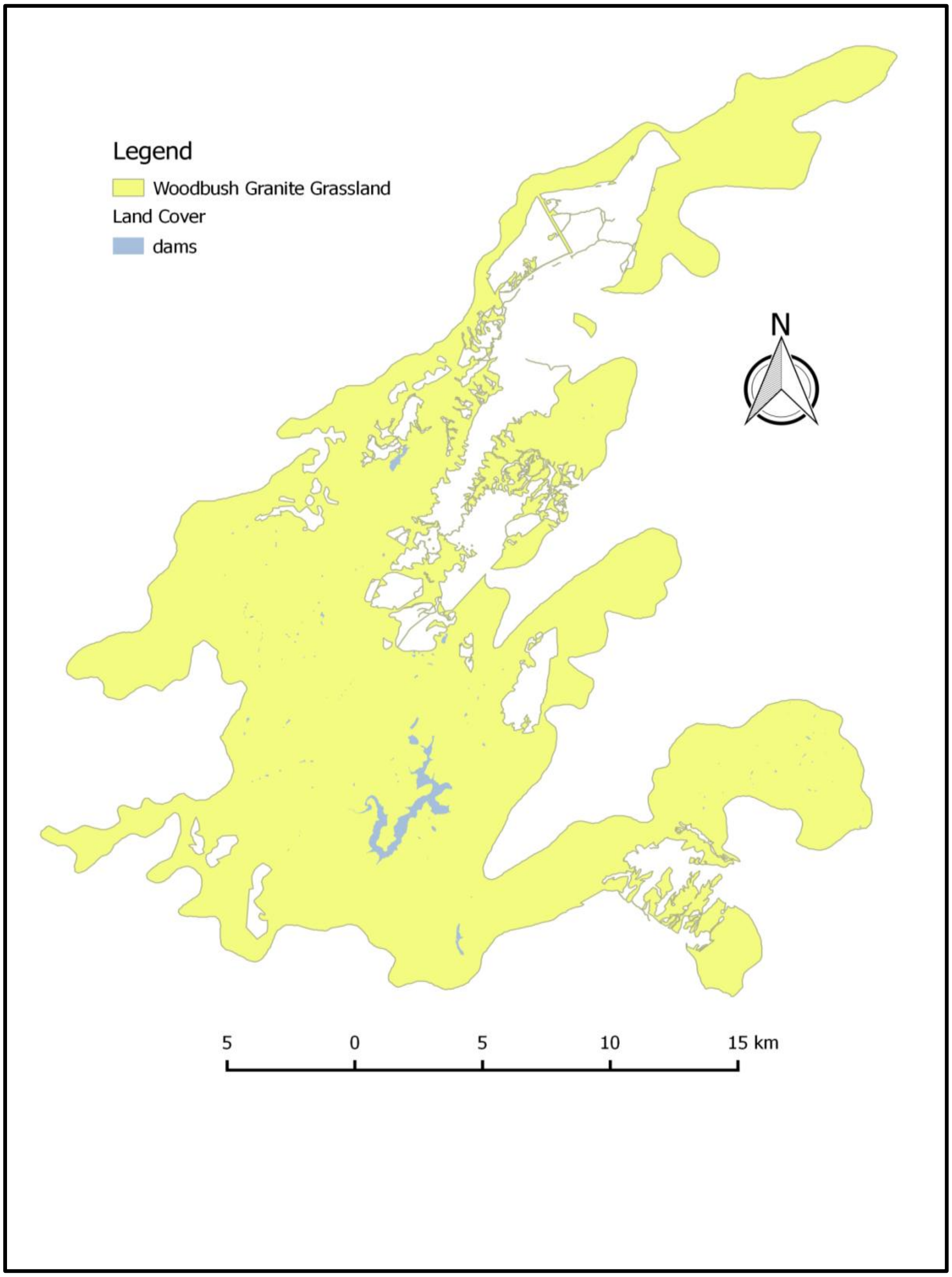


Figure 4.3 Dams of the Woodbush Granite Grassland.

4.4.4 Human settlement

The human settlement cover at the Woodbush Granite Grassland is indicated in Figure 4.4.

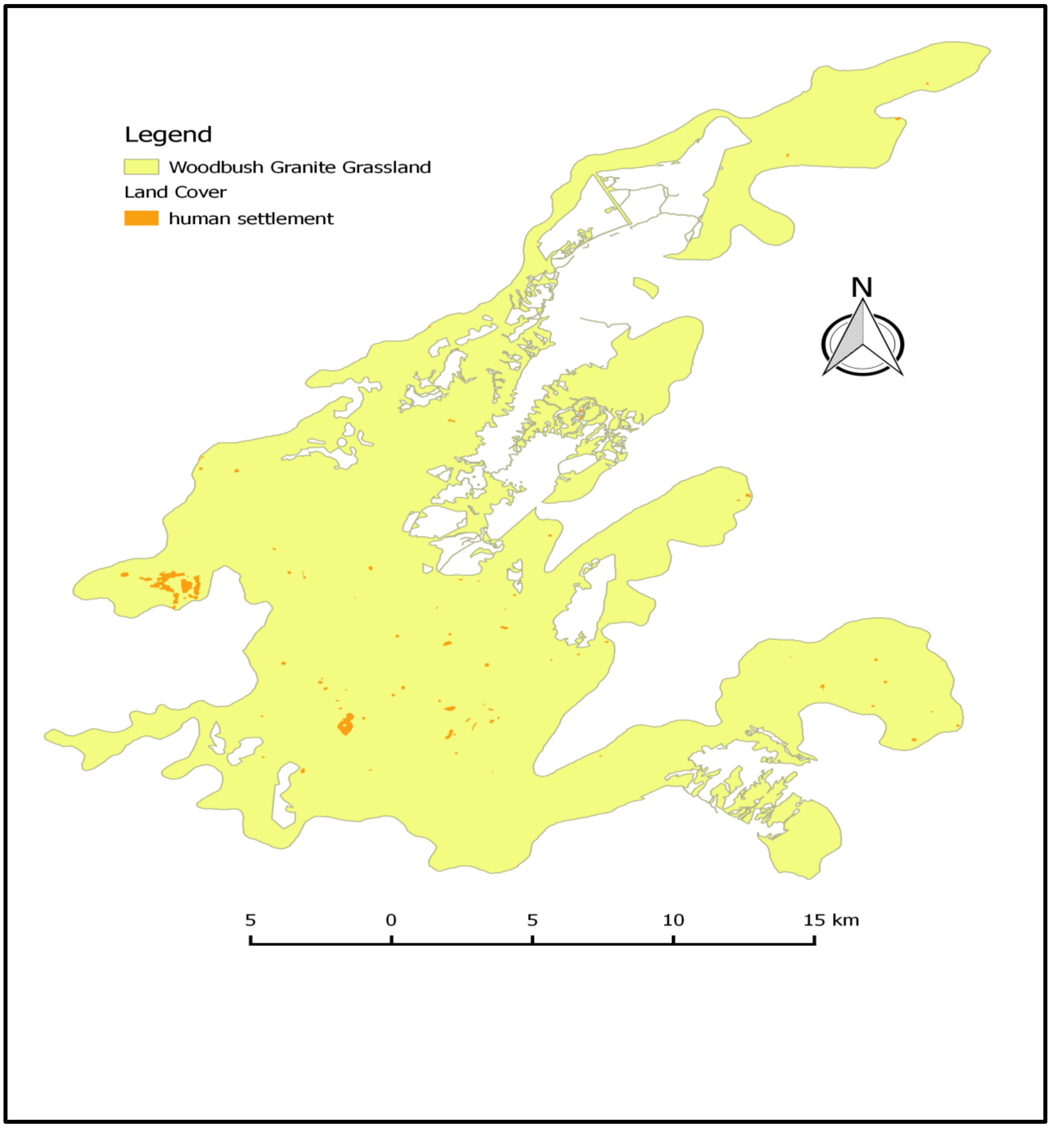


Figure 4.4 Human settlements on the Woodbush Granite Grassland.

4.4.5 Mining

The arrow shows a portion on the Woodbush Granite Grassland where mining activities occurs (Figure 4.5).

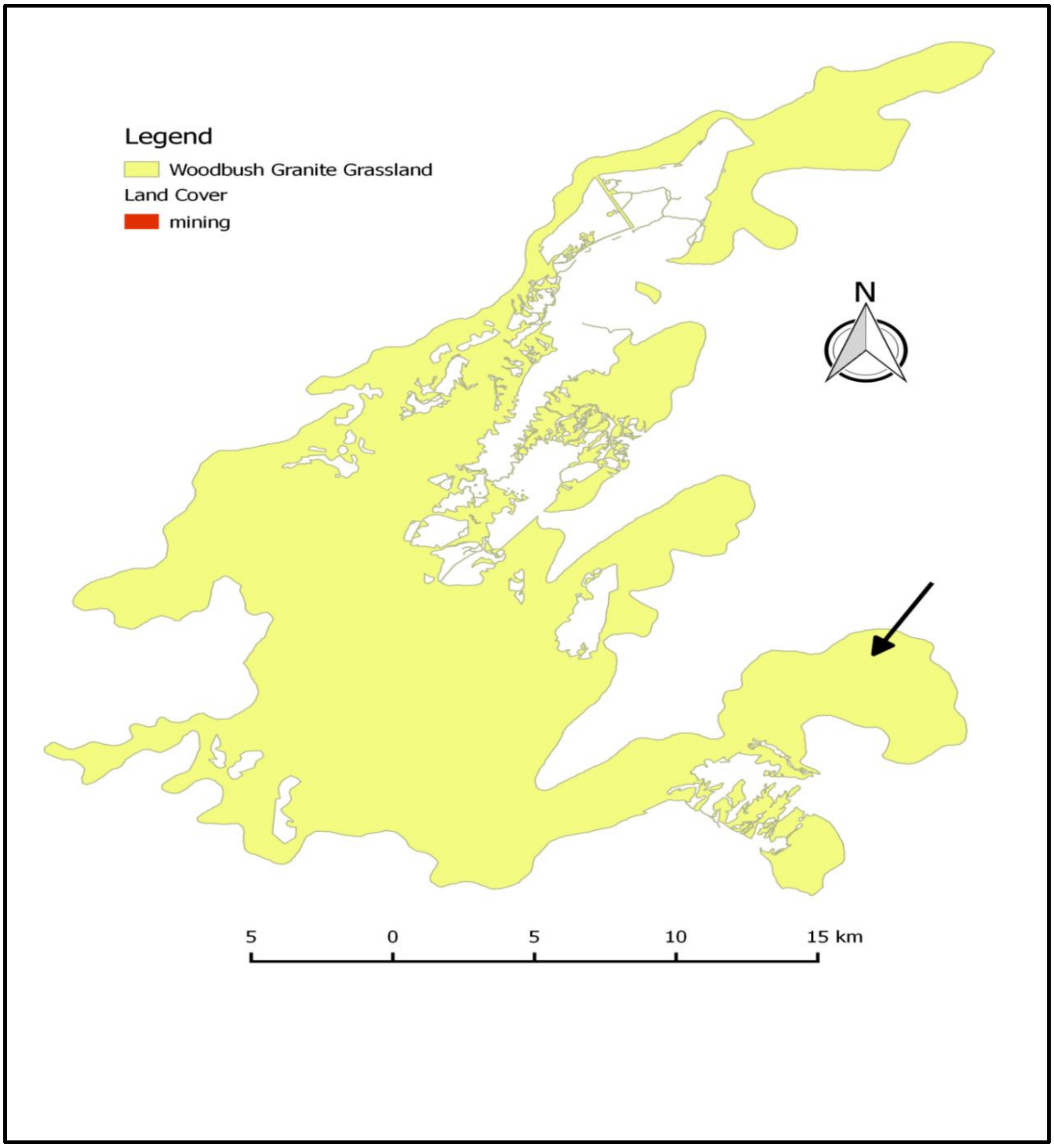


Figure 4.5 Arrow indicates mining on the Woodbush Granite Grassland.

4.4.6 Transformation activities

Figure 4.6 shows the extent of total transformation and land cover categories that have contributed to transformation of the Woodbush Granite Grassland.

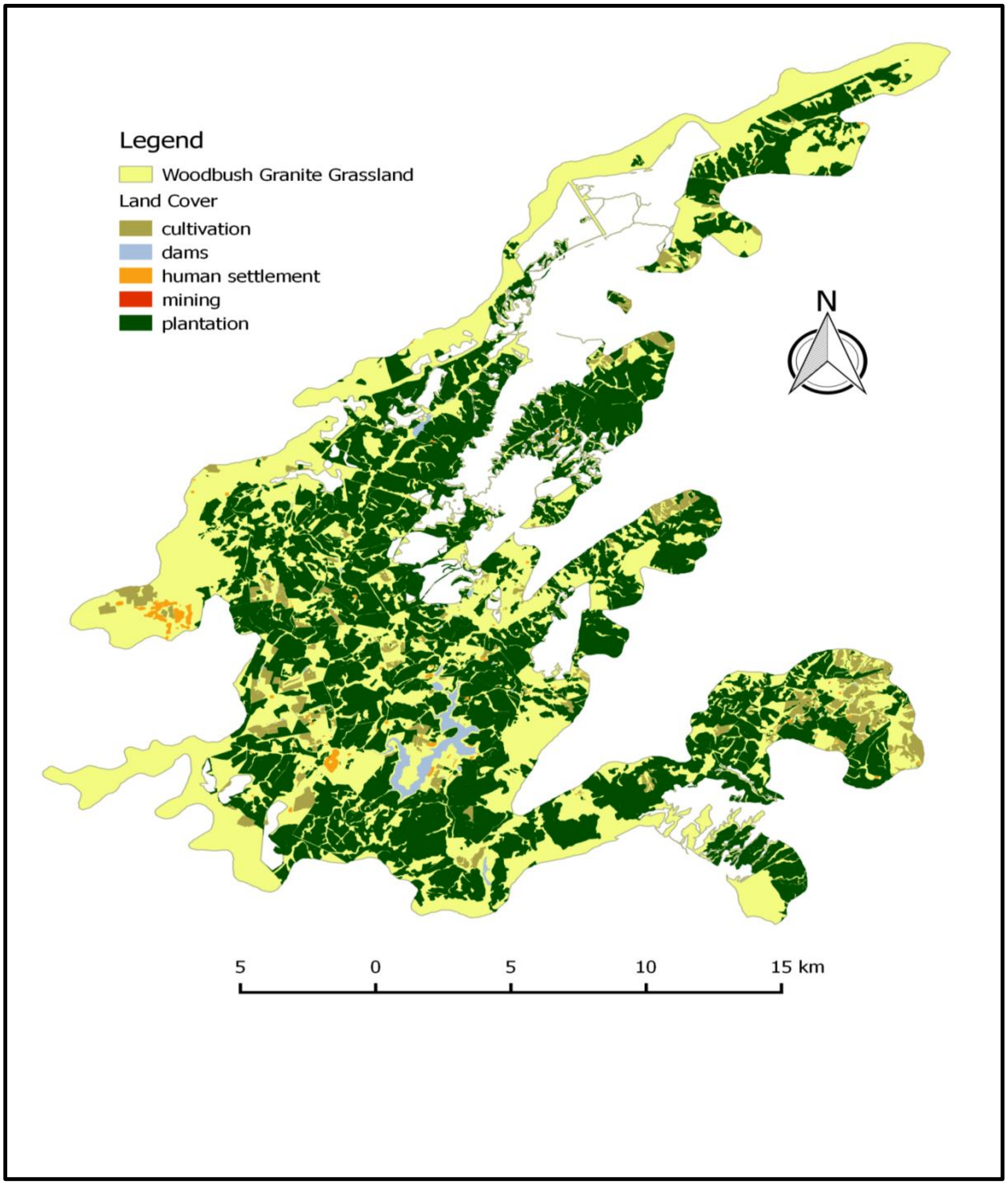


Figure 4.6 Land cover contributing to transformation of the Woodbush Granite Grassland.

4.4.7 The Woodbush Granite Grassland land cover

The grassland land class transformations area were further analysed and the results are presented below on Table 4.2 and Figure 4.7. The area was calculated in square kilometres and hectares that plantation, cultivation, human settlement, dams and mining covered on the Woodbush Granite Grassland, with plantations inhabiting a large portion of the Woodbush Granite Grassland and mining being the lowest contributor on transformation of the Woodbush Granite Grassland. Plantations now cover much of what was mountain grassland in the past.

Table 4.2 Land cover classification that contributes to transformation of the Woodbush Granite Grassland.

Land Cover	**Area (ha)**	**Area (km^2)**	**Percentage (%)**
Plantation	20091.43	200.914341	49.21
Cultivation	1805.23	18.052314	4.42
Dams	434.98	4.349775	1.065
Human settlement	225.92	2.259212	0.55
Mining	0.47	0.004650	0.001
Total			55.246

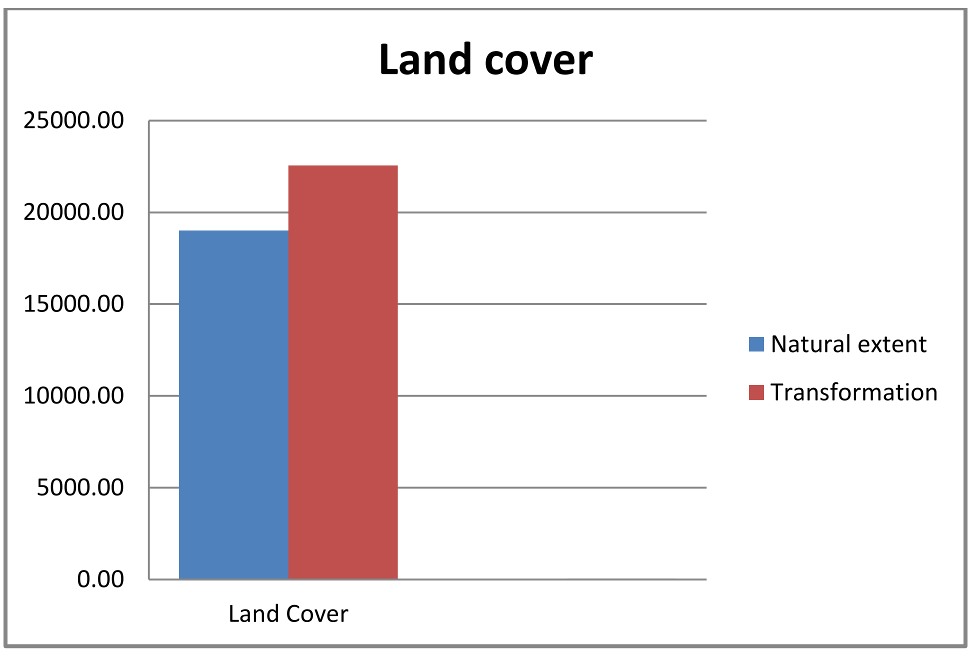


Figure 4.7 Total transformation of the Woodbush Granite Grassland.

4.5 DISCUSSION

4.5.1 Plantations

Afforestation is of particular threat to South African grasslands, because much of the area with the highest levels of biodiversity largely overlaps with the most suitable areas for commercial timber plantations (Allan *et al*., 1997; Neke and Du Plessis, 2004). By 2004, 3.3% of South Africa's grasslands had already been cleared and planted with alien eucalyptus and pine trees (Neke and Du Plessis, 2004), a number which may now have increased. Transformation of Woodbush Granite Grassland has been extensive, mainly due to exotic plantations and to a lesser degree agriculture and urban development (Wessels *et al.,* 2003; Mucina and Rutherford, 2006); in this study plantations transformed a calculated 20091.43 ha of the area, which is irreversible.

Globally, commercial forestry is a rapidly expanding and well-known threat to biodiversity (Rouget *et al*., 2003; Brokerhoff *et al.*, 2008). The continued growth of plantation forestry is a risk to global biodiversity as the plantations themselves contribute little to biodiversity (Pryke and Samways, 2009; Bremer and Farley, 2010), and further expansion of plantations into the Woodbush Granite Grassland is not desired as this will lead to loss of this ecosystem.

4.5.2 Cultivation

Cultivation has played a lesser role in transforming the grassland in the past (Mucina and Rutherford, 2006), and the study attested to this as cultivation contributed a low 1805.23 ha of transformation. But it is now competing with conservation as a land-use on the few remaining intact Woodbush Granite Grassland patches.

4.5.3 Dams

Changes in the landscape structure have direct consequences on energy and water exchange between the surface and the atmosphere (Pielke and Avissar, 1990; Guerschman *et al.,* 2003). Such changes impact the provision of ecosystems goods and services, as biodiversity maintenance and carbon sequestration (Daily *et al.,* 2000). This biome contains a wealth of resources that have potential to be and most of which are currently being exploited for economic benefit in any number of ways. About 434.98 ha of dams contributed to transformation.

4.5.4 Human settlement

The tendency for human settlements to coincide with areas of high species richness has been well documented in the literature (Fairbanks and Benn 2000; Balmford *et al*., 2001; Fairbanks *et al.,* 2002). These areas should be considered as areas of vulnerability that should be red flagged for conservation action (Ricketts and Imhoff, 2003). Much of the Earth's surface has been transformed by human activities involving extensive destruction of natural habitat, and even where habitats remain, they are often degraded with assemblage structures that have been exploited and altered (Gaston *et al.,* 2008). This scenario also applies to the Woodbush Granite Grassland as 225.92 ha of the grassland has been transformed for human settlement. The Haenertsburg Grassland could face urban expansion in the future which would mean more of the grassland will be transformed. Human populations have settled and expanded in the region, causing further transformation and destruction to this vegetation's biodiversity (Reyers and Tosh, 2003; O'Connor and Kuyler, 2009).

Human land use activities have had a high impact upon the available natural resource base resulting in widespread land-cover transformation (Neke & du Plessis, 2004, Reyers *et al.,* 2005). This vegetation is resource rich and provides a wide range of ecosystem services that facilitated human settlement in the area in the past (O'Conner & Bredenkamp 1997; Reyers *et al.,* 2005).

4.5.5 Mining

Agriculture, afforestation, urban expansion and mining are the main drivers of grassland loss (Matsika, 2007). These include large coal and diamond deposits, gold fields and agriculturally productive land (SANBI, 2006). From the results presented, mining activities has contributed very little in transformation with just 0.47 ha. The grassland habitat lost to mining activities is small when compared with the other land cover classes.

4.5.6 The implications of land cover change for grassland conservation

One of the consequences of land cover change is that natural vegetation, and thus the habitat for native species, diminishes and becomes fragmented (Ellis *et al.,* 2010). When this occurs three processes which are closely intertwined take place: habitat loss, i.e. there is considerable reduction in the total amount of original habitat; division of the remaining habitat into smaller units, often patches (habitat fragmentation); and the formation of new land-use types which replace the former vegetation (Fahrig, 2003; Bennett and Saunders, 2010). As patch size decreases, species richness may decline (Bennett and Saunders, 2010) because patches have become smaller than the minimum area required for sustaining populations or individuals of species with larger range requirements (Nol *et al.,* 2005); consequently, in smaller patches many species may be absent.

It is not enough to merely identify the presence or absence of grassland degradation or to confirm or refute predictions of transformation within the grassland biome; it is also important to fit this new information into the context of conservation planning.

CHAPTER 5

MANAGEMENT RECOMMENDATION PLAN

5.1 INTRODUCTION

As the pressure of human activities increases on the natural environment, further conservation efforts are needed to sustain the increasingly fragmented natural landscape. Included in these efforts are the developments of better land use management practices that mitigate degradation and promote diversity. The purpose of a management plan for the Woodbush Granite Grassland is to conserve what is left of the grassland as the area is mostly natural, with few management issues. The proposed management plan will assist with practical recommendations and strategies specifically tailored to the Woodbush Granite Grassland. The recommendations should reduce the negative impacts on the Woodbush Granite Grassland, and stabilize the ecological condition of the Woodbush Granite Grassland.

Balancing resource conservation and utilisation is crucial in the formulation of resource management strategies. According to Sola (2005), sustainable resource use should be based on socially responsible economic development, whilst promoting the resource base as well as the status of the ecosystem. The formulation of management plans should attempt to establish, monitor and manage this equilibrium with an adaptive management strategy as the basis.

South Africa has one of the world's greatest diversity of plant and animal species contained within one country, and is home to many indigenous species. Terrestrial resources are, however, rapidly disappearing, due to conversion of natural habitat for farmland, forestry, human settlement and industrial development. Some species are under threat from over-collection for medicinal, ornamental and horticultural purposes (Department of Environmental Affairs and Tourism, 2004).

The loss of biodiversity through lack of management, mainly from habitat destruction, represents a serious threat. Protected areas, which contribute to the conservation of biodiversity, are often poorly planned and managed. In many instances, local communities have no control over land and biotic resources, and do not share in economic and other benefits derived from their use.

Grassland management keeps grass stands healthy so they continue to provide long term ecological conservation benefits (Uys, 2006). A management plan for the Woodbush Granite Grassland is proposed to mitigate the identified threats on Chapter 3.

5.2 SPECIFIC PURPOSE OF THE STUDY

5.2.1 Aim

Provide a management plan required for maintenance of the Woodbush Granite Grassland.

5.2.2 Objective

Management of threats identified during the study survey.

5.3 WORK PLAN

a. The management system should be implemented through the listed below steps.

Step 1: Strategic discussion and consultation

It involves consultation and identification of the resource problem, its cause(s) and the development of management objectives. All stakeholders such as local people and specialists (environmentalists) (Grundy, 2000; Maundu *et al*., 2001), relevant departments, funding organizations and relevant NGO's need to be consulted (Yeatman, 2004). This step helps in the generation of ideas on how the identified problems could be solved. The roles and responsibilities of villagers, traditional authorities, municipalities, government departments and donors need to be clearly stated and agreed upon. It is upon this step that the criteria, indicators or measures of the problem is developed or adopted (CIFOR C and I Team, 1999; Institute of Natural Resource, 2002).

Step 2: Assessment

Data is gathered and assessed to identify the nature and extent of the resource problem. The problem could be short or long term and, its extent could range from local, provincial or national. It also involves the assessment of financial and human resources required to implement the management plan. This step is undertaken with resource users and staff. Problem and pattern of resource use need to be presented to the wider community (Yeatman, 2004).

Step 3: Development of remedial strategies

This step is based on available resources. The strategies need to aim at meeting the objectives of the plan and be cost effective, practicable, and informative and address benefits sharing mechanism and the socio-economic welfare of the local people. All stakeholders need to be available during this stage (Department of Environmental Affairs and Tourism, 1997).

Step 4: Evaluation

This is the process of evaluating strategy to be implemented based on the information obtained in Step 3. A plan of action can be developed and the people responsible for implementation of the plan could be determined (Miller *et al*., 1995).

Step 5: Awareness campaign

Information can be disseminated through workshops and community meetings (Skottke and Mauambeta, 2000), and the local media (radio, newspapers) (Diouf, 1995).

Step 6: Implementation

The implementation of the remedial action(s) for the suggested strategy needs to be in accordance with the plan (Integrated Sustainable Rural Development Strategy, 2000) (Step 2). Agreements of the plan need also to identify those responsible for implementation (Yeatman, 2004). It is essential that human capacity to implement the remedial option(s) to encourage community participation (United Nations convention to combat desertification, 1994), and to enhance their socio-economic development (Kapungwe, 2000).

Step 7: Monitoring

This stage involves detecting and measuring changes in the biodiversity and to evaluate the successes and failures of strategies (Miller *et al*., 1995). Monitoring can help in the identification of adverse impacts and the remedial actions can be taken (Department of Environmental Affairs and Tourism, 1997). However, monitoring need to be based on the criteria, indicators and measures developed at Step 1.

If the strategy implemented is not effective enough it will require answering “how” it can be effective, which involves the development of strategies (Step 3), but if the strategy is effective in addressing the problem, monitoring should continue. As the process of monitoring continues, reports about the status of the resources need to be written to identify gaps in the plan. Solutions and future predictions should also be achieved (Department of Environmental Affairs and Tourism, 1997).

b. Management plan

Figure 5.1 shows summary flow of the proposed management plan of identified threats of the Woodbush Granite Grassland.

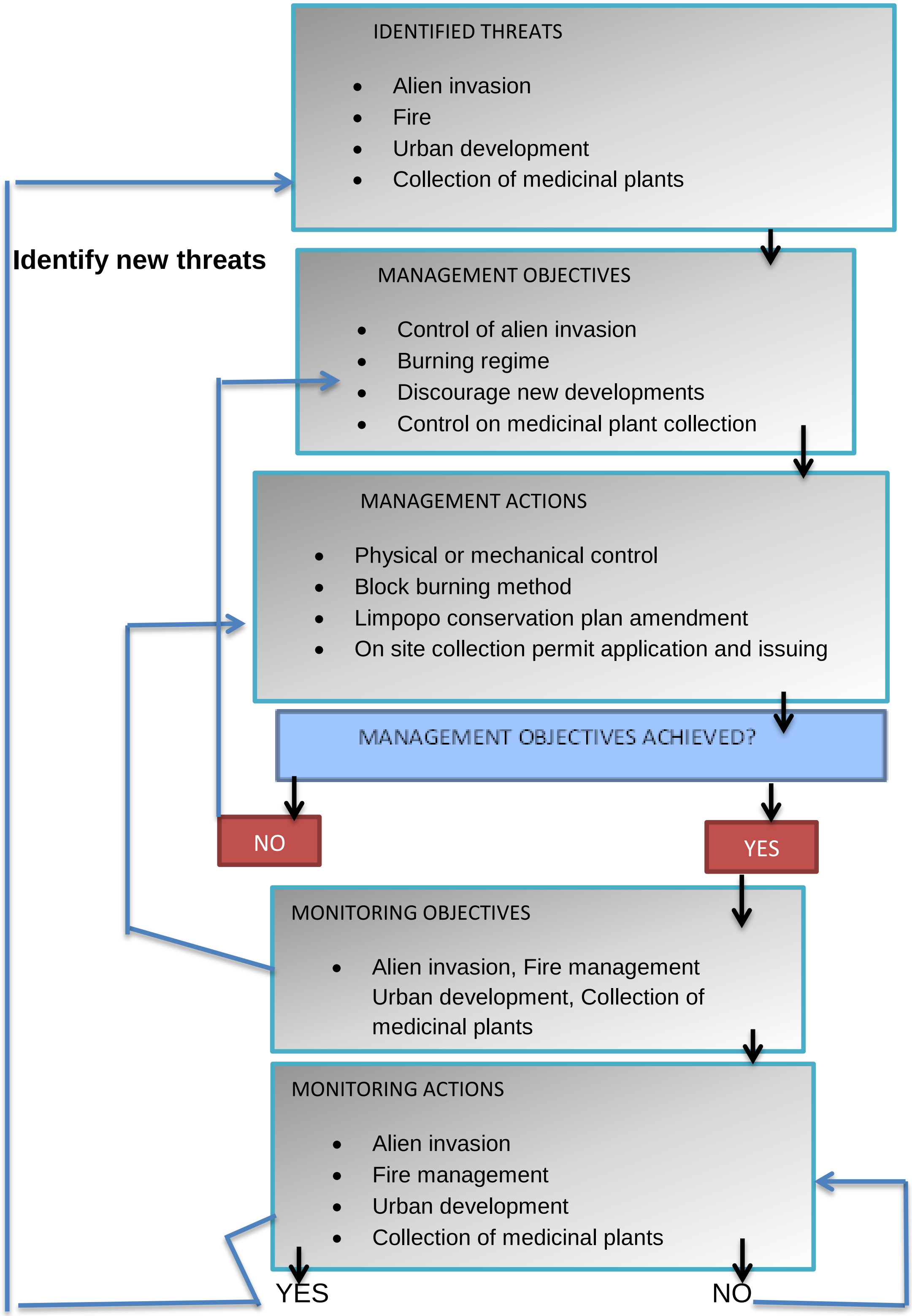


Figure 5.1 Flow chart of the management plan.

5.4 THREATS AND MANAGEMENT ACTIONS

5.4.1 Iron Crown Grassland

5.4.1.1 Alien invasive species

Invasion by alien fauna and flora is a major problem in South Africa, with over 8% of South Africa having been invaded by alien vegetation (Department of Environmental Affairs and Tourism, 2004). Alien organisms can replace large numbers (even whole populations) of native species, and use greater quantities of scarce water resources than indigenous vegetation (Department of Environmental Affairs and Tourism, 2004).

The invader plants and seeds spread rapidly and compete for the growing space of indigenous plants. Many invasive plants are also responsible for hot fires and affect the makeup of the soil structure (Wynberg, 2002). Alien invasive species also threatens the biological diversity by outcompeting endemic species and ultimately homogenous vegetation.

The areas that should be avoided when controlling the *Pteridium aquilinum* are sites where there is little benefit from control and where *Pteridium aquilinum* forms a substitute woodland community, supporting interesting plants and insects, steep sites with deep *Pteridium aquilinum* litter and little opportunity for the recovery of vegetation following treatment. It is therefore advisable to observe *Pteridium aquilinum* at the Iron Crown Grassland before taking any action.

5.4.1.2 Medicinal plant species collection

In the context of major threats posed to natural habitats and the survival of particular species by agricultural expansion, deforestation, and so on, over-exploitation of traditional medicines is occurring. Subject to uncertainties in demographic and urbanization trends, the demand for traditional medicines is set to rise, putting increasing pressures on remaining areas of natural vegetation. In order to ensure that representative wild populations of vulnerable medicinal plant species are maintained, core conservation areas or other protected habitats that will allow natural processes to continue undisturbed by human activities should be designated.

Since many traditional medicinal plants are becoming scarce in other parts of the country, it is therefore important to protect and manage this natural heritage correctly, both for the present and future generations. There are species of medicinal use (importance) in the Woodbush Granite Grassland as confirmed by results in Chapter 3, and therefore there is a need for conservation of those plant species that are being collected as over-exploitation could occur.

a. Management action

I. Regulation for collection

Collection of medicinal plants from the Woodbush Granite Grassland should be regulated. Collectors must have or seek permission for harvesting or collecting medicinal plants on the grassland from appropriate authorities. Regulators therefore check harvesting techniques, availability and public interest in medicinal plants.

b. Monitoring actions

Use of permits to monitor which species, their use and how they are collected. A social approach to quantify use and population monitoring, mapping, demographics of utilized species may be used to monitor medicinal plants collection.

5.4.1.3 Fire

Fire has always played a crucial role in the maintenance of grassland and is considered the most important and dominant driving forces maintaining the grassland ecosystem. Fire can, however, cause degradation, particularly if too frequent burning takes place, or if there is build-up of excessive fuel loads, which results in destructive hot fires. The absence of fire is also detrimental. Large areas of grasslands of southern Africa suffer bush encroachment largely due to the absence of fire, or infrequent burning regimes (Envirodel, 2004).

a. Management actions

Burning should rather be done depending on rainfall / plant growth, varying in season / type of fire, i.e. emulate natural fires leaving some unburned patches, and monitor the grassland.

b. Monitoring actions

Monitoring should be done by keeping records of controlled and accidental fires, so as to know when the right time to burn is.

5.4.2 Haenertsburg Grassland

5.4.2.1 Alien invasive species

The Haenertsburg Grassland site had the highest number on invasive plants, and of major concern is *Pteridium aquilinum* which requires constant monitoring to avoid further spreading into the grassland. Management plan will focus on eradication of *Pteridium aquilinum* as shown in Chapter 3 results, as being the most dominant invasive plant species on all study sites.

The *Pteridium aquilinum* (Bracken) is a vigorous and aggressive fern, spreading rapidly by means of strong underground stems or rhizomes, it is a major weed in many upland and upland margin areas, causing management problems in agriculture, forestry and conservation. Key reasons for managing *Pteridium aquilinum* are to safeguard valuable species that may be shaded out and swamped by litter, and avoid further spread into the grassland. Control of *Pteridium aquilinum* is appropriate in circumstances where it is already invading unimproved grassland of conservation interest, and where there is a dense patch of *Pteridium aquilinum* which may colonise adjacent areas of unimproved grassland, and therefore it must be controlled at the Woodbush Granite Grassland.

Management actions

There are two main different approaches to control the *Pteridium aquilinum*; chemical control and physical control. Factors to consider when assessing the suitability of various *Pteridium aquilinum* control methods include slope, cover, underlying vegetation, litter and the nature of the rhizome system. - *Pteridium aquilinum* control on these sites can lead to severe erosion.

a. Management actions

The main approach recommended for this study area is the physical control because there are water sources in the study area and therefore the use of chemicals is not advisable. Physical methods of control should be the first option for small areas of bracken or light infestations, particularly as they are less likely than chemical methods to harm livestock, and non-target species.

Control of *Pteridium aquilinum* is not achieved instantly. It is a long-term management process, requiring monitoring followed by repeated follow-up control. Control should not be done without considering what vegetation might replace it, as *Pteridium aquilinum* cover closes and litter accumulates, fewer plant species are able to persist.

Physical control involves the cutting or crushing of growing fronds so that the surviving rhizomes are gradually starved. This involves a long-term approach but has the potential advantage of lower cost and is less dependent on weather conditions. Furthermore it does not damage non-target plant species. The aim is to cut twice each season. First cut when the *Pteridium aquilinum* is about 50-75 cm high and again six weeks later. This biannual cutting is likely to be required for at least 3 years. Cutting will need to be repeated when the *Pteridium aquilinum* shows signs of recovery. Complete eradication will not be achieved by cutting alone. Burning of *Pteridium aquilinum* litter is useful to ease cultivation and seeding success. Burning of dead litter without follow up is of no benefit, creates an unnecessary fire risk and may increase frond production.

Cutting or crushing can easily damage sensitive archaeological sites and is a threat to ground-nesting birds. Archaeological features should be marked and these areas dealt with by hand. Where ground-nesting birds occur, either avoid treatment during the nesting and fledging period; consider other forms of bracken control or retain the stand of bracken for its value as a nesting habitat and concentrate efforts on other areas.

b. Monitoring actions

Without effective aftercare, *Pteridium aquilinum* will stage a rapid come-back. Regenerating fronds or areas missed during initial control must be brought under control.

A public awareness campaign should be initiated amongst residents and local schools on invasive plants. The Haenertsburg Primary School and neighbouring farms must be encouraged to apply to get stakeholders such as LEDET, DWS, and WfW to assist in clearing invasive plants on the grassland and Department of Agriculture, Forestry and Fisheries for donations of indigenous plants to replace alien plants at their gardens and the graveyard.

5.4.2.2 Medicinal plant species collection

a. Management action

i. Co-management approach for conservation of medicinal plants

The government and local communities can co-manage the collection of medicinal plants on the grassland, in that way both parties can play a role in sharing responsibility of protecting the grassland and controlling plants collection on the Woodbush Granite Grassland. A co-management committee be formed so that it will engage local people in decision-making process affecting their living environment. The government and other stakeholders such as NGO's (None-governmental Organisation) can give collectors technical support, train them on sustainable harvesting methods, proper management of medicinal plants and encourage them to start medicinal plants nurseries.

ii. Cultivation and propagation of medicinal plants

The collected medicinal plants should be propagated and cultivated to meet the growing demand for herbal medicine. Cultivation is better than collecting raw material as there will be little remaining.

b. Monitoring action

Use of permits to monitor which species, their use and how they are collected. A social approach to quantify use and population monitoring, mapping, demographics of utilized species may be used to monitor medicinal plants collection.

5.4.2.3 Fire

The Haenertsburg village and surrounding plantations have been developed in areas which were previously grassland. Consequently fire is a serious threat to the people and their property

a. Management actions

To implement an adaptive management strategy, by burning depending on rainfall / plant growth, vary season, frequency, intensity. The application of fire has to be planned annually to adapt to conditions.

b. Monitoring action

Monitoring can be done by keeping all records of the fires (Planned and accidental)

5.4.2.4 Urban development

The biggest impact that humans have on grasslands is by developing open areas for urban development. Haenertsburg Grassland is under threat of urban development as compared to other sites of the study area, there was an attempted land grab of the natural areas adjacent to Haenertsburg grassland (Desmet *et al.,* 2013).

a. Management action

I. Environmental laws

Incorporation of biodiversity management objectives into appropriate environmental laws and policies at national and provincial levels is one way of managing urban development on important ecosystems.

II. Strengthening coordination and collaboration between spheres of government and working with champions within the regulatory authority and professional associations dealing with property development is another action that can be adopted. For example; before developing the Haenertsburg area, the area must be evaluated on the following criteria; the fauna and flora that live in the grassland, if the creatures are threatened, the impact of the proposed activity on the grassland and cumulative impacts.

b. Monitoring

Monitoring should be done by spheres of government responsible for land use planning and development. Within the Limpopo Province, the primary responsibility of managing and monitoring biodiversity vests with the Limpopo Department of Economic Development, Environment and Tourism and local municipalities.

5.4.3 Ebenezer Dam Nature Reserve

5.4.3.1 Alien invasive species

The Ebenezer Dam Nature Reserve had invasive species (identified in Chapter 3) which require constant monitoring to avoid further spreading into the grassland. Management plan will focus on eradication of *Pteridium aquilinum* as shown in results on Chapter 3; it was identified as the most common and dominant invasive plant species on all study sites.

a. Managing actions

Physical control involves the cutting or crushing of growing fronds so that the surviving rhizomes are gradually starved. This involves a long-term approach but has the potential advantage of lower cost and is less dependent on weather conditions. Furthermore it does not damage non-target plant species. The aim is to cut twice each season. First cut when the *Pteridium aquilinum* is about 50-75 cm high and again six weeks later. This biannual cutting is likely to be required for at least 3 years. Cutting will need to be repeated when the *Pteridium aquilinum* shows signs of recovery. Complete eradication will not be achieved by cutting alone. Burning of *Pteridium aquilinum* litter is useful to ease cultivation and seeding success. Burning of dead litter without follow up is of no benefit, creates an unnecessary fire risk and may increase frond production.

Cutting or crushing can easily damage sensitive archaeological sites and is a threat to ground-nesting birds. Archaeological features should be marked and these areas dealt with by hand. Where ground-nesting birds occur, either avoid treatment during the nesting and fledging period; consider other forms of bracken control or retain the stand of bracken for its value as a nesting habitat and concentrate efforts on other areas.

b. Monitoring actions

An effective aftercare of the cleared area of the *Pteridium aquilinum* must be done to avoid a rapid come-back. Regenerating fronds or areas missed during initial control must be brought under control.

A public awareness campaign should be initiated amongst the community and local schools on invasive plants.

5.4.3.2 Medicinal plant species collection

a. Managing actions

I. Customary restrictions

Customary restrictions that are a feature of traditional conservation practices need to be seen as an important guide to control measures in resource areas where medicinal plants are used. They indicate the forms of control to which the local user groups can relate. The following forms of control could therefore be implemented; seasonal restrictions for certain species, the prevention of up-rooting or ring-barking, the involvement of specialists rather than commercial gatherers.

b. Monitoring actions

Use of permits to monitor which species, their use and how they are collected. A social approach to quantify use and population monitoring, mapping, demographics of utilized species may be used to monitor medicinal plants collection.

5.4.3.3 Fire

a. Managing actions

A detailed burning program should be drafted before any burning is implemented, the plan should not only consider areas that are ready for burning immediately, but also areas that could be burnt in years to follow (Bothma, 2002). All forms of fire protection must adhere to standards of the National Veld and Forest Fire Act No.101 of 1998.

The ability to achieve biodiversity conservation objectives during veldfire operations is significantly determined by the veldfire management activities undertaken before and after a veldfire. If these management activities are undertaken thoroughly and with sound logic then the environmental management objectives of the grassland will be met. A map showing firebreaks, access tracks and block burning plan must be prepared and agreed to by the fire protection group. Burning should be done depending on rainfall / plant growth, vary season, frequency, intensity. The application of fire has to be revised annually to adapt to conditions.

a. Fire regime

The burning regime to be used in prescribed burning refers to the type and intensity of fire and the season and frequency of burning. It is recommended that fires burning with the wind as surface head fires in grassland be used in prescribed burning because they cause least damage to the grass sward but can cause maximum damage to woody vegetation if required (Trollope, 1999).

b. Timing of burn

Timing of burning is legislated by the National Veld and Forest Fire Act No.101 of 1998. The time of year when grasslands are burned can influence the ecological impacts. Summer burning has a greater impact on woody growth than spring burning and can remove more humus than spring fires. Summer fires also burn more deeply, killing the roots of woody plants. Late spring and summer burns, however, will also impact grassland birds; thus burning should take place before or after nesting if birds are present. Seasonal timing of burns can also influence invertebrate diversity and density.

c. Size of burn

To avoid eliminating species from the grassland, it is recommended that only a portion of any grassland habitat be burned in any given year. Leaving a portion of habitat unburned allows species from these unburned areas to recolonize adjacent burned areas. Staggering burns within a grassland also allows for the development and continuous availability of different age structures within grassland, adding to habitat and species diversity. Burning 20-30% of habitat annually is recommended for bird species that prefer recently burned grasslands.

d. Frequency of burn

Frequent burning may eliminate fire sensitive species (e.g. insects with poor dispersal abilities and plants intolerant of fire). Thus, the frequency that grassland is burned should allow for the recolonization of desirable species.

e. Safety

Identify areas under fire threat, direction of potential fire and optimal placement of firebreak. Fire protection equipment for fire fighting should be available. Invasive alien plants posing a fire hazard must be well observed before taking action of removal.

f. Fire burning programme

Prescribed burning is one of a set of necessary interventions in the management of any fire-prone and fire-adapted vegetation type. The reasons for burning grasslands are to reduce fuel loads, and therefore hazard, to rejuvenate the fire-adapted and fire-dependent vegetation and to form an essential part of control operations aimed at eliminating invasive plants. Figure 5.2 is a summary of the ecological criteria that must be met for a prescribed burn.

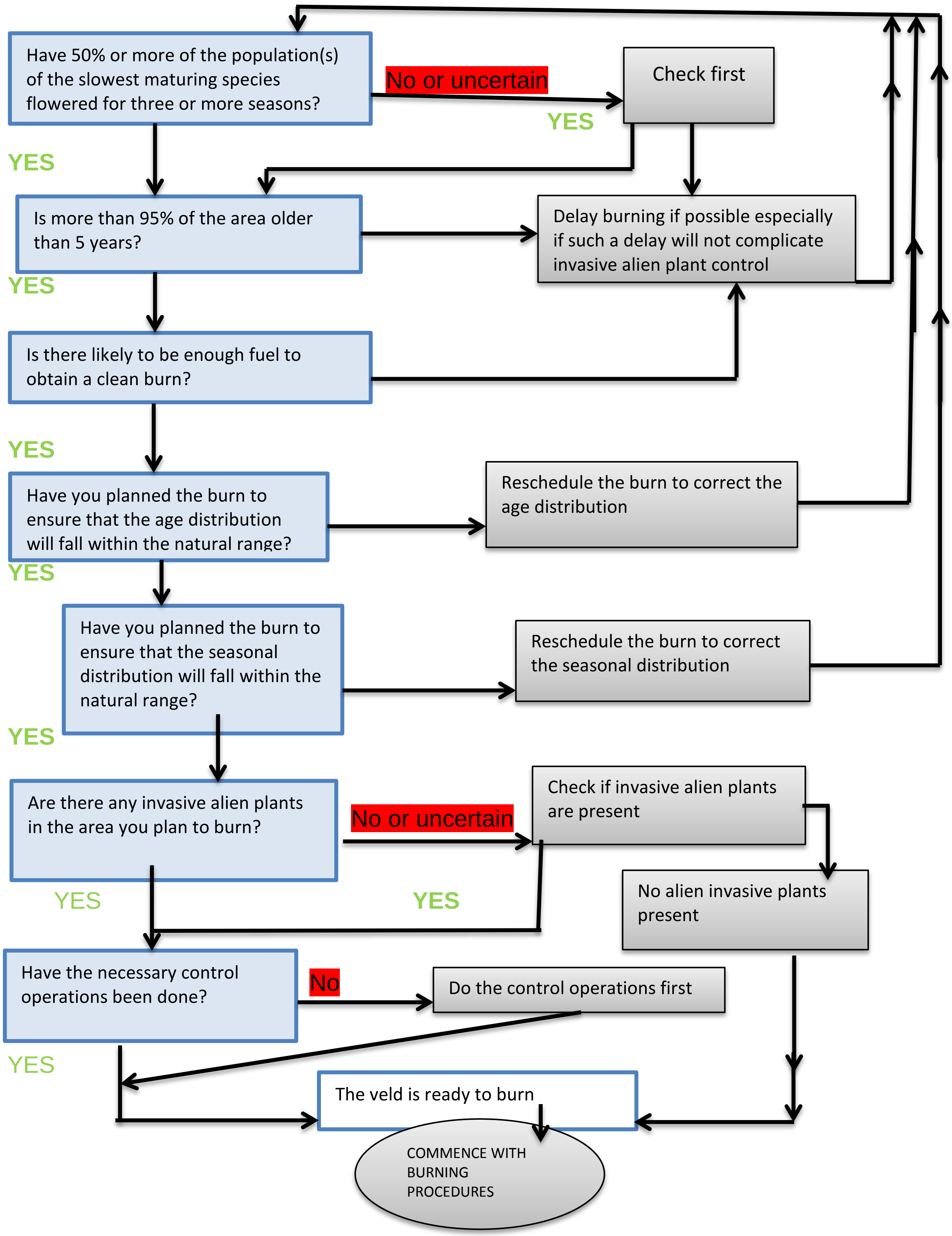


Figure 5.2 Flow chart for the ecological criteria that must be met for a prescribed burn (Greg and Jackie, 2004).

b. Monitoring

After the prescribed burn has been completed, patrolling and inspections should continue until the veldfire has been extinguished. During the patrolling phase, hazardous situations where a veldfire could most likely reignite should be identified. These areas should be carefully guarded, and not left unattended until the risk of flare-up has passed.

Awareness

Negotiate roles of sectors (neighbouring landowners, Letaba fire protection association, Working on Fire, and Haenertsburg office of the Greater Tzaneen Municipality), and educate Haenertsburg School, community and workers in roads camps on annual fires, what the laws says about starting fire and prohibited fires during high-risk fire season.

5.4.4 Ebenezer Dam Perimeter Grassland

5.4.4.1 Alien invasive species

a. Managing actions

It is best if the bracken is observed before taking any action, because it is not invading a big portion at this side.

5.4.4.2 Medicinal plant species collection

a. Managing actions

i. Education and training

The conservation of medicinal plants is by necessity a long term project requiring the development of trained staff supported by organizations and a general public that is aware of the issues at stake. Improvement in national education standards is a key factor in the conservation issue which will come about only as a result of economic development in the African nations. As well as policy decisions this would influence the levels of education available.

Improvement in national education standards is a key factor in the conservation issue which will come about only as a result of economic development. As well as policy decisions which would influence the levels of education available, the following recommendations are made with a view to increasing public awareness of the value of medicinal plant resources: Instituting campaigns that promote the importance of habitat and medicinal plant conservation and encouraging the cultivation of medicinal plants. Target groups would include: rural communities, government and decision-makers.

b. Monitoring

Use of permits to monitor which species, their use and how they are collected. A social approach to quantify use and population monitoring, mapping, demographics of utilized species may be used to monitor medicinal plants collection.

5.4.4.3 Fire

a. Managing actions

It is best if an adaptive management be used, and that is by burning depending on rainfall / plant growth, vary season, frequency, intensity.

b. Monitoring actions

Monitoring to be done by keeping records of all fires on the study area.

5.5 Transformation by plantations on the WGG

a. Management actions

i. Strengthen EIA implementation

This can be done by building capacity of the municipal and provincial environmental departments and councilors in reviewing EIAs and land use applications to avoid further transformation of the Woodbush Granite Grassland. Environmental awareness of the value of the ecosystem services supplied by the grassland amongst government, private sector associations, farmers and agricultural consultants/advisors is needed for new and existing plantations.

b. Policy level interventions

Develop implementable certification for small growers so that company initiatives can support environmental interventions in grasslands. Improve guidelines and tools for biodiversity management in priority areas which are not part of protected area network such as the Woodbush Granite Grassland, to assist the decision-making system, and improved biodiversity management practice tools, guidelines and capacity (e.g. inventory, monitoring systems, management objectives, and fire regimes).

CHAPTER 6

DISCUSSION AND CONCLUSION

6.1 DISCUSSION

The Woodbush Granite Grassland is endemic to Limpopo Province, and is the only provincial ecosystem that is critically endangered. Given the vulnerable and critically endangered status of the grassland units, the confirmed occurrence of medicinal plants and species of conservation importance (endemic), it is concluded that the WGG is a very sensitive habitat which needs to be protected and conserved. Transformation of WGG has been extensive, mainly due to exotic plantations and to a lesser degree agriculture and urban development. The area is also invaded by a number of alien plants and subject to bush encroachment from both natural forest and the sour bushveld vegetation unit (Mucina and Rutherford, 2006). Globally, increasing human population growth rate is leading to landscape transformation and therefore, increasingly fragmented landscapes which threaten biodiversity. Alien species invasions add to the Woodbush Granite Grassland biodiversity crisis. This species-rich and diverse vegetation unit is an important centre for plant endemism that provides vital ecosystem services such as water filtration and storage.

The vegetation survey and mapping results documented the threats to the Woodbush Granite Grassland, transformation of the grassland and the need for a management plan. This chapter covers discussion of the sections or chapters of the study as follows:

a. Identified threats of the Woodbush Granite Grassland (alien invasive plants, urban development, collection of medicinal plants and fire).
b. Transformation of the Woodbush Granite Grassland primarily by plantations.
c. A management plan for the Woodbush Granite Grassland.
d. Species of conservation importance.

6.1.1 Identified threats

a. Alien invasion

Invasive alien plants have been ranked alongside deforestation, urbanisation, pollution and cultivation as major agents of land cover change (Cronk and Fuller, 1995). Invasion of plant species on the Woodbush Granite Grassland as reported in Chapter 3, showed that the most problematic invading species with conservation concern was found to be the *Pteridium aquilinum,* which is invading a most parts of the study area. Other alien invasive plants that were recorded on the grassland are listed in Chapter 3. The management plan in Chapter 5 provides methods which the invasive species can be controlled or managed to prevent further spread through-out the grassland.

b. Collection of plants for medicinal use.

Of particular concern is ‘special tea’ (*Athrixia phylicoides*) – a plant that is mostly collected on the grassland as indicated by the results in Chapter 3. Other plants used for medicinal purposes are listed in Chapter 3 and management for collection of this plant species is provided in Chapter 5. Suggestions on how to manage collection of species is outlined on the management plan.

c. Fire

A management plan has been provided for control of fires on the Woodbush Granite Grassland. There is a need to implement and adapt a management strategy, i.e. burn depending on rainfall / plant growth, vary season, frequency, intensity. The application of fire has to be planned annually to adapt to conditions, and fire records are to be kept.

d. Urban development

The Haenertsburg Grassland was found to be the site mostly threatened by urban development, the management plan provides suggestions on how to protect and manage developments that might occur on the grassland. Further developments on the Woodbush Granite Grassland are not desired because of its current status. Developments that involve the clearance of 300 m² or more of natural vegetation within the Woodbush Granite Grassland are subject to permission being granted by the Department in terms of NEMA, failing this ecological infrastructure asset (particularly with regard to water regulation and medicinal plant collection) in the area would be lost.

6.1.2 Grassland transformation

Across most of the original extent of grasslands, including the WGG, only isolated patches of natural grasslands are left, in which ecosystem services are unprecedentedly disrupted, exacerbating habitat and species losses and providing opportunity for the introduction of invasive alien organisms (Neke and du Plessis, 2004; O'Connor, 2005).

It is clear from the information presented in Chapter 4 that much of this threatened ecosystem is transformed by plantations, and this can be mitigated by having and using a management plan for the grassland. The Haenertsburg Grassland is critical to meeting conservation targets for the Woodbush Granite Grassland.

6.1.3 Management plan

Management of grasslands strives to maintain biological diversity. While species of conservation concern are important and should be considered at all times, management of grasslands should also strive to maintain the greatest number and variety of plants and animals. For example, leaving unburned patches and edges throughout the year will provide cover for small mammals and wildflowers for butterflies.

Biodiversity information for the Woodbush Granite Grassland is not available at an appropriate scale needed for decision makers. It is clear that the Woodbush Granite Grassland is in need of a management plan, therefore a proposed management plan is provided and it aims at reducing risks to the grassland. The level of understanding on conservation, protection of ecosystem and issues related amongst members of the community and surrounding communities should be maximized. Information can be disseminated through workshops and community meetings (Skottke and Mauambeta, 2000). Conservation of the remaining natural portions of this threatened ecosystem must be accommodated within all EIPs, EMPs and IDPs.

6.1.4 Species of conservation importance

It is well documented that there are species of conservation importance as seen in Chapter 3, which includes endemic species and plant species of medicinal use. South African grasslands are rich in plant species, and display a high spatial ß-diversity, especially of forb species (Mucina and Rutherford, 2006). More specifically, the WGG forms part of the Wolkberg Centre of Plant Endemism, which is rich in endemic plant species.

6.2 RECOMMENDATIONS

Several specimens could not be identified and may represent important species: These are *Helichrysum* spp., *Thesium* spp., *Pellaea* spp., *Pelargonium* spp., *Tetradenia* spp., *Indigofera* spp., *Gladiolus* spp., *Geigeria* spp., *Rhyncosia* spp. and *Anthospermum* spp. Further work on this study area will require that such species are identified properly.

6.2.1 Researchers and research promotion

Researchers play a crucial role in the identification of resource problems at the most basic level and are able to suggest objective, scientific-based solutions. Researchers contribute to an enhanced understanding of management issues (Von Maltitz and Shackleton, 2004). In this study, the followings options for research are recommended:

a. Efficient monitoring and assessment of resources for sustainable utilization.
b. Phytosociological and floristic studies of the Woodbush Granite Grassland.
c. Plant collection and use of medicinal and natural product (social approach to quantify use, mapping and population monitoring of utilized species).
d. Effect of season or intensity of burn on the grassland.
e. Population mapping and monitoring of identified rare/ threatened species.

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APPENDICES

Appendix 1

Modified Braun–Blanquet vegetation data sheet

Altitude (m):			
Aspect (Bearing):		Soil	
Local topography:		Erosion category	
Vegetation		Cover: Small stones -	
Cover total (%):		Cover: Medium stones -	
Height (highest) trees (m):		Cover: Large stones -	
Cover tree layer (%):		Rock:	
Height lowest trees (m):			
Cover shrub layer (%):			
Height (highest) shrubs (m):		Maximum height herbs (cm):	
Cover herb layer (%):			
Height lowest shrubs (m):			
Aver height (high) herbs (cm):		Cover litter layer (%):	
		Cover open water (%):	
		Cover bare rock (%):	

Appendix 2

SCALE	DESCRIPTION
Rock size	Gravel (<10mm), Small stones (>10-50mm), Stones (>50-200mm), Rocks (<7200mm)
Rockiness of soil	0=0%, 1=1-5%, 2=5-25%, 3=25-50%, 4-50-75%, 5=75-100%
Soil structure	None (1), Poor (2), Intermediate (3), Strong block (4)
Soil consistency	Loose (1), Soft (2), Hard (3)
Surface erosion	None (1), Medium (2), Donga (3)
Soil type	A (gravel), B (sand), C (rocky soil), D (stony soil), E (bark), F (leaf), G (roots), H (water)
Topographic position	1=crest, 2=upper slope, 3=mid-slope, 4=lower slope, 5=flat, 6=depression
Degree of tracking by animals	None (1), Medium (2), Strong (3)
Biotic effect	1=pasture, 2=recently burned, 3=garden, 4=roadside, 5=grazed, 6=disturbed, 7=none seen, 8=animal/insect track, 9=plantation, 10=abandoned land, 11=cultivated land, 12=other
Life form	1=tree, 2=shrub, 3=dwarf shrub, 4=herb, 5=graminoid, 6=geophyte, 7=epiphyte, 8=climber, 9=parasite, 10=succulent, 11=hydrophyte, 12=bryophyte, 13=lichen, 14=scrambler, 15=saprophyte, 16=lithophyte, 17=other, 18=grass
Habitat	1=hilltop, 2=hill slope, 3=ridge, 4=dry streambed, 5=ditch, 6=plain, 7=depression, 8=wetland, 9=valley, 10=mountain top, 11= mountain peak, 12=other (specify)
Cover tree layer (%)	0=0%, 1=1-5%, 2=5-25%, 3=25-50%, 4=50-75%, 5=75-100%
Cover shrub layer (%)	0=0%, 1=1-5%, 2=5-25%, 3=25-50%, 4=50-75%, 5=75-100%
Cover herb layer (%)	0=0%, 1=1-5%, 2=5-25%, 3=25-50%, 4=50-75%, 5=75-100%

Cover litter layer (%)	0=0%, 1=1-5%, 2=5-25%, 3=25-50%, 4=50-75%, 5=75-100%
Cover open water (%)	0=0%, 1=1-5%, 2=5-25%, 3=25-50%, 4=50-75%, 5=75-100%
Cover bare rock (%)	0=0%, 1=1-5%, 2=5-25%, 3=25-50%, 4=50-75%, 5=75-100%